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Application of electrical resistivity method to identify suitable location of shallow tube well for irrigation

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ABSTRACT

Agricultural drought becomes more appearance due to climate change and uncertain weather pattern. The current and continuing drought in many parts of the world, combined with ever increasing demands from both traditional and new water users, including municipal, industrial, agricultural and environmental needs, has impacted groundwater resources. Supplementary irrigation becomes important to overcome short term drought ensuring successful cultivation. Apart from obtaining the irrigation water from the traditional water sources (surface run off and rainfall) for irrigation, other alternative water source needs to be explored. The most feasible water source and relatively abundance is the ground water.Identify suitable location for shallow tube well development using electrical resistivity method has been extensively used. This method once of the surface geophysical methods can reduce risk and unnecessary costs by assisting in the siting of wells location. Technique based on resistivity can be used to interpret the characteristics of aquifer and thus to identify suitable location for tube well. The surveys were conducted at three different locations in Perak and Kelantan situated in Peninsular Malaysia which was mainly aluvial deposits lithology.The shallow tube well in quartenary aquifer into the ground will consider for groundwater identification.The resistivity values of highly discharge of groundwater approximately in ranges of 4.4Ωm to 20 Ωm with flowrate at range 45 m³/h to 47 m³/h.The depths of tube well were in between 9 to 24 m. The groundwater aquifers are found in saturated sand, coarse sand with some gravelly sand**.**

Keywords: Geophisical method, tube well, irrigation

Introduction

Studies indicate that farms irrigated by groundwater have higher crop yields than farms irrigated by surface water (Bardhan, 2012). Usage of groundwater for irrigation has been used by farmers around the Southeast Asian region. Countries like Thailand, Indonesia, Philippines, and Malaysia itself makes groundwater as a source of additional water for irrigation (Mohd Fauzie et al., 2013). In 1994, an 8% utilize groundwater for irrigation system in Malaysia. It is because most of the geological conditions of the land covered by alluvial deposits (Mohd Fauzie et al., 2013].

Groundwater basin can be defined as a hydro geological unit containing one large or several aquifers which are interconnected and interrelated (Antholt and Wennergren, 1982). In the valley between mountain ranges groundwater basins may sit in the middle of the river basin. In addition, in areas of limestone and sand dunes, the drainage basin and groundwater basin may have a whole different configuration. Groundwater basin concept is important because the hydraulic continuity that exists for groundwater resources. To ensure the availability of groundwater continues, ground water exploration is necessary to know the location and the amount of groundwater (Hasbrouck, 2003).

Furthermore, groundwater can't be seen above the earth surface, a scope of techniques can be supply in sequence of concerning its happening with certain conditions even its properties. Surface investigations allow us in deciding the information about type, porosity, water content and the density of subsurface creation. It is usually done with the help of electrical and seismic characteristics of the earth and without any drilling on the ground. The data supplied by this technique are partly reliable and it is less expensive (Hasbrouck, 2003). It gives only indirect sign of groundwater so that the underground hydrologic records must be inferred from the surface investigations. Right interpretation requires additional data from the sub surface investigations to confirm surface findings. It is generally achieve by geophysical method like electrical resistivity & seismic refraction method.

An electrical resistivity of rock formations limit the amount of current flowing through the formation when an electrical potential is applied. The resistivity can be defined as the resistance in ohms of a cubic meter unit (Ωm). The resistivity of rock formations vary over a wide range, depending on the material, density, porosity, size, and shape of the pores, the content and quality of water, and also the temperature(Hago, 2000). There is no fixed

limit to the resistivity of various kinds of rocks. Igneous and metamorphic produce a resistivity in the range between 10^2 to $\mathbf{10^8}$ Ωm, while the sediments and non-consolidated rocks which are electrical resistivity ranging between $\mathbf{10^0}$ to $\mathbf{10^4}$ Ωm (Ashvin, 2011). Groundwater contains various dissolved salts Geophysical exploration is a scientific measurement of the physical properties of the Earth's crust to survey mineral deposits or geological structures. Geophysics methods can detect differences or anomalies, physical properties found in the earth's crust**.**

Materials and methods

Area of the study

In Malaysia, there are a number of states that are actively engaged in agricultural activities, such as kedah, Perak, and Kelantan. crops such as vegetables, fruits,and grains were . Water resources are important for the sustainability of agricultural activities. Areas lacking in water require suplementary irrigation besides rain as a major source. There are not many areas that provide water supply for agriculture. Especially smallholders who carry out small farming activities. Many places, when the rainy season passes, it will face a a short drought. water shortage happen suddenly. Shallow well to get additional water supply at that time.This studies were located at the west Malaysia. Three locations were selected shown in table 1.

The Site lithology based on a map established by the Department of Mineral and Geoscience Malaysia.

Table 1: Site information

Places	Coordinate	Lithology	Crops
Seberang Perak,Perak	100°56'27.085"E 4°5'24.335"N	Clay, silt, sand and gravel - undifferentiated (Continental)	Paddy, corn
Bachok, Kelantan	102°25'34.36"E 5°58'40.314"N	sand (mainly marine)	Tapioca & sweet potato

Electrical Resistivity Method (ERM)

The electrical resistivity imaging was conducted using ABEM Terrameter LS2 and Lund electrode selector system ES464. For data collection, 41 electrodes were arranged in a straight line with constant spacing and connected to a multicore cable. The data were processed by using inversion software RES2DINV (Asry et al., 2012). In data acquisition, there are various types of array that suitable to be applied which depends on several factors. Gradient, Schlumberger, and Pole-dipole were the common array used in investigates the underground layer. The array configuration has a substantial influence on the resolution, sensitivity and depth of investigation and it is ironically conductive, this enables electric currents to flow into ground. As a result, by calculating the ground resistivity it gives the possibility to the availability of water (Ashvin, 2011).

Figure 1: Terrameter LS 2

During data acquisition, Schlumberger array was used as this array is capable in imaging deeper profile data and suitable for areas with homogeneous layer Schlumberger array with 5 m equal electrode spacing and two cables with total layout length of 200 m was used in interpret the potential shallow aquifer in this study.

The factor influence the ERM based on the principle that the earth material is being tested acts as a resistor in a circuit. Inducing electric current to the ground could be differentiating the ability of material to exhibit characteristics of resistivity value. The images of ERM could be presenting the material exist in the ground. Interpreters should analyze the image to identify the existing of groundwater.

The location of groundwater obtained from the layer of shallow groundwater based on the image of resistivity. The parameters of interest include location and depth of initial groundwater positions.

In order to verify the availability of water in existing subsurface conditions, tube well drilling was implemented. Tube well depth was measured and pumping test was conducted to validate the availability of water obtained from images from electrical resistivity methods.

Method of pumping test

The pumping test conducted in order to identify the type of aquifer.
Pumping test also to verify the optimum discharge of tubewell can be extracted in m3/hr. Pumping test was conducted to verify the electrical resistivity result, carried out immediately after the completion of the well construction. Submersible pumps were used to pump the water from the tube wells, and the discharge rates were measured with a weir tank. The valve was installed to control and vary the discharge rates. The method weir tank based on the standard of procedure from Hudson(1993).

Results and discussion

In Perak the studies was to explore the shallow groundwater resources for the aerobic rice plantation. The potential of groundwater are very high due to topography and litholagy information. The ERM was tested in this area to searching perfect location and estimate the depth of tubewell for the development of infrastructure. After a few lines of ERM was implement in this area, the 2D Image from the ERM was selected for the tubewell location. Figure 2 show the image of the shallow groundwater in quarternary aquifer. The resistivity data ranges in between 0-400 Ωm. The potential of saturated shallow groundwater was detected around 10-30 m depth which are resistivity index are from 0-30 ohm m.
The tubewell 1 drilled until the layer of coarse sand with gravel founded. Drilling stopped at 11 m depth . The pumping test was conducted. The flowrate was 45 m^3/hr.

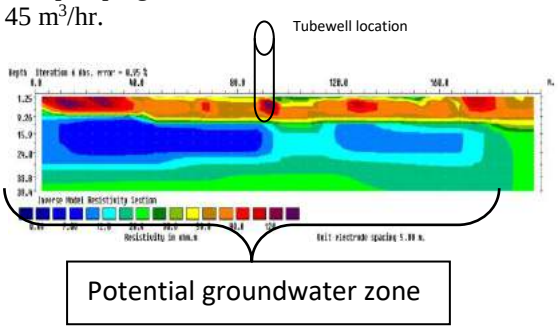

Figure 2: Electrical resistivity imaging at the survey site for Seberang Perak 1

Another resistivity conducted at different location in Seberang Perak 2 showed resulted in between range 0-150 Ωm. 30 m depth was boring to extracted the groundwater resources. The aquifer showed the thickness of sand to gravel layer was very thick and suitable to development of tubewell at specific location. From the image, it is hard to find the hard layer or rock appear in the diagram. Groundwater discharged was measuered in between 43 m^3/h-49 m^3/h. average discharge 44 m^3/h. it slightly lower than tubewell 1. This two(2) tubewell was succesfully detected and tested with the ERM .

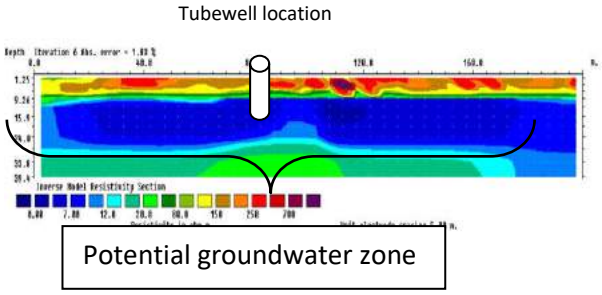

Figure 3: Electrical resistivity imaging at the survey site for Seberang Perak 2

ERM studies also implement in Kelantan which located at east coast Peninsular Malaysia. The lithology at this area are marine sand. Bachok famous with tapioca and sweet potato plantation. Almost small farm in this area were used tubewell as water sources for suplementary irrigation. From the figure 4 showed that the saturated confined aquifer were located at depth 8-10 m from the ground level. Besides that, other alluvial deposition still covered up surrounding the aquifer layer. The resistivity data in ranges 0 – 500Ωm. the first 5 m of the layer slightly high value due to the embankment or road which is different compared to original ground level. Below the road layer probably sand and gravel layer which show the resistivity value 0-10 Ωm. it located from the ground level. To verify the depth of an aquifer, well boring were conducted at proposed location. The resulted show the depth of tubewell was 8.5 m from the ground level to the coarse sand layer where the value of resistivity was 8-9 Ωm . This resulted also proofed ERM could use as a surveying grondwater especially for exploration shallow groundwater for agricultural purposes.

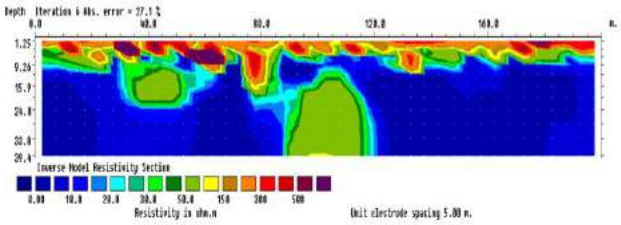

Figure 4: Resistivity imaging at the survey site for Bachok, Kelantan

Conclusion

Geophysical method more reliable than most conventional method in groundwater exploration. Conventional method based on the experience of boring contractor to located the location of tubewell sometime it take risk and difficult to define the specification of tubewell . Try and error well drilling is one of the conventional method which applied a direct way in exploring subsurface groundwater, however the cost is very expensive.Since the cost of

development in agriculture sector slightly increase nowadays, geophysical method can be tools to assist in groundwater exploration especially in agriculture industry to reduce the cost of farm infrastructure This technique was also helped to improved the understanding of groundwater aquefers. Groundwater in the form of unconfined aquifer is obtainable between a depth of 9-24 m. In summary ,the resistivity of the aquifer layer is in between 0-20 Ωm at marine sand area potentially shallow groundwater.

Table 2: Result of Tubewell exploration

Tube well	Depth (m)	Resistivity (Ωm)	Discharge (m^3/hr)
Seberang Perak 1	24	15	45
Seberang Perak 2	11	4.45	47
Bachok 1	9	8-9	N/A

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