Groundwater Assessment Using Geophysical Survey at Insat, Perlis, Malaysia

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Abstract. In this study, a 2D geo-electrical resistivity survey was conducted at Institute of Sustainable Agrotechnology (InSAT) Padang Besar, Perlis to locate potential groundwater zone. A set of ABEM Terrameter SAS 400 was used to measure resistivity and chargeability value of 400-meter survey line. Then, the measured data was analysed using RES2DINV software to produce resistivity and chargeability imaging profiles. It was found that, there is one groundwater reservoir detected at a distance of 180 m from left end at distance 0 m. The groundwater reservoir zone was located at 50 m depth below ground surface. The resistivity and chargeability values of this zone varied between 500 to 5000 Ωm and 0 to 2 ms, respectively.

1. Introduction

Sufficient water supply is a vital process throughout the growing stages in all plants. Even though Malaysia has high annual rainfall of approximately 2600 millimeters, which is above the global average, the distributions of the rainfall are uneven [1]. This has caused certain areas to experience limited water supply problem. In addition to that, there are many inter-related changes to the weather due to climate change. Thus, it affects the pattern of rainfall and vegetation system. The changes in amount and distribution of water especially may modify the environment [2].

In Malaysia, surface water is the main source for fresh water supply including for irrigation. This source however is limited due to above problems. The increasing in water demand and pollution of this source also contributes to the problems. Therefore, a clean, low cost and yet sustainable alternative should be investigated. Thus, the most suitable and readily available alternative source to the surface water is groundwater.

Groundwater forms as an alternative source to fulfill the water demand specifically in the states of Kelantan and Perlis. In 2011, the statistic showed that one-third of the water supply in Perlis comes from groundwater sources [3]. 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. The utilization of groundwater can also help to solve water shortage in the areas where surface water is limited.

Nowadays, groundwater has become an important source of water to meet the increasing requirement for domestic, industrial and agricultural needs. With the new technology on geophysical technique approach, Malaysia will be able to tap this resource effectively and in sustainable manner, and at the same time be able to protect it from any adverse effect [4].

In order to explore and determine the potential location of this alternative resource, geophysical technique approach was applied in this study. The geophysical technique such as electrical resistivity
survey has increased the possibility to find the location of groundwater resources [5-7]. The resistivity imaging profile of the survey line represents the subsurface profile. This subsurface profile shows the geological formation of that particular area which may then indicate the suitable layers that hold groundwater. Therefore, this study was conducted to detect the potential groundwater zone based on resistivity imaging profile using geo-electrical resistivity method.

2. Material and Materials

2.1. Study Area
This study was carried out at Institute of Sustainable Agrotechnology (INSAT), Universiti Malaysia Perlis. The area covers 300,000 m² which consists of a main office, laboratories and more than 50 greenhouses. The study location lies on latitude and longitude of 6°39′15.25″N and 100°15′50.37″E, respectively and was marked ‘X’ as in Figure 1. The area is relatively flat at 53m above mean sea level. The average annual temperature and precipitation of study area is 32°C and 1869 mm, respectively.

Figure 2 shows geological map of Perlis. Generally, the state composed of six geological formations; Kubangpasu Singa, Setul, Chuping Limestone, Alluvium, Granite and Bukit Arang. Based on this map, the study area is composed of a Kubang Pasu - Singa formation. The Kubang Pasu – Singa formation consists of shale, siltstone and sandstone. There is also slightly thin layer of chert. Arenitic rocks mostly have poor sorted such as expansive rocks and can also be composed of archos and sub-archos [8]. Argillite rocks consist of shale of various colors, from dark gray, gray, red to brown. The laminate in the shale is clear. In addition to shale, there are also siltstone. In the northeastern part of Perlis, Yap [8] divided the sequence of the Kubang Formation to three facies; Passage beds facies, Dominant sandstone facies, and Argilary rock facies.

2.2. Geophysical Method
A 2D geo-electrical method that consists of electrical resistivity and induced polarization survey were conducted using ABEM Terrameter SAS4000 equipment set. A resistivity survey line was spread over the length of 400 m as suggested in the instruction manual [10]. Figure 3 shows field arrangement of resistivity survey while Figure 4 shows exact location of the survey line in study area. The line started from point A to point C (where B is a centre) extending from south-east to west-east direction.
A total of 41 electrodes were used in the survey with electrode spacing of 5 m. Pole-dipole array was selected in this study as it has relatively good horizontal coverage [11]. In addition, the array has a significantly higher signal strength as compared to dipole-dipole array and it is not sensitive to telluric noise as the pole-pole array. The induced polarization and resistivity data were generated and recorded automatically by the resistivity meter. These data later were extracted and processed using RES2INV software [12] to convert the apparent resistivity data to true resistivity by inversion method. The resistivity meter measures apparent resistivity from which pseudosections were developed and subsequently inverted to true resistivity 2D sections [13].

In this survey, the focus was directed to the contrast of the resistivity values which is expected to reflect the geological structures. The chargeability values also have been analysed for the determination of an expected groundwater potential zone at the study area.

3. Results and Discussions

Figure 5 and 6 present the respective resistivity and chargeability profiles of study area. The resistivity values obtained were ranging from 0 Ωm to 10,000 Ωm while the chargeability values were ranging from 0 ms to 500 ms. The maximum depth of imaging profile is 135.5 m beneath ground surface. It can be seen that, the resistivity patterns in Figure 5 can be divided into two sections; A-B and B-C. This is due to different pattern appeared. The trend clearly shown resistivity values increased with the increased of depth for A-B cross section resistivity profile. In addition, the A-B resistivity profile was identified with three underlying zones. The zones are Zone 1 or top layer, Zone 2 or intermediate layer and Zone 3 or bottom layer. However, the three underlying zones was overlapped by zone 4.

It is believed that, zone 1 composed of clay soil as the resistivity values was ranging from 10-100 Ωm. Palacky [14] has concluded that the clay soil has resistivity within the same range. This finding has been supported by Keller and Frischcknecht [15] and Daniels and Albert [16]. Their study have found that clay soil falls within the resistivity range of 1-100 Ωm. Other study also concluded to the same interpretation [17]. Meanwhile, Zone 4 is expected to be the zone of true residue soil due to low resistivity value. It might be clay soil that extending from zone 1 or other rocks. It is difficult to confirm this geological body as resistivity values decreases when the rocks are saturated with water. Zone 2 and 3 were observed to be composed of sedimentary rocks due to high resistivity values. Zone 2 was expected to compose of moderate weathered rocks (100-500 Ωm) while zone 3 was possibly compose of completely into highly weathered rocks (500-5000 Ωm). Based on the resistivity range, the rocks might be shale, siltstone or/and sandstone. This assumption was aligned with geological map of Perlis as in Figure 2 as the formation of this study area is Kubang Pasu – Singa Formation. Keller and Frischcknecht [15] indicated that resistivity values for shale and sandstones are within 20 - 2000 Ωm and 8 - 4000 Ωm, respectively. In addition, Telford et al [18] proposed the range of siltstone to be in between 1.5x104 to 5.6x108 Ωm depending on water content.
From chargeability imaging profile in Figure 6, half of the profile area on the right side is consists of materials that have a very high chargeability measurement. The measurement was ranging between 10 ms and 500 ms and represented by the colour scheme between brown to purple. The high chargeability reading is probably due to highly contaminated area [19-20]. However, through the chargeability profile of Figure 6, there is a possibility of freshwater reservoir that might presents. The area is suspected to contain groundwater due to its low chargeability values [18]. The area is on left side of Figure 6 filled with greenish-blue colour. The chargeability values of this area were ranged between 0 – 2 ms. The expected freshwater reservoir can be found at 180 m from point A with a depth of 50 m below ground surface. Based on groundwater zone that have been detected, a water well can be constructed in the suggested location later.

**Fig. 5.** Resistivity imaging analysis result

**Fig. 6.** Chargeability imaging analysis result

4. **Conclusions**

In this study, the results showed that geo-electrical resistivity was proven as a successful method as it is widely applied in finding the potential groundwater zone. It was found that, the area consists of three layers with overlapping formation of carbonate rocks. The three layers were identified as clay soil, moderate weathered rocks, and highly weathered rocks respectively based on resistivity value. The chargeability image revealed that, there is one potential zone was detected to contain groundwater based on low chargeability value. The zone was located 180 m from point A at 50 m below ground surface. The results obtained have laid an important platform from which groundwater well can be constructed at suggested zone of groundwater later.
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