Uncovering the Failure of Groundwater Drilling with the Assistance of the Geoelectric Method: Case Study at Pondok Pesantren At Taqwiin Karangasem Bali

I Nengah Simpen

Earth Physics Laboratory, Physics Department, Matematics and Science Faculty, Udayana University Jl. Raya Kampus UNUD, Bukit Jimbaran, Kuta Selatan, Badung, Bali 80361

Abstract

Research has been carried out to uncover the failure of groundwater drilling with the help of the geoelectric method at Pondok Pesantren At Taqwiin Karangasem Bali. The problem that lies behind this research is that the Pondok Pesantren At Taqwiin previously had a small cubang as a water source for washing and bathing purposes. Cubang's water conditions are relatively good with a TDS of 146 ppm, and lime of 130 ppm. Next to the cottage there is also a river whose water flows all year round. The land next to the hut is also always wet so the trees can thrive. Paying attention to such a situation, the cottage party in the manufacture of drilled wells immediately carried out drilling. Finally, up to a depth of 140 m, there is no source of water yet. After that, the drilling was stopped. Taking into account this situation, the question can be asked, namely: Why has no water source been found until a depth of 140 m? Furthermore, this experience is expected to be used as a lesson to find water sources in the future. The research uses the 1D geoelectric method. Data analysis modeling using Ras1divn program. The analysis modeled that the soil consisted of seven layers, with an average model error rate of 6.49%. Overall, the real resistivity of the rock layers at the study site appears that the lower the resistivity, the greater the resistivity. The first layer, which is the surface layer, up to a depth of 8 m has a low resistivity of about 12 Ω.m. This layer is thought to contain a lot of water, this is in accordance with the moist soil surface. The second layer, from a depth of 8 m to 18 m the resistivity has increased to 20 Ω.m. This means that the water content has decreased. And so on until the seventh layer with a resistivity of 100 Ω.m. at a depth of 100 m which means the water content is decreasing. As a result, if drilling is carried out in this area, no aquifer is found, only seepage water will be obtained. This condition is in accordance with the results of drilling that during drilling only seepage water was found from small seeps near the surface. This condition would have been able to answer the problem at the beginning that the drilling failure around the Pondok Pesantren At Taqwiin was caused by the fact that there was no water source below the surface. This research is expected to be a lesson in the future in the search for water sources (aquifers) research needs to be done first.

Keywords: *groundwater, cubang, geoelectric, failure, drilling*

I. Introduction

Pondok Pesantren At Taqwiin is the only Islamic boarding school located at the foot of Lempuyang Hill, Karangasem Bali. There are 250 students staying at this lodge. The number of students who stay in Islamic boarding schools causes a lot of water to be provided every day. The average water requirement per person is 150 liters/person/day, thus, each day requires 37,500 liters of water or 37.5 m3. There are so many water needs every day, with the help of funds from Indonesian Bank, the Islamic boarding school took the initiative to build boreholes as a source of drinking water. Previously drinking water was obtained from gallons of water, while for washing and bathing purposes, seepage water in the form of a cubang was used. The At Taqwiin Islamic Boarding School previously had a small cubang as a water source for washing and bathing purposes. This Cubang is located inside the Islamic boarding school (Picture 1). Cubang water conditions are relatively good, based on the results of measurements of TDS 146 ppm, and carbonat 130 ppm. Next to the cottage there is also a river whose water flows all year round. The land next to the hut is also always wet so the trees can thrive. Taking into account such a situation, the cottage party in making the drilling well immediately carried out drilling. Finally, up to a depth of 140 m, there is no source of water yet. Then the drilling was stopped (Figure 2).

Figure 1. Cubang as a Water Source at the At Taqwiin Islamic Boarding School

Figure 2. Drilling for Water Sources at Pondok Pesantren At Taqwiin

Taking into account this situation, the following questions can be asked: Why has no water source been found until a depth of 140 m? It is hoped that this question can be answered in this research. Furthermore, it can be used as a lesson to find water sources in the future. The problem of water sources, including ground water consists of four things, namely the problem of quantity, the problem of quantity, the problem of equity and the problem of availability over time [1]. The level of the problem is very dependent on the characteristics of the area such as the condition of the aquifer, the characteristics of the aquifer constituent materials, water balance and human activities[2]. Therefore, the analysis of the potential of water sources becomes very important [1]. Groundwater does not guarantee its existence evenly in space and time [3].
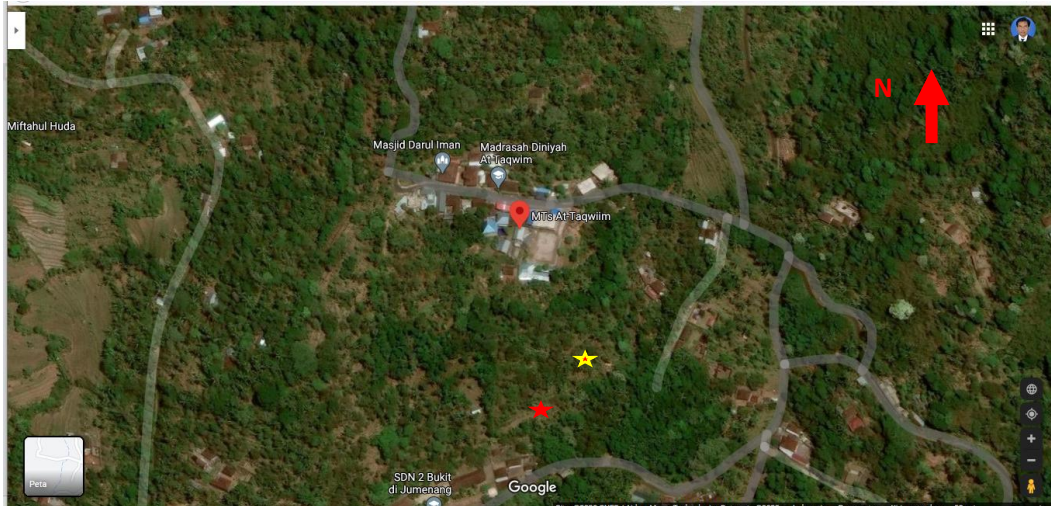
Finding the position of groundwater sources (aquifers) has often been used with the help of the geoelectric method [4][5][6][7][8]. This method works based on DC electric current with low frequency [5]. The implementation is done by injecting an electric current into the ground, then measuring the injected current (I) and the resulting potential difference (V), so that rock resistivity can be calculated. However, the resistivity obtained is in the form of apparent resistivity. To get the real resistivity, the data were analyzed using the Res3divn, Res2divn or Res1divn programs depending on the dimensions of the research being conducted. The results obtained are in the form of a resistivity measurement map so as to get a general description of the rock resistivity at the measurement location. Based on this resistivity map, the position of the aquifer can be interpreted. The geoelectric method has proven successful in groundwater surveys[9]. Research can be carried out with various configurations such as Wenner, Schlumberger, Wenner-Schlumberger, and dipole-dipole configurations. Which configuration to use the results are relatively the same.

This study uncovers the above failures with the help of the geoelectric method using a one-dimensional (1D) Wenner configuration so that it is expected to reveal the rock resistivity in the study area. This resistivity map will be interpreted later.

II.   Research Method

2.1 Place and time of research

The research was conducted in the At Taqwiin Islamic Boarding School, Karangasem. The research method used is the geoelectric method. The tool used is the SkillPro geoelectric set with Werner 1D configuration. The measurement location is around the geographical position at 8.412583 South Latitude and 115.640211 East Longitude, at an altitude of 324 m above sea level. The measurement position can be seen in Figure 3. The study was conducted on September 20, 2020.

Source: https://www.google.com/maps/place/MTs+At-Taqwiim/@-
8.4122859,115.6401408,385m/data=!3m1!1e3!4m5!3m4!1s0x2dd20766700e240d:0x9f7bd5b2a97dc3d8!8m2!3
d-8.4120843!4d115.6400496

★ : Measurement position
★ : Drilling position

Figure 3. Research Locations

2.2 Data collection method

Data retrieval using the geoelectric method. The workings of the geoelectric method can be explained as follows. As explained earlier, geoelectric works by injecting electric current into the ground and then measuring the potential difference. So the quantities measured are the electric current and the resulting potential difference. Because the current and potential difference are small, the current is measured in milli amperes (mA) and the potential difference is measured in milli volts (mV). The schematic of how the geoelectric method works can be seen in the image below.
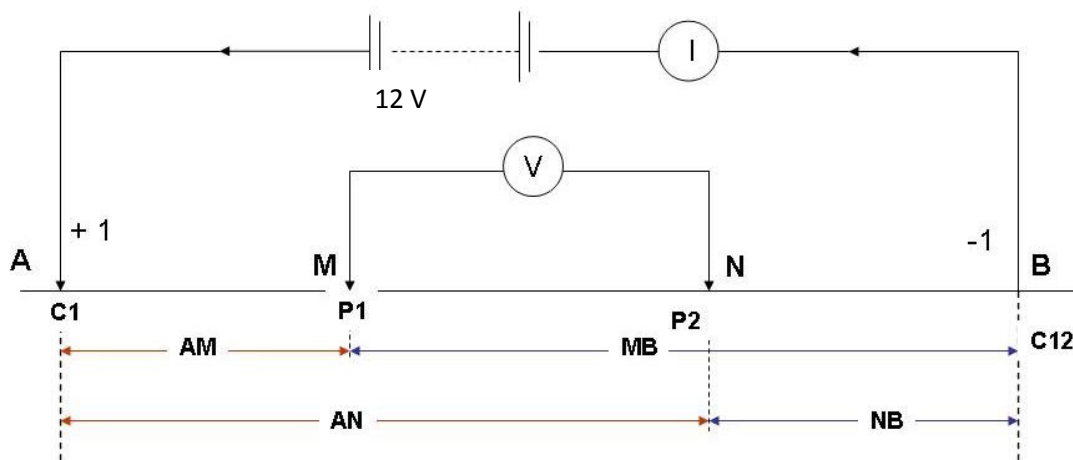

Figure 4 Schematic of the geoelectric method

Rock resistivity is obtained from the relationship between these two quantities, namely[10][11][12]:

$$\rho_a = K \frac{\Delta V}{I} \ \Omega.m \quad (ohm.m) \ \text{........................(1)}$$

where ρ_a: measured apparent resistivity, K: geometric factor, depending on the configuration of the geoelectrical measurement, in this study using the Wenner configuration, so that $K=2\pi a$, where a is the distance between the electrodes, namely in Figure 4 a=AM=MN=NB, so for Wenner's configuration becomes[10][11][12]:

$$\rho_a = 2\pi a \frac{\Delta V}{I} \ \Omega.m \quad (ohm.m) \ \dots\dots\dots\dots\dots(2)$$

So in this study only measure the distance between the electrodes (a), the injected current (I) and measure the resulting potential difference (ΔV). The resistivity obtained is in the form of apparent resistivity. To get the real resistivity, it is necessary to do modeling so that the results are close to the smallest possible error. There are various modeling programs, including Res1divn/Res2divn, Ip2win, RockWork and others. The method of data collection depends on the desired backfill dimensions. For measurements in one dimension (1D) the measuring point is fixed, for 2D measurements the measuring point is moved. In this study, the Wenner 1D configuration was used using the Res1divn modeling program. The first data collection used the distance between the electrodes (a) 10 m, then the distance between the electrodes (a) was added by 6.67 m.

The steps taken in conducting the research are as follows:
 1) Create a measuring path
2) Electrode installation
3) Measurement cable installation
4) Take measurements
5) Data analysis and interpretation
6) Report generation

2.3 Methods of data analysis and interpretation

The measurement results were analyzed with the Res1dinv program so as to produce a relationship between resistivity and depth at the measuring point. Interpretation is carried out based on resistivity data, and is also supported by local and regional geological data in the research area so that final results are obtained regarding the position of the planned drilling point and the depth to obtain water.

III.   Research Results

3.1 Geological condition of the research area

When data collection the weather is sunny. The surface of the research area appears to be forested, the soil at the measurement site looks moist. There is a seepage spring (well) in the area above it (Figure 1). The location of this research is at the foot of Lempuyang Hill. Geologically, the Lempuyang area consists of Seraya volcanic rock groups, especially volcanic breccias interspersed with lava, which is an old volcanic product consisting of very solid volcanic breccias and breccias, solid lava and tuff[13][14][15]. Generally have a low pass with a discharge of less than 5 l/s.[14][15] An example of drilled breccia rock is shown in Figure 4.

Figure 5. Drilled Breccia Rock

3.2 Results of measurement, analysis and interpretation of data

The measurement data can be seen in Table 1. a is the apparent resistivity value obtained from equation (2) after entering the values of a, I and V

Table 1 Measurement Result Data

No.	a = AM=MN=NB (m)	ρ_a (Ω.m)
1	10.00	16,38
2	16,67	22,22
3	23,33	28.47
4	30,00	30,16

5	36,67	37,64
6	43,33	41,66
7	50,00	50,70
8	56,67	52,10
9	66,33	55,97
10	70,00	53,58
11	76,67	70,03
12	83,33	69,77
13	90,00	65,07
14	96,67	76,70
15	103,33	76,41
16	110,00	65,06
17	116,67	78,54
18	123,33	82,14

Information; a = AM=MN=NB : distance between electrodes a : apparent resistivity calculated using equation (2)

Globally, the measurement data shows that the lower the resistivity, the greater the resistivity, but this is only the apparent resistivity. To get the real resistivity, it is necessary to process the data using the Res1divn modeling program. The measurement results after being analyzed with the Res1dinv program produce a graph plot of the relationship between real resistivity and depth. Interpretation refers to resistivity data, and local and regional geological data of the study area. The measurement results and their interpretation can be described as follows.
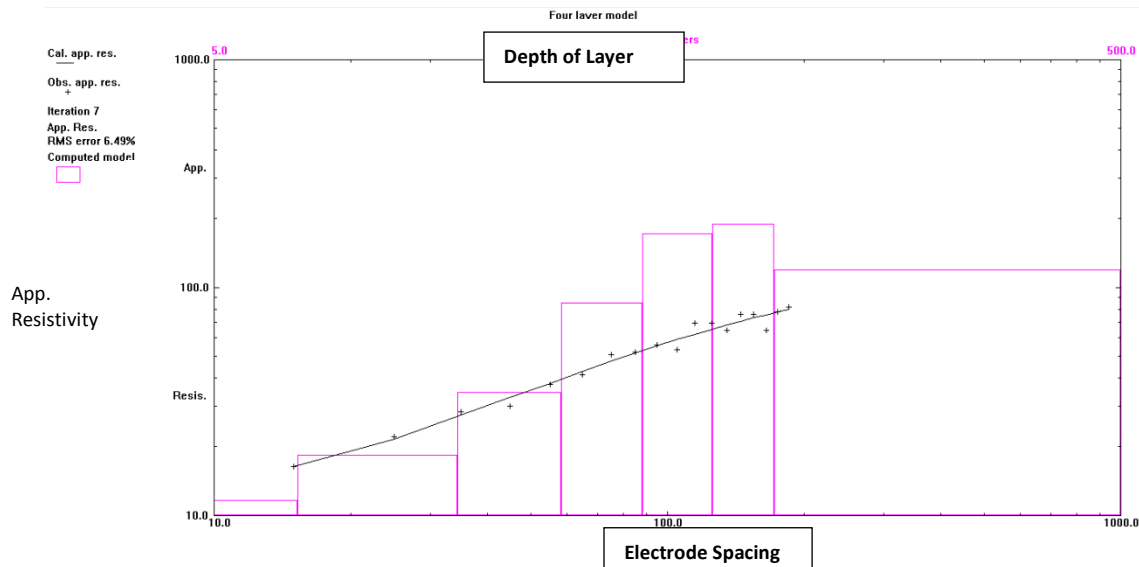

Figure 6. Plot of the Relationship between Resistivity and Depth

The analysis modeled that the soil consisted of seven layers, with an average model error rate of 6.49%. Overall, the real resistivity of the rock layers at the study site appears that the lower the resistivity, the greater the resistivity. The first layer, which is the surface layer, up to a depth of 8 m has a low resistivity of about 12 .m. This layer is thought to contain a lot of water, this is in accordance with the moist soil surface. The second layer, from a depth of 8 m to 18 m the resistivity has increased to 20 .m. This means that the water content has decreased. And so on until the seventh layer with a resistivity of 100 .m. at a depth of 100 m which means the water content is decreasing. As a result, if drilling is carried out in this area, no aquifer is found, only seepage water will be obtained. This condition is in accordance with the results of drilling that during drilling only seepage water was found from small seeps near the surface. This condition would have been able to answer the problem at the beginning that the drilling failure around the At Taqwiin Islamic Boarding School was caused by the fact that there was no water source below the surface. Furthermore, this research is expected to be a lesson in the future in the search for water sources (aquifers).

IV. Economic Job Review

A review of the implementation of the work economically can be carried out as follows: a, Cost of geoelectric survey for one observation point: Rp. 10,000,000,- b. The drilling cost is Rp. 1.000.000,-/m depth (for the Pondok Pesantren At Taqwiin area), the drilling depth which has been carried out is 140 m, which means that the cost of Rp. 140,000,000,- From the two components above, there is a difference in the value of the rupiah as much as Rp. 130,000,000, - If only a geoelectric survey was carried out first, the cost of Rp. 130,000,000, - could be saved. Likewise for other groundwater drilling, if a geoelectric survey has been carried out, the position/depth of the water source can be estimated, so that drilling is not in vain.

V. Conclusion

Based on the results of geoelectrical measurements, data analysis and interpretation, it can be concluded that in the research area there is no water source, although on the surface there is a basin and river water flows throughout the year, it is only seepage water near the surface. Water comes from condensation of water vapor in the upstream area (forest) so that water droplets are formed and then fall in the form of a small drizzle that enters the ground but does not reach deep. This water can appear as seepage water in the basin and seepage in rivers

VI. Suggestions

Based on this research, it can be suggested that in making boreholes it is necessary to research the presence of groundwater in the research area. One method that can be used is the geoelectric method. THANK-YOU NOTE We thank Mr. Ali Musbah, S.Ag.MA as the Management of the At Taqwiin Islamic Boarding School Karangasem Bali, according to the Work Certificate No. : PP.At.IV/20/09/2020 for the opportunity given to conduct research.

Bibliography

[1]. Cahyadi, A. dan Hidayat, W. 2017. Analisis Karakteristik Hidrogeokimia Airtanah di Pulau Koral Panggang, Kepulauan Seribu, DKI. Jakarta. *Jurnal Geografi,* 9(2): 99-108.

[2]. Setiawan, T., dan N.M. A. Asgaf. 2016. Analisis Karakteristik Akuifer Dan Zonasi Kuantitas Air Tanah di Dataran Kars Wonosari dan Sekitarnya Kabupaten Gunungkidul, Provinsi Daerah Istimewa Yogyakarta. *Jurnal Lingkungan dan Bencana Geologi*, 7(3), Desember 2016: 145 -154

[3]. Cahyadi, A. 2012. Permasalahan Sumberdaya Air di Pulau Karang Sangat Kecil (Studi Kasus di Pulau Pramuka, Kabupaten Kepulauan Seribu, DKI Jakarta). *Prosiding Seminar Nasional Pengelolaan Sumberdaya Alam dan Lingkungan.* Semarang: Program Studi Ilmu Lingkungan Universitas Diponegoro.

[4]. Karunia, D.K., Darsono, Darmanto. 2012. Identifikasi Pola Aliran Sungai Bawah Tanah di Mudah, Pracimantoro dengan Metode Geolistrik. *Indonesian Journal of Applied Physics.* 2(2): 91-101.

[5]. Simpen, I N dan I W. Redana. 2016. *Pendugaan Posisi Akuifer dengan Metode Geolistrik dalam Rangka Membuat Sumur Bor di Villa Puri Persada Denpasar.* Laboratorium Mekanika Tanah Jurusan Teknik Sipil Fakultas Teknik Universitas Udayana. Denpasar.

[6]. Luthfin,A., H. Cahyadi, dan Jufri, 2020. Identifikasi Batuan Pondasi Candi (Andesit) di Bawah Permukaan Sekitar Candi Badut dengan Metode Geolistrik Resistivitas, *Indonesian Journal of Applied Physics*. 10 (2):106-115.

[7]. Muhardi, Faurizal, dan Widodo. 2020. Analisis Pengaruh Intrusi Air Laut terhadap Keberadaan Air Tanah di Desa Nusapati, Kabupaten Mempawah Menggunakan Metode Geolistrik Resistivitas. *Indonesian Journal of Applied Physics.* 10 (2):89-96.

[8]. Eddy Hartantyo, E. 2020. Vertical Electrical Sounding Analysis for Local Subsurface Water Bearing Identification Due to Isolated Hill. Case-study: Madurejo Village, Prambanan District, Yogyakarta Province, Indonesia. *Indonesian Journal of Applied Physics*. 10 (1):50-55.

[9]. Susilo, A., Sunaryo, and Fina Fitriah. 2018. Ground Investigation Using Resistivity Method and Drilling for Drought Mitigation in Tulungagung, Indonesia, *International Journal of Geomate*. 15,(47):124-131.

[10]. Telford, W. M., Geldart, L.P. dan Sheriff, R.E., 1990. *Applied Geophysics, Second Edition*. Cambridge University Press, New York.

[11]. Muhardi dan Wahyudi.2021. Prediksi Tipe Longsor di Desa Clapar Menggunakan Metode Geolistrik Resistivitas Konfigurasi Dipol-dipol, *Jurnal Lingkungan dan Bencana Geologi*. 11(2): 115-123

[12]. Shinta Kiky Rachmawati1,D.K., Y. Sudradjat, L. Handayani, D. D. Wardhana.2021. Metode Geolistrik Konfigurasi Dipole-Dipole Untuk Penetapan Bidang GelincirGerakan Tanah di Jajaway, Palabuhanratu, Sukabumi. *Jurnal Lingkungan dan Bencana Geologi*. 11(1): 47-56

[13]. Probo-Hadiwidjojo, M.M, H. Samodra dan T.C Amin. 1971. *Peta Geologi Bali.* Pusat Penelitian dan Pengembangan Geologi. Bandung.

[14]. Sudadi. P, H. Setiadi, BR Denny, Salahudin Arief, S. Ruchijat dan S. Adi, 1985, *Peta Geohidrologi Indonesia Lembar Bali*, Direktorat Tata Lingkungan Geologi dan Kawasan Pertambangan. Bandung.

[15]. Nudiana, Wayan dan Hendri Setiadi. 2008. *Peta Sebaran Cekungan Air Tanah Pulau Bali.* Departemen Energi dan Sumberdaya Mnineral Badan Geologi Pusat Lingkungan Geologi. Bandung.