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Aquifers Selection to Aid Geoelectrical Methods on Drilled Well Building near the Beach

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Abstract

The aquifer was a rock form wherein the water was collected and as well as able to release water economically. The aquifers near the beach were susceptible to intruded sea water, especially areas that have a lot of groundwater taking, therefore, if building a well, should be chosen aquifer that had not been intruded sea water. It was needed a way thus, the water taken is not salt water or brackish water. This study has a long-term goal of finding a way to choose aquifer by geoelectric method aid. In order to build a drilled well, for getting the right aquifer. The research had been conducted in Candidasa Karangasem Bali with the geoelectric method. The results showed that there were two aquifers types, i.e. free aquifer with resistivity was 33.9 ohm.m and distressed aquifer with a resistivity was 70 ohm.m. Taking into account the two resistivity magnitudes, then, the free aquifer was thought to have been intruded by the sea water, while the distressed aquifer was thought to have not been intruded by sea water. Based on water samples on three dug wells that take water in a free aquifer, obtained electric conductivity 850.00, 1288,81, and 1341,55 µmho/cm, means the water has been intruded by sea water. Drilled well water samples, taking water in the distressed aquifer, obtained electric conductivity 200.00 µmho/cm, means the water has not been intruded by sea water. Thus the geoelectric method could be used to select the aquifer in order to build a well near the beach.

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Contents

1. Introduction

An aquifer is a rock form wherein the water is collected as well as capable of releasing water economically.[14, 15] There are three aquifers types i.e. free aquifers, distressed aquifers, and semi-distressed aquifers.[8] The water in aquifers is influenced by the aquifer environment.[24] The free aquifer its infiltration region around the aquifer. The distressed aquifer its infiltration region deep in the upstream, therefore, it has undergone some filtering. Whereas the semi-distressed aquifer has a distant infiltrating region upstream but also has infiltration around the aquifer.[4]

There is free aquifer near beach aquifers, distressed aquifer, and semi-distressed aquifer. The aquifers near the beach are susceptible to be intruded seawater, especially areas that have a lot of groundwater taking, if the well is built, should be chosen aquifer that has not been intruded seawater.[11] It is needed a way, therefore, the water taken is not salt water or brackish water. [22, 23]

There are several factors that determine the magnitude of the rocks resistivity value, i.e. material types, water content, rock porosity, and chemical properties of the fluid fillers.[2, 9, 10] The presence of water in a rock formation causes the rock to behave as an aquifer, consequently the resistivity of the rock formation changes. The resistivity aquifers near the beach-dependent on the aquatic salinity present in the aquifer.[12,16] One geophysical method that can describe the formations rock resistivity is the geoelectric method. Thus, the geoelectric method is expected to aid the selection of aquifers on building drilled well to obtain good water, not brine or brackish water. The research was conducted in Candidasa Karangasem Bali in order to drill wells near the beach because the research found at Candidasa Beach has been intruded by seawater however uneven. This situation is very good used as a case study.[7,17] The research is expected to be a model in choosing aquifers if the drilled well is built near the beach.[20,21]

2. Research Method

In order to achieve the research, objective is to obtain the aquifer image in the research area based on the geoelectric data and to get the water quality in the aquifer in the research area, the research is conducted by the following steps.

2.1 Perform Geoelectric Measurements

The measurements using geoelectric sets are performed at the drilled well site. The equipment used is a set of geoelectric equipment (Figure 1) consisting of main unit geoelectric along with a laptop for interface, electrode, cable, meter, yarn, hammer, battery, and mat. Measurement steps include:

1) Create a measurement line.
2) Install the geoelectric device set.
3) Attach the connecting cables.

4) Build measurements in accordance with the configuration used.
5) Transfer of the data.

Figure 1. Geoelectric tool set

2.2 Geoelectric Data Analysis

Data processing program used Res2divn Program. The data is to transfer from the main unit is first converted into data *.DAT. This data then is analyzed by Res2divn program, therefore, the image is obtained a resistivity counter of a cross-section of the measurement line. Based on the picture of the resistivity contours, can be interpreted the position of each aquifer and can also suspect water conditions each aquifer with the following categories:

Table1
Sediments resistivity increased seawater

No.	Resistivity (Ohm.m)	Sediments	TDS Range mg/l	Description
1	0.5 - 2.0	Soils with little grains or saturated clay	≥20000	Seawater or salty water
2	2.0 - 4.5	Grain of sand or saturated clay	10000-20000	Saltwater
3	4,5 - 10.0	Sandy clay or sandy clay	10000-5000	Brackish water
4	10.0 - 15.0	Sand, gravel, and clay	5000-1500	Brackish water
5	15.0 - 30.0	Sand, gravel slightly clay	1500-700	Low-quality groundwater
6	30.0 – 70,0	Sand, gravel, little clay	100	Medium quality groundwater
7	70.0 - 100.0	Sand, tidal clay and small	Low	good quality groundwater
8	More than 100	Rough sand, non-clayed gravel	Very low	Very good quality groundwater

Source:[1]

2.3 Drilling

Drilling is maintained at the position and depth wherein, it is thought good water, not intruded seawater by the geoelectric data. The purpose of drilling is obtained water samples in distressed aquifers or in intrusion areas. The water samples in free aquifers are obtained from the dug wells.

2.4 Measuring water electrical conductivity

The water samples are taken from dug wells and drilled wells then is measured electrical conductivity. An electrical conductivity measurement results are categorized as follows.

Table 2
Well water classification near the beach based on seawater intrusion level

No.	conductivity range (μmho/cm, 25°C)	Intrusion classification
1	≤ 200,00	Not intruded
2	200,01-229,24	Medium intruded
3	229,25-387,44	Slightly intruded
4	387,44-554,67	Rather high intruded
5	≥534,68	High intruded

Source: Davis and Wiest (1996)

3. Results and Analysis

Candidasa is located in Karangasem Regency of Bali Province. It geographically lies in the position of approximately S = 80 30 '37,458' 'and E = 1150 34' 29,629 '' and an altitude about 12 m above *mean sea level* (msl). The Geologic in around Candidasa is an alluvium sandy.[6,18] Candidasa area is a developing tourist area along the beach. Many villas and hotel are under construction. The study area is located at S = 8.514300 and E = 115.580191, on the beach, wherein, it is planned to be drilled well. In the research area, there are many dug wells owned by the local residents. Three of them are shown in Figure 2 on figure research location.

Source: https://www.google.co.id/maps/@-8.5140498,115.5793704,398m/data=!3m1!1e3?hl=id
1, 2, 3: dug well

Figure 2. Research location

Measurement Results and Data Analysis

The measurements used geoelectric SkillPro set property Soil Mechanics Laboratory of Civil Engineering Department, Faculty of Engineering, Udayana University, by Wenner configuration. In accordance with the geographic circumstances of the research area, the measurement line is made in the east-west direction, the electrode spacing is 4.00 m, and the length of the measurement line is 188 m, the distance of the measuring lane to the beach between 7-20 m (Figure 2). The measurement result is a strong quantity of the injected current (I) and the potential difference generated (ΔV). The two quantities are analyzed using the Res2divn Program, with interfaces, therefore, unlike to show the resistivity contour of the cross-section of the measurement as well as Fig. 3. The figure is described as follow.

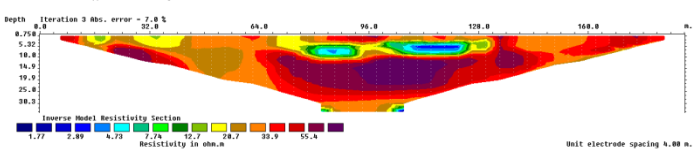

Figure 3. Cross section of resistivity contour measurement line

It generally appears that the research area has a small resistivity about 1.77 ohm.m - 55.4 ohm.m, however, there are some parts that have resistivity around 70 ohm.m. In accordance with Table 1, a small resistivity area is aquifer area but has been intruded sea water, its water from brackish saltwater categorization to low-quality groundwater as it has been intruded seawater. In the free aquifer, there are dug wells made by the local residents. Based on geoelectric survey results, the free aquifer has a resistivity is 33.9 ohm.m, means this area is low-quality water. The result of the electric conductivity measurement of a dug well water sample can be seen in Table 3. Based on Table 2, the high electric conductivity value in each well indicates that the well has been intruded by seawater.

Table 3
Conductivity value of the dug well

No.	Well number	Depth (m)	Rock resistivity (ohm.m)*	Well water conductivity (µmho/cm)	Explanation**
1	1	4	39,9	1341,55	There has been an intrusion
2	2	6	39,9	850,00	There has been an intrusion
3	3	5	39,9	1288,81	There has been an intrusion

Note:
* based on the geoelectric data
** based on Table 1 and Table 2

In the area with the higher resistivity value is 70 ohm.m is a distressed aquifer. A distressed aquifer is surrounded by the protective layer. Based on Table 1, this area is an intrusion aquifer region, therefore, when building a drilled well, the water in this aquifer is better used. In the present research lies in the position on 94 - 98. After drilling, the rock layer is obtained as follows:

Table 4
Rock layer drilling results

No.	Depth (m)	Rock type	Explanation
1	0,00 - 1,50	Sandy clay	
2	1,50 – 4,00	White sand	
3	4,00 – 5,00	White sand, there is a bit of coral	
4	5,00	Start to see water	There is water but salty (after felt)
5	5,00 – 8,00	Sand with coral	There is still water
6	9,00 – 11,00	Sand with coral (coral bigger than before)	There is still water, but stench

7	11,00 – 12,00	Sandy clay, rather hard texture	There is still water
8	12,00	Started there was nice water	There is still water
9	12,00 – 17,50	The fractured rocks containing the alluvium sand as an aquifer as figure 4	There is still water
10	17,50 – 18,00	Sandy clay, rather hard texture	Drilling stopped

The good water starts to be discovered in depth at 12 m after penetrating a rather hard rock. This aquifer a stone fracture that is mixed with alluvium sand. The sample of the rocks and alluvium sand took during drilling can be seen in Figure 4. Unlike the soil, the layer has begun to soften, or the fractured stone has run out, the drilling is stopped at a depth at 18 m. Furthermore, the well-fitted casing with the screen of depth at 14 m down.

Figure 4. Example of the alluvium rock and sand on drilling

The drilled well water then measured its electric conductivity, the result is obtained 200.00 µmho/cm. Based on Table 2, and the drilled well water obtained is not intrusive. The results of this research in accordance with the results of research found that in Candidasa has in nutrition seawater but not evenly.[7,19] If the drilled well is built, a geoelectrical method can aid the selection of aquifer, thus, the water is obtained, not salt water or brackish water.

4. Conclusion

Based on the research results it can be concluded that the geoelectric data indicate in the research area there are two aquifers types, namely free aquifers and distressing aquifers, in the framework of the drilled well, can choose a distressed aquifer that is not intruded seawater, in this study has resistivity 70 - 100 ohm.m, in the research area, the dug well water around the drilled well quality is ugly due to it has intruded seawater, while the drilled well water has a good quality because not intruded seawater yet. It may be suggested that if the building of the drilled well near the beach, its better conducted the geoelectric survey carried out first to determine the position and condition of the aquifer.

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