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Interpretation of groundwater potential based on the Cooper Jacobs method combined with Schlumberger geoelectricity in Simpang Tiga Village, Pekanbaru City

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ABSTRACT

This study aims to analyze the aquifer parameter values including storativity, transmisivity, and hydraulic conductivity in Simpang Tiga Village, Pekanbaru City. This research is motivated by the community's increasing need for water due to higher population growth, and the Simpang Tiga Village which is close to the city center. Pumping test results using the Cooper Jacobs method showed an aquifer transmisivity value of 247.21 m^2/day in the high category and a storativity value of 0.0845. The results of the geoelectrical test with the Schlumberger configuration obtained that the aquifer layer is in the fourth layer with a thickness of 11 m. The hydraulic conductivity obtained is 22.473 m/day and is included in the fast category.

Keywords: Aquifer; hydraulic conductivity; storativity; transmissivity; underground water

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INTRODUCTION

Water is the most needed resource for the survival of life, be it for humans, animals, or plants, all need water for their survival. The availability of water on earth is very limited both in terms of the availability of storage space, time, quality and quantity [1]. An aquifer is a geological formation that can store and pass water in large quantities. The water stored in this aquifer is called groundwater [2].

The activity of finding and utilizing groundwater to meet both domestic and industrial needs, it is necessary to know the geometric structure or characteristics of the water-bearing layer below the surface. One approach taken to investigate the potential of aquifers for groundwater exploitation is by analyzing pumping test data. Pumping tests are carried out to measure the value of the decrease in the groundwater level, which is produced from the pumping process in the well [3]. The pumping test data can then be analyzed using statistical models such as the Cooper Jacob to determine the aquifer parameters [4].

The Simpang Tiga sub-district area is the area with the lowest population density in the Bukit Raya sub-district with a figure of 2116 residents/km^2 of its area. However, its location which is not far from the city center will certainly accelerate progress in the sub-district. Currently, one star-rated hotel and a BPR bank have been recorded in this sub-district. With the growth of industry, economy, and population density growth, of course, it will be directly proportional to the increasing amount of water needed. In this case, the policy of exploration and exploitation of water properly is needed so that the water in this sub-district remains fulfilled but does not burden the aquifer in the area. Investigating the characteristics of the aquifer in this sub-district is important to do. One way is to conduct a pumping test using the Cooper Jacobs method and combined with the Schlumberger configuration geoelectric method so that the aquifer parameters are obtained.

LITERATURE REVIEW

Groundwater

Groundwater is different from soil water. Groundwater is water that is in the aquifer layer or saturated zone. While soil water is water that is in the unsaturated zone.

Aquifer

An aquifer is a geological formation that is saturated so that it can be used as a supplier of water in economical quantities because this formation is able to store and pass water. Todd (1955), stated that etymologically aquifer comes from Latin, namely from the word aqui or aqua which means water and the word ferre which means to carry, so etymologically aquifer can be interpreted as a water-bearing layer [5].

Aquifer Characteristics

An aquifer is a geological formation that is able to store and carry water which is very useful for human life needs. However, the ability to store or carry water for each aquifer in each place is different. This ability is influenced by the type of rock that makes up the aquifer. Some characteristics or parameters of aquifers that determine the potential for groundwater in an aquifer include hydraulic conductivity, transmissivity, and storativity.

Hydraulic conductivity can be defined as a coefficient value that indicates the ability of rocks to pass unit volumes of water along permeable media through pore cavities in unit time. Transmissivity is the ability of an aquifer to pass or transmit water through a vertical plane as thick as an aquifer with a width of one unit length and one unit hydraulic gradient. Storativity is a coefficient that indicates the volume of water that can be released or stored by an aquifer area per unit change in the position of the groundwater table.

RESEARCH METHODS

The research method (see Figure 1) begins with a literature study to understand the relevant theories, followed by a field survey to collect initial data on the location. Next, field data collection was carried out through direct measurements and geoelectric experiments to obtain information about the subsurface structure of the land. Pump tests were carried out to evaluate the characteristics of the aquifer, after which the data obtained were processed using the Cooper-Jacobs method to determine parameters such as transmissivity and storativity. Interpretation of the aquifer layers was carried out using special software (Progress Software), where hydraulic conductivity was calculated as a measure of the soil's ability to conduct water. Finally, all data were thoroughly analyzed and conclusions were drawn based on the findings of the entire research process.

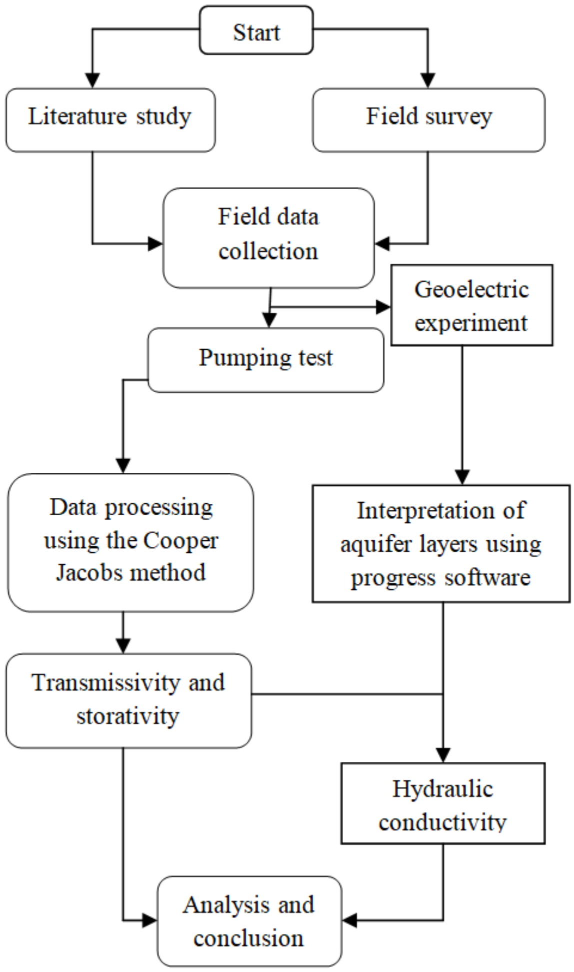

Figure 1. Research flow.

RESULTS AND DISCUSSION

This research was conducted in two stages, the initial stage of the pumping test. The pumping test was conducted with a constant discharge of Q = 0.005625 m^3/s and the distance between the test well and the monitoring well was 5.4 m. The pumping test data was then plotted into a semi-log graph and the results were as follows Figure 2.

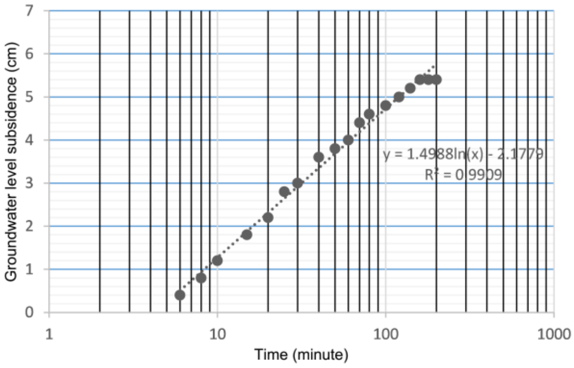

Figure 2. Semilog graph s vs t.

Based on the graph, the decrease in groundwater level during one log period Δs = 3.6 cm and the line equation $s = 1.4988 \ln (t_0) - 2.1779$. From this line equation, t_0 can be calculated when s = 0 as follows:

$s = 1.4988 \ln (t_0) - 2.1779$
$0 = 1.4988 \ln (t_0) - 2.1779$
$t_0 = 4.28$ minutes = 0.00297 days

Furthermore, the aquifer transmissivity value can be calculated as follows:

$T = (2.3 \times Q) / (4 \times \pi \times \Delta s)$
$T = (2.3 \times 0.0005625) / (4 \times 3.14 \times 0.036)$
$T = 0.002861\ m^2/s$
$T = 247.21\ m^2/day$

Based on the calculation results, the transmissivity of the aquifer layer in the Simpang Tiga sub-district, Pekanbaru city is 247.21 m^3/day. From the transmissivity coefficient value obtained, the aquifer in the Simpang Tiga sub-district, Pekanbaru city has a high category of transmissivity value, with groundwater potential for smaller important areas, and an estimated water discharge of 5 – 50 liters/s. Furthermore, the aquifer storativity can be calculated as follows:

$S = (2.25 \times T \times t_0) / r^2$
$S = (2.25 \times 247.21 \times 0.00297) / (5.4)^2$
$S = 0.0566$

Based on the calculation above, the aquifer storativity in the Simpang Tiga sub-district, Pekanbaru city is 0.0566. The size of the aquifer storativity affects the depression of the groundwater table due to pumping. Aquifers with large storativity, the depression of the groundwater table will tend to be smaller and its influence is also not extensive, conversely aquifers with small storativity, the depression of the groundwater table due to pumping tends to be larger and its influence is wider.

The second stage of the research is to conduct a Schlumberger configuration geoelectric experiment. The geoelectric path data obtained in the field is then processed using Microsoft Excel to obtain the geometry factor and apparent resistivity values, then processed using Progress 3.0 Software to interpret the layer material below the path. The results of the appearance of subsurface material along the path as seen in the following image:

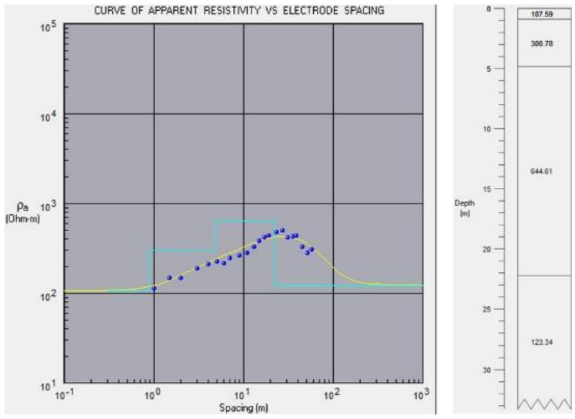

Figure 3. Schlumberger configuration geoelectric path data graph.

The image (see Figure 3) above explains the subsurface conditions along the path. The depth of the layer read by Progress Software is 33 m, with an RMS error value of 12.10%. The first layer of the subsurface with a thickness of 1 m has a resistivity value of 107.59 Ωm, which can be interpreted as the first layer containing sand, the second layer with a thickness of 4 m has a resistivity value of 300.78 Ωm, which can be interpreted as the second layer containing sandstone.

The third layer obtained a resistivity value of 644.61 with a layer thickness of 18 m, the third layer is interpreted as containing rock and sand, the fourth layer with a thickness of 11 m and a resistivity of 123.34, this fourth layer is interpreted as an aquifer or layer containing groundwater.

Based on the transmissivity and thickness of the aquifer, the hydraulic conductivity of the aquifer can be calculated as follows:

K = T / D
K = 247.21 / 11
K = 22.473 m/day

Based on the calculation results, the hydraulic conductivity value was obtained as 22.473 m/day. These results explain that the aquifer has a fast hydraulic conductivity category, and show that the rocks that make up the aquifer are hard sand and/or sand mixed with gravel.

CONCLUSION

The results of the pumping test using the Cooper Jacob method obtained an aquifer transmissivity of 247.21 m^2/day so that it is included in the category of aquifers with high transmissivity, and a storativity of 0.0566. The results of resistivity measurements in Simpang Tiga Village, Pekanbaru City with Progress Software show that the aquifer is in the fourth layer at a depth of 22 m, with a thickness of 11 m, and a resistivity value of 123.34 ohm-meters. The hydraulic conductivity value is 22.473 m/day so that the hydraulic conductivity of the aquifer is included in the fast category.

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