Mapping Data at Fatmawati Sukarno Bengkulu State Islamic University to Estimate of Sustained Groundwater Resource Potential by Analyzing Aquifer Depth Lithology in Selebar Subdistrict, Bengkulu

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ABSTRACT

Rapid development in one city often ignores the availability of groundwater. This can have negative impacts on the environment and the sustainability of future development. However, information regarding the availability of groundwater reserves is still quite difficult to access and not easy to analyze. Without a good understanding of groundwater reserves, development can risk water supply shortages, environmental damage, and long-term unsustainability. Geoelectric resistivity explains the nature of electrical flow in rocks at a certain depth. This is done through the injection of low-frequency electric current into the earth's surface. The potential electrode records the result as a potential difference. Next, we will obtain a variation of the voltage difference with the same current. With certain calculations, resistance variations will be obtained, which can interpret information about the structure, depth, and type of material through which it passes. This research is aimed at determining the resistivity value of rocks as a reference for groundwater drilling wells. The resistivity geoelectric method was carried out in the research area in Selebar Subdistrict. The results showed that the alleged water-bearing layers were found at varying depths, starting from the layer suspected of being the groundwater-bearing layer is at a depth of approximately 9.94-25.53 meters and thickness about 15.59 meters as unconfine aquifer. Then at above 161.43 meters as confined aquifers and consisted of sandstone, clay, groundwater, and gravel rock lithology.

Keywords: Aquifer, groundwater, resistivity, sustainable, sandstone

INTRODUCTION

Water is the main material for the life of all living things, including humans, animals, and plants. Water has many functions for life, including: for consumption, cleanliness, sanitation, production materials and so on. The distribution of water on the earth's surface varies and is uneven, so the use of water must be done wisely for the sake of further survival.

According to Kodoatie (2012), until now the most important material for sustainable life is water. The long geological process of the Big Bang event allows water to have important minerals needed for development. With its unique characteristics, this water resource is included in the category of renewable energy and is dynamic. The dynamics of groundwater that occurs continuously based on the water cycle requires a very long time. If there is inappropriate and inappropriate water extraction, then the longer it takes, the water will run out.

Indonesia is an archipelagic country with most of its area consisting of water. The National Coordinating Agency for Surveys and Mapping in 2023 stated that 97% of the total water area is salt water, the remaining 3% is fresh water. Salt water includes sea and ocean areas, while fresh water includes rivers, lakes, surface water and groundwater.

The best water resource for clean water and drinking water use is groundwater. Rapid development growth can be a serious threat to the availability of groundwater reserves. Without sufficient understanding of the condition of water resources, excessive use can occur and result in a water crisis in the future (Efendi, 2003).

Rapid development often ignores the analysis of groundwater availability. This can have negative impacts on the environment and the sustainability of future development. However, information on the availability of groundwater reserves is often quite difficult to access and not easy to analyze quickly. Without a good understanding of groundwater reserves, development can face the risk of water supply shortages, environmental damage, and long-term unsustainability (Noor, 2005).

Presidential Regulation (Perpres) Number 45 of 2021 delegates the transfer of the status of IAIN Bengkulu to the State Islamic University (UIN) Fatmawati Sukarno Bengkulu. This status has caused campus development to accelerate, various academic and non-academic activities to increase, and the movement of people involved in it to become denser, including the number of students, educators, administrative staff and so on has also increased. This is not only within the administrative boundaries of the State Islamic University of Fatmawati Sukarno Bengkulu, but also in its surroundings. Currently, the number of rental housing buildings (houses/boarding rooms) intended for students from outside Bengkulu City is increasing along with the increasing number of UIN Fatmawati Sukarno Bengkulu students. Along with this, the number of small and medium enterprises (SMEs) around the campus that support livelihoods and academic smoothness has also increased, such as restaurants, photocopying businesses, screen printing, and so on.

According to Wahyudi (2009), exploitation of groundwater resources without proper control and principles based on hydrological principles causes an unbalanced state of carrying capacity and holding capacity. Utilization and reservation of water resources must be adjusted to the quantity conditions as the threshold of its availability and the standard requirements of its quality as the suitability of use, so that efforts can be planned to increase groundwater resource reserves. Therefore, a reference is needed for the existence and potential of groundwater reserves for the development of a region so that spatial and regional planning can be appropriate and able to accompany a policy to be right on target. By using groundwater reserve availability analysis, we can identify potential problems and take steps to maintain a balance between water resources and development (Davis, 1966).

One way to determine the potential of groundwater resources is to use one of the geophysical methods, namely geoelectric resistivity. This method detects the resistivity value in rocks covered in the measurement area at a certain depth (Telford, 1990). This study aims to determine the resistivity value (rho) of groundwater against the depth of the aquifer layer (h). The Schlumberger configuration is used to confirm the potential of groundwater at several points.

MATERIALS AND METHODS

Before conducting groundwater estimation measurements using the geoelectric resistivity method, planning/design through survey design is required. The things that must be considered include in conducting the survey must not disturb the activities of residents, damage plants, disturb the balance of the environment and so on and from an environmental perspective that the water source should be a maximum of 1 km (Asra, 2012).

Data acquisition is the stage of data collection in the field. Data collection is carried out by measuring in the field/investigation location using the active geophysical method of geoelectric resistivity (resistance type). The geoelectric resistivity method (resistance type) is one of the groups of geoelectric methods used to study subsurface conditions by studying the nature of electric current in rocks below the earth's surface. The principle of this method is that electric current is injected into the earth's nature through two current electrodes, while the potential difference that occurs is measured through two potential electrodes. From the results of measuring the current and electric potential difference, variations in the price of electric resistivity in the layer below the measuring point can be obtained.

In certain circumstances, subsurface measurements with a fixed current will obtain a variation in voltage difference which will result in a variation in resistance which will carry information about the structure and material it passes through. This principle is the same as assuming that the earth's material has resistive properties or like the behavior of a resistor, where the materials have different degrees in conducting electric current.

With the geoelectric method, it is possible to determine the characteristics of subsurface rock layers to a depth of about 300 m, so it is very useful to determine the possibility of an aquifer layer, namely a rock layer that is a water-bearing layer. Generally, what is sought is a confined aquifer, namely an aquifer layer that is flanked by impermeable rock layers (eg clay layers) at the bottom and top (Muhammad, 2012).

The configuration used in the geoelectric estimation in this investigation is the Schlumberger configuration (Figure 1). The principle of the Schlumberger configuration is by conditioning the spacing between potential electrodes to be constant while the spacing between current electrodes changes gradually (Sheriff, 2002). This principle is carried out by moving the electrodes a certain distance, then the resistivity values will be obtained at a depth that corresponds to the electrode distance. By moving the electrodes a certain distance, the resistivity value will be obtained at a depth that corresponds to the electrode distance.

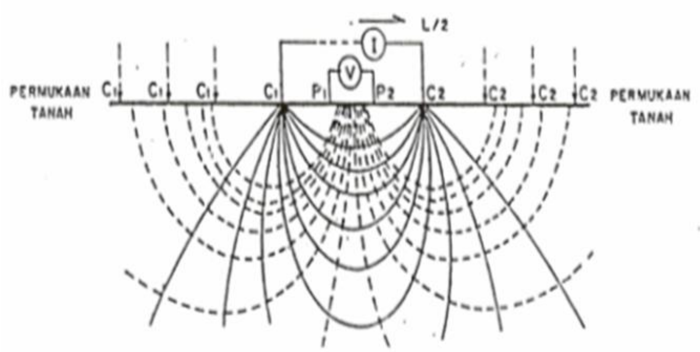

Figure 1. Schlumberger Configuration Schematic

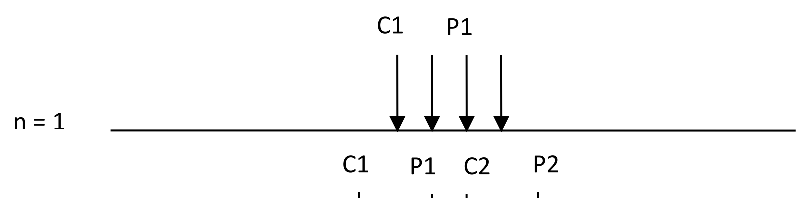

Figure 3. Sketch of electrode planting Schlumberger configuration

This Schlumberger configuration is superior because it is able to detect non-homogeneous rock layers by comparing the resistivity value of the MN/2 electrode distance change. The voltage reading on the MN electrode becomes smaller as the AB electrode distance increases. To interpret the measurement, it is assumed that the thickness of the subsurface layer is limited and the electrical properties are isotropic (measurements from various directions have the same value).

After recording data from field acquisition, the data is then processed using special software. The data entered into this software is AB/2 and the apparent resistivity that has been measured. The results of the processing are in the form of sounding data, namely layer thickness, depth, and actual resistivity values in the vertical direction.

Interpretation of resistivity data is based on the assumption that the earth consists of layers of soil with a certain thickness and has isotropic homogeneous electrical properties, where the boundaries between layers are considered horizontal. Resistivity surveys will provide an overview of the distribution of subsurface resistivity.

RESULTS AND DISCUSSION

Driscoll (1987) explains that groundwater zones are generally divided into 2 (two), namely the vadose zone and the phreatic/saturated zone. Water in the vadose zone is also called shallow groundwater which occurs due to the absorption process of surface water (Suripin, 2005).Water from the ground surface can enter this zone through infiltration, and then move through the soil pores to the saturated zone. Intermediate Vadose Water plays a key role in the hydrologic cycle by moderating the movement of water to the saturated zone and influencing the quality of water that reaches the groundwater. Understanding the intermediate groundwater zone is important in water resources management and soil conservation, especially in the context of agriculture and environmental conservation. Hydrologists and soil scientists monitor and study this zone to optimize water and agricultural management and to protect groundwater quality.

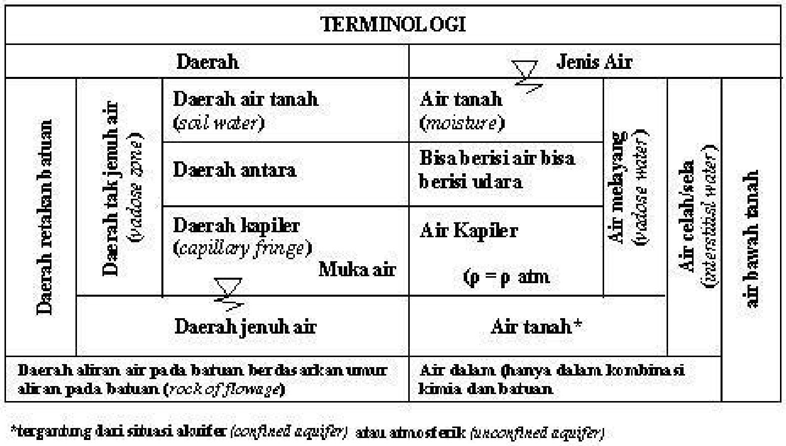

Figure 4.Terminology of Groundwater Flow Types and Their Locations
Source: Kodoatie and Sjarief (2005)

Interpretation of resistivity estimation data is divided into 2 (two) types, namely direct interpretation and indirect interpretation. Through direct interpretation, field data is processed in such a way that layer parameters can be obtained directly from field data. While indirect interpretation is done by making a model first and then matching it with data from the field.

In this activity, interpretation is carried out through a combined method, namely direct and indirect interpretation. The value of the resistivity of the data in the field (ohmm) at the estimated depth (m) is plotted against the distance of the electrode spacing on a log graph to form a curve or curved lines. For the purpose of stratigraphic interpretation, the field result curve is compared with the standard curve and has been published. These curves are theoretical models for a simple layer geometry.

The apparent resistivity function can be expressed as a function of half the span of the current electrode per thickness of the first layer, namely:

$$\rho_a = \rho_a f(\frac{AB}{2d_1})$$

Information :

ρa	=	First layer resistivity (ohmm)
AB/2	=	Current electrode span (m)
d1	=	Thickness of the first layer (m)

In the apparent resistivity function, all layer parameter information is contained. The boundary values are obtained for large AB/2 and small AB/2, for large AB/2 the apparent resistivity curve will go to the deepest resistivity value while for small AB/2 it will go to the top layer resistivity value. If ρa is plotted against AB/2 d1 by making the layer parameters fixed, a curve will be obtained for certain layer parameters (Teti, 2008).

According to Robinson (1988), there are several basic assumptions used in the geoelectric resistivity method, as follows:

1. The subsurface consists of several layers that are limited by horizontal plane boundaries and there is a resistivity contrast between the layer boundary planes.

2. Each layer has a certain depth, except for the bottom layer, its thickness is infinite.
3. Each layer is assumed to be isotropically homogeneous.
4. There is no source of current other than the current injected above the earth's surface.
5. The injected electric current is direct current.

Certain resistivity values will be associated with certain geological conditions. To convert resistivity values into geological forms, knowledge of each type of resistivity is required for each type of material and survey structure (Fadilah, 2020).

The resistivity values of rocks, minerals, soils and chemical elements in general have been obtained through various measurements and can be used as a reference for the conversion process (Table 1). The actual resistivity value can be done by matching or by the inversion method. This study uses the interpretation of the results of processing geoelectric field acquisition data using the inversion method.

Table 1. Conversion of Resistivity Values (Telford, et,al.,1990)

No	Material	Resistivity meter (Ohm-meter)
1	Air	-
2	Pyrite (pyrite)	0.001 – 100
3	Quartz	500 – 800,000
4	Calcite (Calcite)	1 x 1012 – 1 x 1013
5	Rock Slat (Rock Salt)	30 - 1 x 1013
6	Granite (Granite)	200 – 100,000
7	Andesite (Andesite)	1.7 x 102 – 45 x 104
8	Basalt	200 – 100,000
9	Limestone	500 – 10,000
10	Sandstone	200 – 8,000
11	Shale	20 – 2,000
12	Sand	1 – 1,000
13	Clay	1 – 1.00
14	Ground Water	0.5 – 300
15	Sea Water (Sea water)	0.2
16	Magnetite (Magnetite)	0.01 – 1,000
17	Dry Gravel (Dry Gravel)	600 – 10,000
18	Alluvium	10 – 800
19	Gravel	100 – 600

Track 1

The length of the measurement path is +150 meters, inthe former STQ location is located in the campus area of Fatmawati Sukarno State Islamic University, Bengkulu. Measurement spacing using the Schlumberger configuration.The weather conditions during the measurement were sunny and hot.

Measurement Point 1

Operator	:Fadilah	Tracks	:STQ 1
Date	:June 8, 2024	Coordinate	: S 03049'91"

			E 102019'90,6"
Location	:STQ	Direction	:W 330N

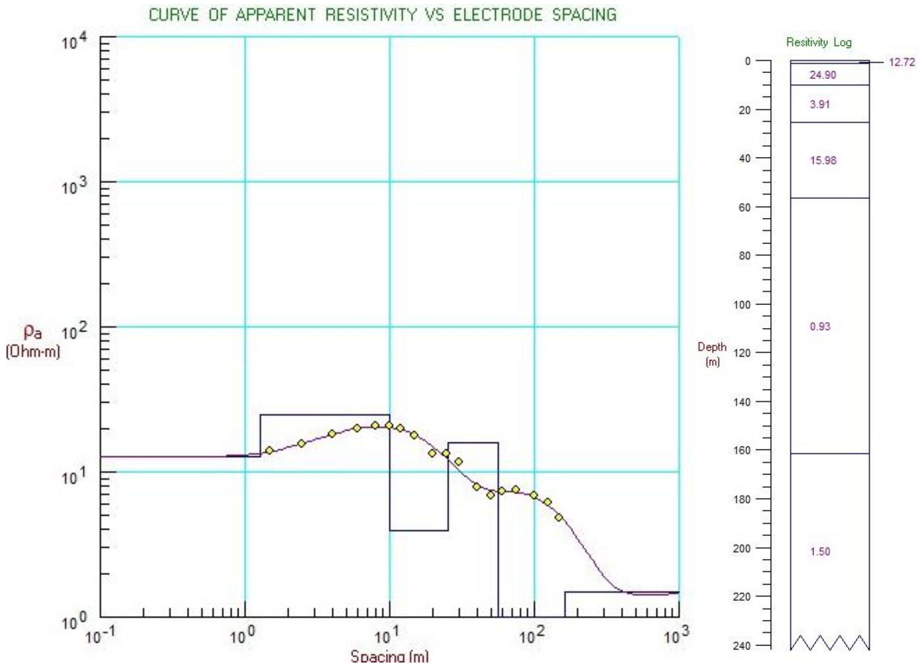

Figure 5. Rock Resistivity Curve and Log versus Depth on Track 1

Table 2. Coating Information in Track 1

Layer	Depth (m)	Thickness (m)	Resistivity (ohm m)	Types of Rocks
1	0 –1.28	1.28	12.72	Overburden, alluvial, sand
2	1.28–9.94	8.66	24.90	Sand, gravel, pebbles
3	9.94–25.53	15.59	3.91	Clay sand, soft wet, contains a lot of water, thought to be an unconfined aquifer
4	25.53–56.68	31.15	15.98	Clay sand, soft wet, contains a lot of water, possibly brackish
5	56.68–161.43	104.75	0.93	Clay sand, soft wet, contains a lot of water.
7	> 161,43	~	1,50	Sand, clay, contains water, suspected to be a groundwater bearing layer

Geoelectrical resistivity measurements in track 1 research located in the ex-STQ area of UIN Fatmawati Sukarno Bengkulu. The location of the suspected water can be found by observing changes in rock types in each layer. Based on the results of field data processing and descriptions of rock layers at this point, the layer suspected of being the groundwater-bearing layer is at a depth of approximately9.94-25.53 meters with a layer thickness of 15.59 meters as an unconfined aquifer and a depth above 161.43 meters as a confined aquifer, namely there is clayey sandstonewhich is thought to be a groundwater bearing layer.

Track 2

The length of the measurement path is +150 meters, inthe former STQ location is located in the campus area of Fatmawati Sukarno State Islamic University, Bengkulu.The measurement space uses the Schlumberger configuration. The weather conditions during the measurement were sunny-hot.

Measurement Point2

Operator	:Fadilah	Tracks	:STQ 2
Date	:June 9, 2024	Coordinate	: S 03040'91" E 102017'74,3"
Location	:STQ	Direction	:E 150W

Track 3

The length of the measurement path is +100 meters, inThe location of the library is located in the campus area of Fatmawati Sukarno State Islamic University, Bengkulu.Measurement spacing using the Schlumberger configuration. Weather conditions during measurement overcast.

Measurement Point3

Operator	:Fadilah	Tracks	:Library
Date	:June 10, 2024	Coordinate	: S 03048'91" E 102022'50,6"
Location	:STQ	Direction	:S230W

Track 4

The length of the measurement path is +100 meters, inlocation around the back of the Student Center which is located in the campus area of Fatmawati Sukarno State Islamic University Bengkulu.Measurement spacing using the Schlumberge configurationr.The weather conditions during the measurement were sunny and hot.

Measurement Point 4

Operator	:Fadilah	Tracks	:SC
Date	:June 11, 2024	Coordinate	: S 03027'91" E 102010'34,7"
Location	:STQ	Direction	:S 410W

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