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Potential Aquifer Exploration using Electrical Resistivity Imaging at Rumbio Jaya, Kampar, Riau

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Abstract – Groundwater sustainability has become a serious issue as a water resource needed by society. Therefore, electrical Resistivity Imaging was carried out at Rumbio Jaya, Kampar, and Riau to study groundwater aquifer's electrical characteristics. The equipment used is a Geocis resistivity meter with (32) multi-electrodes alignment. Wenner configuration electrode was applied in this survey. The 2-D Electrical Resistivity inversion results indicate there are three resistivity zones; (1) Low resistivity value (0.0093 – 4.84 Ωm) representing conductive clay; (2) intermediate resistivity value (1.07 – 171 Ωm) indicate as potential aquifer layer; and (3) a high resistivity value (61 – 4000 Ωm) occupying as bolder of rock. All the zones have different thicknesses and depths, but mostly clay layers dan boulders are shown as lenses in the aquifer of the study area. Meanwhile, the aquifer layer is found easily at a depth of 1 meter up to 30 meters.

Keywords: Groundwater, Aquifer, Geocis, Resistivity, Wenner, Rumbio Jaya.

Introduction

The need for water is a basic need for the life of living things. The need for clean water sources is increasingly limited, especially on surface water, because the pollution process is a significant problem nowadays. Groundwater is an alternative that is most often used by the community, especially in Indonesia, as a source of clean water to meet their daily needs. Lots of unsustainable groundwater use sometimes becomes the following problem. Groundwater exploitation without monitoring causes groundwater ecosystems to become unsustainable (Putra *et al.*, 2021).

The electrical resistivity method is the most commonly used method for groundwater exploration and investment (Hamzah *et al.*, 2007; Jumary *et al.*, 2002; Saad *et al.*, 2012; Suryadi *et al.*, 2019; Suryadi *et al.*, 2019). Some of the advantages and advantages of using the resistivity method are (Wahab *et al.*, 2021): (i) easy and fast data acquisition; (ii) cost and time efficiency; (iii) ability to provide information about the depth of the groundwater depth range from a few meters to hundreds of meters below the surface; (iv) the results can be shown with 1D, 2D, and 3D models, this will help solve many hydrogeological problems such as the extension of aquifer distribution, monitoring of aquifer contamination, determining recharge areas for aquifers, to determining seawater intrusion in coastal aquifers. Several geophysical methods can be used in groundwater exploration, such as the electromagnetic method (Asry *et al.*, 2012). This method can be used to detect shallow aquifers and deep aquifers (Anoop *et al.*, 2021). However, this method requires costly equipment and is rather challenging to use in residential areas because it must avoid noise such as the power grid. Therefore, the most common use is the resistivity method with various electrode configurations, where this method can be used in areas with electrical noise and other noise.

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A geoelectric study was carried out in Rumbio Jaya District, Kampar Regency, Riau Province, Indonesia (Figure 1). This study aims to study the characteristics of electricity and aquifers around the study area. In addition, this study also seeks to describe the subsurface geological conditions as a reference for sustainable groundwater management.

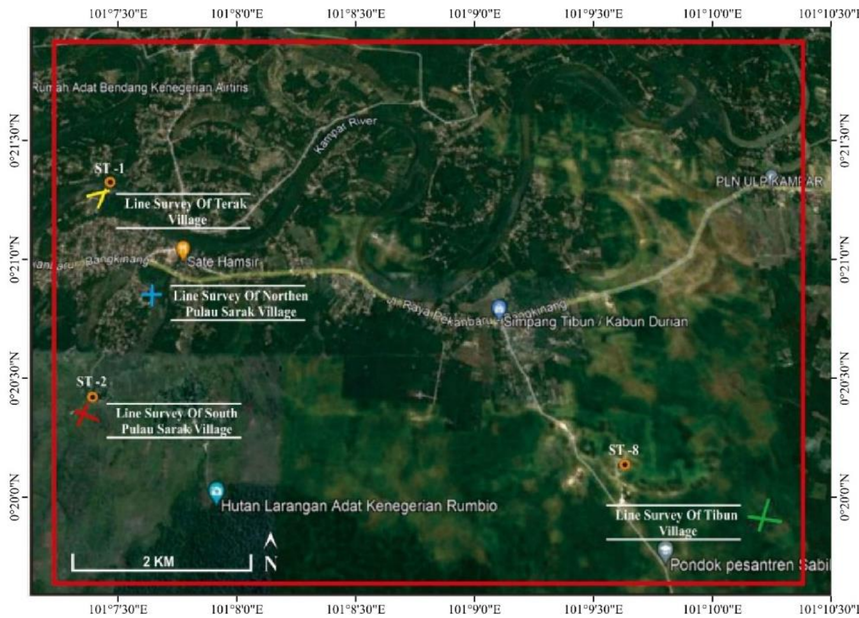

Figure 1. distribution of geoelectrical line map at the study area.

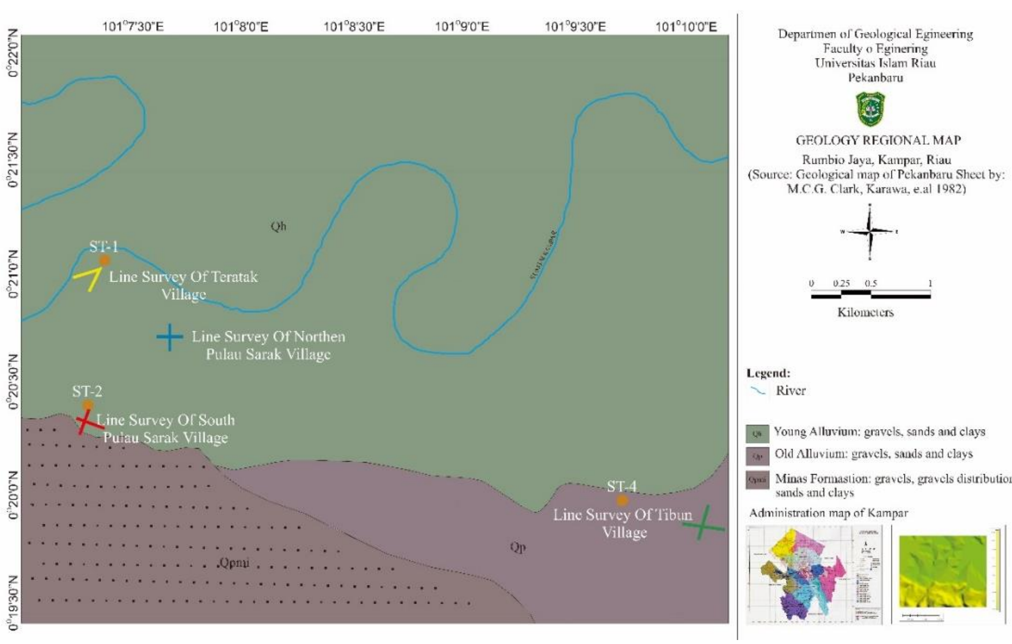

Figure 2. The regional geology map of the study area shows that it consists of alluvium deposits.

Outline of the study area

The study area is located in Rumbio Jaya District, Kampar Regency, Riau Province, Indonesia. More specifically, 4 locations have been determined, namely in the southern part of the village of Pulau Sarak, the village of the northern part of the Island of Sarak, the village of Teratak, and the village of Tibun. In addition, one of the locations is very close to the Sikumbang Springs (MATAS), namely the southern part of the Pulau Sarak Village. Geologically (Figure 2), the study area is covered by alluvial deposits consisting of gravel, sand, and clay deposits (Clarke *et al.*, 1982).

Methods

In this study, the instrument used is a Geocis resistivity meter. Geodis equipment components consist of the main module, extension module, 32 electrodes, 32 cables, 32 crocodile claws, 32 connectors, and power supply. To get the value of the subsurface resistivity, an electric current is injected into the ground through the electrode and calculates the potential (voltages) using the other electrode. The basic principle is that only four electrodes take one resistivity value data. We can interpret the geological conditions below the surface based on the resistivity values obtained. Data acquisition of Geocis Resistivity Meter uses the principle of multi-electrode where 32 electrodes are arranged in a straight line. The distance between the electrodes used in this study is 6 meters (Figure 3). A total of 8 resistivity survey lines were carried out with a maximum stretch of 182 meters. Figure 4 shows data acquisition on the field.

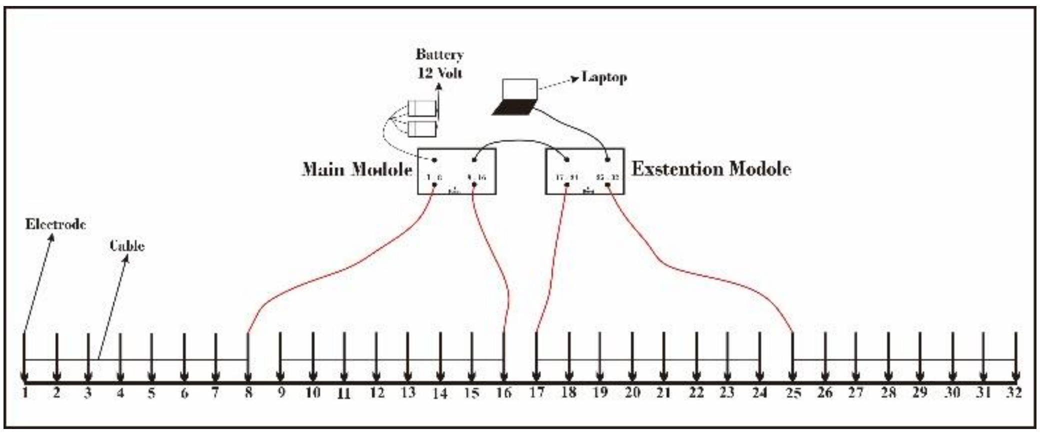

Figure 3. Instrument arrangement for data acquisition in the field (Suryadi *et al.*, 2020).

Figure 4. Instrument set up for geoelectrical data acquisition on the field.

The electrode configuration used is the Wenner configuration (Hamzah *et al.*, 2007; Loke & Barker, 1995; Suryadi *et al.*, 2020), where the distance between the current and potential electrodes is the same (Figure 5). based on the Wenner configuration used, the resistivity value calculates using the formula:

$$\rho a = k\ V/I \qquad (1)$$

$$k = 2\pi a \qquad (2)$$

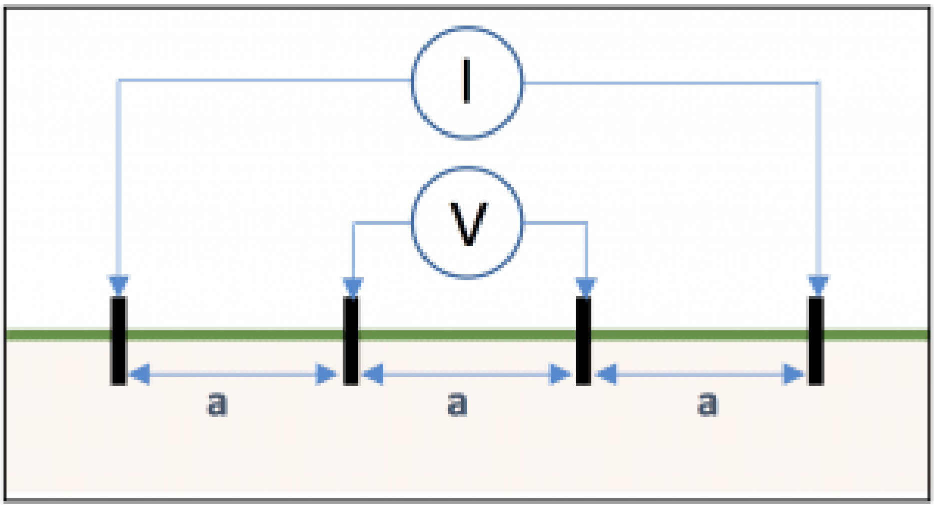

Figure 5. Wenner electrodes configuration (Loke & Barker, 1995).

The resistivity data will automatically generate according to the processing software system used. The software used is RES2DINV to develop a 2-dimensional resistivity model. In addition, additional supporting data for the validation of resistivity results is drill log data around the study area, which is secondary data from previous studies (Suryadi *et al.*, 2018).

Results

A total of eight tracks were processed to produce a 2-dimensional resistivity cross-sectional model. The resistivity value will describe the subsurface conditions to determine the position of the aquifer. The groundwater content in a layer below the surface will affect the resistivity value. Groundwater will usually contain a lot of dissolved electrolytes (ionically conductive), where the solution can be a good conductor of electric current in the soil (Wahab *et al.*, 2021). The results and discussion will be divided into four sections based on the location of resistivity data collection.

The southern part of Pulau Sarak Village

The 2-dimensional resistivity model for the southern part of the village of Sarak Island shows that there are three types of zone based on the resistivity value (Figure 6). Zone 1 indicates a low resistivity value of 0.0883 – 2.52 Ωm. This zone is identified as a clay zone that has high conductivity. In Line 1, the clay layer looks like lenses that can be found at a depth of 5 – 25 meters. While at line 2, clay layers are often seen at a depth of 1-15 meters. Zone 2 expresses a moderate resistivity value of 1.07 – 50 Ωm representing the aquifer layer at a depth of 1 – 24 meters. The potential depth of an aquifer varies due to clay lenses in the aquifer layer. Zone 3 shows a relatively high resistivity with a value of 13 – 150 Ωm. The zone with this resistivity value is close to the surface (1-6 meters deep) at line one and deep below the surface (20-24 meters deep) at line 2. Those who are close to the surface are interpreted as slightly moist sand because the value of its resistivity is not too high, while in Line 2, it is interpreted as a boulder.

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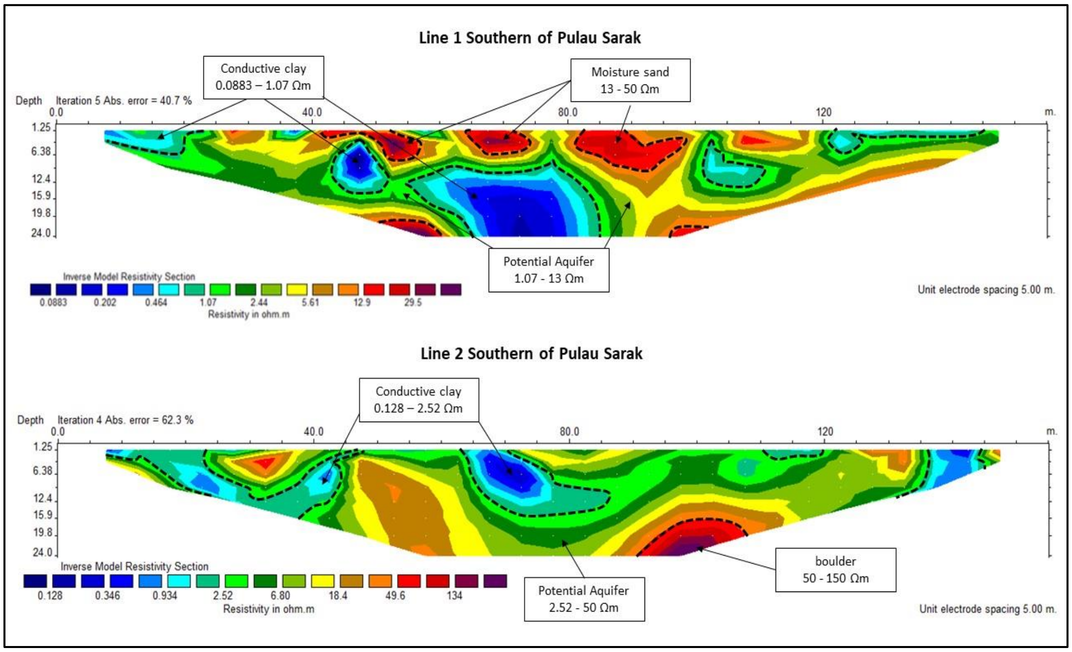

Figure 6. 2D resistivity modeling at the Southern part of Pulau Sarak Village.

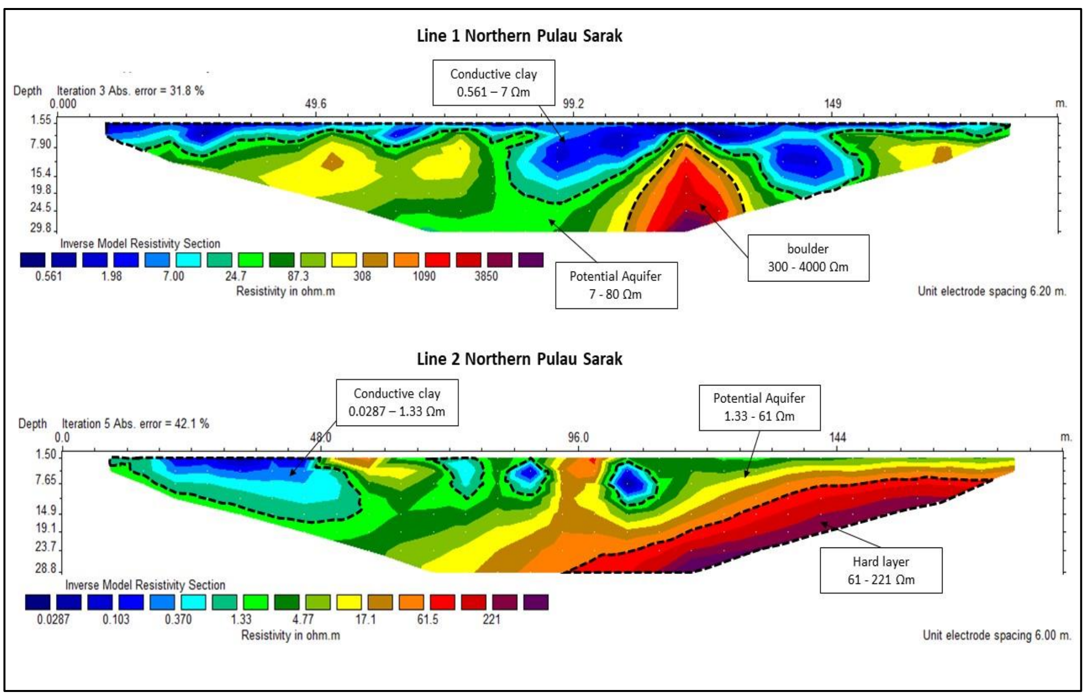

Figure 7. 2D resistivity modeling at the Northern part of Pulau Sarak Village

The northern part of Pulau Sarak Village

The results of the 2-dimensional resistivity modeling in the northern part of Sarak Island show three types of zoning (Figure 7). Zone 1 was characterized by a low resistivity value of 0.0287 – 7 **Ω**m. This value represents a clay zone with high conductivity. In Line 1, the clay layer spreads on the surface to a depth of 8 – 20 meters, while in Line 2, the clay appears to form lenses in the layer with moderate resistivity values. Zone 2 is interpreted as a potential aquifer layer with a resistivity value of 1.33 – 80 **Ω**m. This layer represents a layer of sand found to a depth of 30 meters. Finally, zone 3 shows a high resistivity value of 61 – 4000 Ωm. this zone is interpreted as rock boulders at Line 1 and Line 2 as a compacted layer.

Teratak Village

The results of the analysis of the 2-dimensional modeling of the geoelectric trajectory in Teratak village show a very varied variation in resistivity values (Figure 8). The Teratak village can be zoned into 3 zones based on the resistivity value. Zone 1 is a zone that has a low resistivity value of 0.00986 – 4.84 Ωm. This resistivity value interprets a clay layer that has a high conductivity. At Line 1, clay is found near the surface to a depth of 8 meters with an undulating pattern for the bottom.

In contrast, line 2 layers of clay are shown as a relatively thick layer with a depth of 7-25 meters. Zone 2 is characterized by a moderate resistivity value of 3 – 100 Ωm, where this zone is interpreted as a sand layer that has the potential as an aquifer layer. At Line 1, the layer is found at a depth of 2-29 meters. While at Line 2, it is seen from the surface to a depth of 15 meters. Zone 3 has a high resistivity value that characterizes rock boulders. This zone has a resistivity value of 50 – 1000 Ωm. These boulders are identified in the aquifer layer as the lens inside.

Tibun Village

For the line survey at Tibun Village, the results of the inversion model show that low resistivity zones were found at depths of more than 5 meters with resistivity values of 0.00933 – 1.33 Ωm. This zone is identified as a layer of clay in the form of lenses and traps a lot of water in it. Zone 2 is indicated by a moderate resistivity value of 1.26 – 171 Ωm, interpreted as a potential aquifer layer. This layer comes up at 1.5 – 28 meters with an undulating pattern. The other zone is a zone of high resistivity values, which can be found relatively close to the surface at a depth of 2-8 meters. The range of resistivity values is 100 – 900 Ωm. This layer expresses a boulder of rock because of its very high resistivity value (Figure 9).

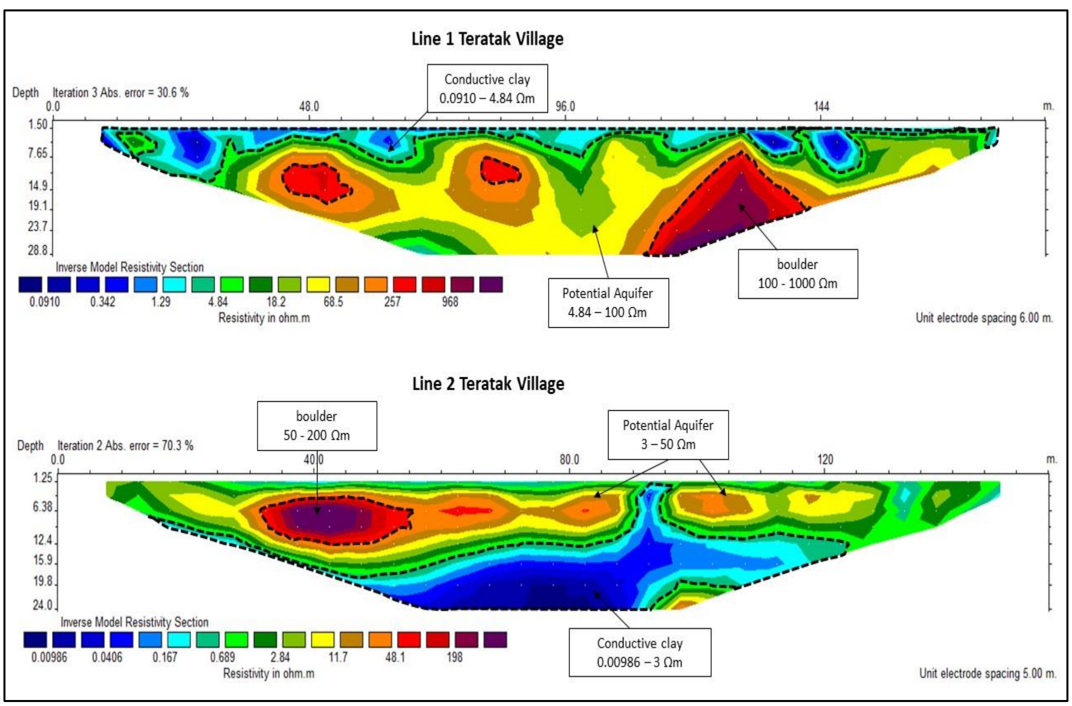

Figure 8. 2D resistivity modeling at Teratak Village

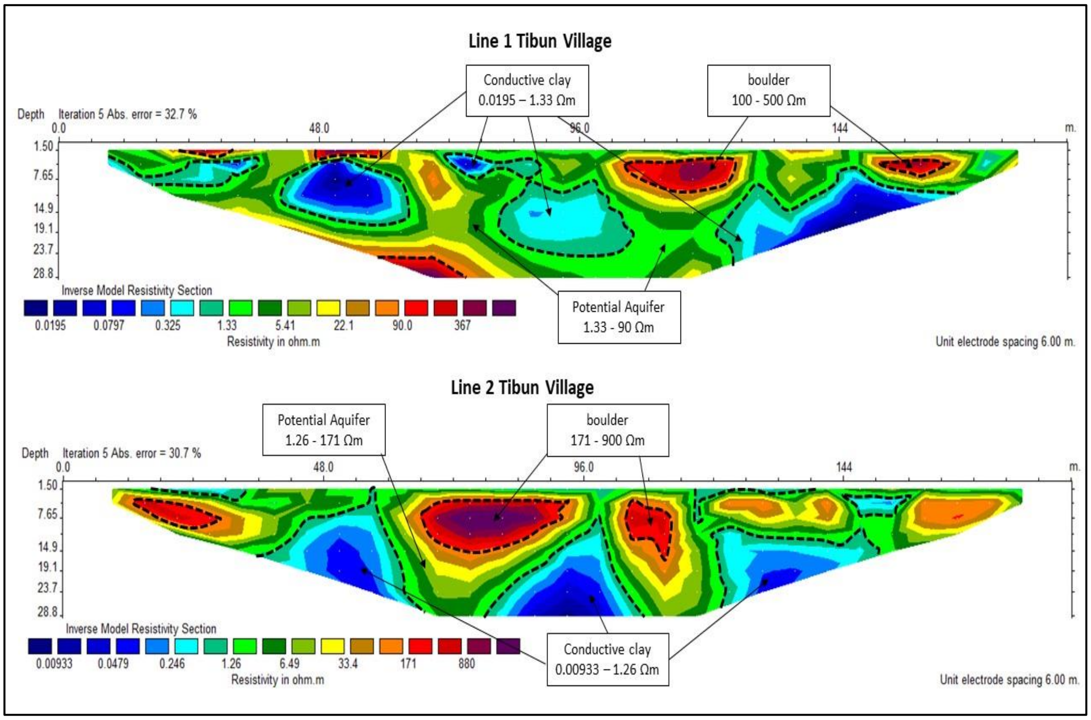

Figure 9. 2D resistivity modeling at Tibun Village.

Discussion

In the present study, the Rumbio Jaya area has relatively homogeneous geological characteristics based on the model generated from the analysis of geoelectrical data at four different locations (Table 1). Therefore, a low resistivity value may indicate an aquifer layer. But in this study resistivity value is away too low, so we interpret it as a clay layer. The clay layer has the ability to store water but cannot pass it due to low permeability. Because of that, clay is a very conductive material with shallow resistivity values.

Table 1. Interpretation of resistivity value at study area.

Location	Coordinates	Resistivity Value (Ωm)	Interpretation	Depth
Southern part of Pulau Sarak Village	N 00^0 20’ 05.1“ – E 101^0 07’ 32.6”	0.0883 - 2.52 1.07 - 13 13 – 150	Clay Sand (Aquifer potential) Boulder	1-24 meter
Northern part of Pulau Sarak Village	N 00^0 20’ 37.4“ – E 101^0 07’ 45.6”	0.0287 - 7 1.33 – 80 61 – 4000	clay Sand (Aquifer potential) Compacted layer	1-30 meter
Teratak Village	N 00^0 21’ 06.7“ – E 101^0 07’ 26.7”	0.00986 - 4.84 3 - 100 50 – 1000	Clay Sand (Aquifer potential) Boulder	2-29 meter
Tibun Village	N 00^0 19’ 34.7“– E 101^0 10’ 06.2”	0.00933 - 1.33 1.21 - 171 100 - 900	Clay Sand (Aquifer potential) Boulder	1.5-28 meter

Very high resistivity values with mostly rounded geometries demonstrate boulders of rock found near the ground. In addition, in Pulau Sarak, there are also indications that a layer with a high resistivity value (61 – 4000 m) is suggested as a layer that has compacted. Therefore, the main target in this study is a layer that has the potential as an aquifer, indicated by a resistivity value of 1.07 – 171 Ωm in general. This interpretation is also supported by the results of previous studies where the resistivity value for groundwater ranges from 1 to 100 m (Saad et al., 2012). According to the geoelectric data modeling results in the study area, the depth of the aquifer is from 1 meter to 30 meters from the surface. In addition, several locations show the type of confined aquifer in the southern part of Sarak Island and Teratak villages. A confined aquifer because the upper part of the aquifer is covered by clay which is an impermeable layer.

Conclusion

Based on the study results, it can be concluded that the Rumbio Jaya area is an area with excellent groundwater potential in terms of quantity. There are two types of aquifers, confined aquifers and unconfined aquifers. Confined aquifers were found in the southern part of Pulau Sarak Village and Teratak Villages, while other villages were dominant with unconfined aquifers. The resistivity values that indicate the Aquifer layer in the study area are 1.07 to 171 Ωm with a depth of 1 to 30 meters. This study hopes that the use of groundwater can be carried out sustainably to prevent groundwater from being polluted.

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References

Anoop, S., Ashwathi, C. Baburaj, V.H. and Pillai, R.S. 2021. Hydrogeochemical status and geoelectrical characteristics of the shallow aquifers of Kalanad Basin, Kasaragod, Kerala, India. Appl. Water Sci. 11, 1–16. https://doi.org/10.1007/s13201-021-01361-0

Asry, Z., Samsudin, A.R. Yaacob, W.Z. and Yaakub, J. 2012. Groundwater investigation using electrical resistivity imaging technique at Sg. Udang, Melaka, Malaysia. Bull. Geol. Soc. Malaysia 58, 55–58.

Clarke, J., Kartawa, W. Djunuddin, A. Suganda, E. and Bagdja, M. 1982. Geological Map of The Pekanbaru Quadrangle, Sumatra. PPPG.

Hamzah, U., Samsudin, A.R. and Malim, E.P. 2007. Groundwater investigation in Kuala Selangor using vertical electrical sounding (VES) surveys. Environ. Geol. 51: 1349–1359. https://doi.org/10.1007/s00254-006-0433-8

Jumary, S.Z. Hamzah, U. and Samsudin, A.R. 2002. Teknik-teknik geoelektrik dalam Pemetaan air masin di Kuala (Mapping of groundwater salinity at Kuala Selangor by geoelectrical techniques).

Loke, M.H., and Barker, R.D. 1995. Least-square deconvolution of apparent resistivity psuedosection. Geophysics 60: 1682–1690.

Putra, D.B.E., Hadian, M.S.D. Alam, B.Y.C.S.S.S. Yuskar, Y. Yaacob, W.Z.W. Datta, B. and Harnum, W.P.D. 2021. Geochemistry of groundwater and saltwater intrusion in a coastal region of an island in Malacca Strait, Indonesia. Environ. Eng. Res. 26: 0–2. https://doi.org/10.4491/eer.2020.006

Saad, R., Nawawi, M.N.M. and Mohamad, E.T. 2012. Groundwater detection in alluvium using 2-D electrical resistivity tomography (ERT). Electron. J. Geotech. Eng. 17 D: 369–376.

Suryadi, A., Batara, and Amir, S.N. 2019. Electrical Resistivity Imaging (ERI) and Induced Polarization (IP) Survey to Solve Water Drought Problem at Alor Gajah, Melaka, Malaysia, in: IOP Conference Series: Materials Science and Engineering. https://doi.org/10.1088/1757-899X/532/1/012025

Suryadi, A., Choanji, T. and Wijayanti, D. 2018. Infiltration Rate of Quarternary Sediment at Rumbio Jaya, Kampar, Riau. J. Geosci. Eng. Environ. Technol. 3: 57. https://doi.org/10.24273/jgeet.2018.3.1.1223

Suryadi, A., Islami, F.U. Kausarian, H. and Putra, D.B.E. 2020. Geophysical Survey on Open Dumping Landfill for Monitoring Spread of Leachate: A Case Study in Pekanbaru, Riau, Indonesia. J. Geosci. Eng. Environ. Technol. 5: 121–126. https://doi.org/10.25299/jgeet.2020.5.2.5340

Suryadi, Adi, Putra, D.B.E. Kausarian, H. Prayitno, B. and Fahlepi, R. 2019. Groundwater exploration using Vertical Electrical Sounding (VES) Method at Toro Jaya, Langgam, Riau. J. Geosci. Eng. Environ. Technol. 3: 226. https://doi.org/10.24273/jgeet.2018.3.4.2226

Wahab, S., Saibi, H. and Mizunaga, H. 2021. Groundwater aquifer detection using the electrical resistivity method at Ito Campus, Kyushu University (Fukuoka, Japan). Geosci. Lett. 8. https://doi.org/10.1186/s40562-021-00188-6