Indonesian Physics Communication

Department of Physics, Universitas Riau, Pekanbaru, Indonesia
p-ISSN 1412-2960 | e-ISSN 2579-521X

Vol. 21 | No. 3
November 2024

Web: https://kfi.ejournal.unri.ac.id
E-mail: kfi@ejournal.unri.ac.id

Interpretation of aquifer layers in peatland areas using the Wenner configuration geoelectric method in Rimba Panjang Village, Tambang District, Kampar Regency

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ABSTRACT

Geoelectric is a geophysical method used to determine the geological conditions of the earth's subsurface based on the variations of rock resistivity value. Interpretation of the aquifer layer is carried out on 2 paths with a length of 300 meters each. The lithology of the study area consists of layers of clay, peat, clay, sand, coarse sandstone, dry gravel, mudstone, limestone, tufan sand to siltstone. According to the data processing results, it shows that the aquifer in Rimba Panjang Village is at a depth ranging from (12.8 – 24.9) meters below ground level with medium groundwater potential. Interpretation using Res2Dinv Software as well as geological maps of the surrounding area informed the subsurface conditions and the presence of groundwater aquifers of the study area. It was found that the resistivity interval of trajectory 1 are (164.341) Ωm, (709 – 1477) Ωm, to (1477 – 3075) Ωm while of trajectory 2 are (864 – 1642) Ωm, (1642 – 3118) Ωm, to (3118 – 5921) Ωm. It can be concluded that the deeper the soil layer, the higher the moisture content. Because the deeper the soil layer, the lower the maturity of the peat, so that the soil is able to hold more water.

Keywords: Aquifer; geoelectrical method; peat; Res2Dinv; Wenner configuration

Received 18-09-2023 | Revised 17-10-2023 | Accepted 04-11-2024 | Published 30-11-2024

INTRODUCTION

Water is a component that moves actively continuously through the surface and also through the lower part of the earth's surface [1-3]. Water has a very important role in human life, all living things certainly need the availability of water, the availability of water on the face of the earth is very limited, both in terms of quality and quantity [4-6].

Groundwater is one of the components of the flow of water on earth which is called the hydrological cycle where water is often used in the survival of all living things after going through the process of evaporation (precipitation) from the sea, lakes, or rivers, then condensation occurs in the atmosphere, and then becomes rain that falls to the earth's surface. The rainwater that falls on the earth's surface moves through the earth's surface (run off) and some enters below the earth's surface (infiltration) [7].

The soil structure of a place depends on geological and climatic conditions. This event affects the condition of the soil layer structure in various regions. The type of rock layer passed by groundwater is obtained by finding the resistivity value of a material formation below the ground surface. The conditions of inundated, flooded and non-inundated areas have different depths depending on the thickness of the layer and the presence of aquifers [8].

Aquifers are permeable underground layers that contain water, rocks, fractures, and materials that are not united. Geoelectric measurements aim to further explore the concept of physics in the earth's layers including the method of subsurface resistivity, to determine the distribution of resistivity in the aquifers that make up the subsurface layer and to interpret the measurement data obtained. The method used in this study is the geoelectric method with Wenner's rules. Physical parameters that can provide an overview of water quality are resistivity, conductivity, and salinity [9].

The presence of groundwater is known by identifying the composition of rocks from the earth's subsurface structure referring to differences in resistivity values using geoelectric exploration [10].

Previous research has been conducted by Nuryanti 2020 on the determination of low aquifers using the Wenner rule geoelectric method and hydrogeochemistry in Rimba Panjang Village, the results of the study based on data analysis stated that the aquifer is at a depth of less than 8 meters below the ground surface with a resistivity interval ranging from (89.2-1023.9) Ωm. The groundwater layer obtained from the processing of data from trajectories 1 and 2 shows the distribution of groundwater [11].

The use of the Wenner method is expected to be a step in horizontal land mapping and its nature is spread so that it can provide a cross-section of the distribution of groundwater and aquifers in the peat area of Rimba Panjang Village, namely the Gean de Green II housing.

LITERATURE REVIEW

Water sources, namely surface water and groundwater, must be managed sustainably to avoid further water scarcity [12].

Sustainable groundwater exploitation must be based on an understanding of the geology and hydrological conditions of the aquifer, because the productivity of aquifers in various regions is highly dependent on the subsurface soil layer [13]. Groundwater is found in permeable geological structures called aquifers, which are water-holding structures that allow large amounts of water to pass through. Groundwater is also found in aquicludes (semi-permeable bases) structures that contain water but cannot move it quickly enough to replenish large supplies of wells or springs of sand and gravel, alluvium, and glacial deposits.

Sandy estuarine deposits are excellent sources of water [14, 15]. Rock resistivity is the ability of a material or rock to block the flow of electric current in a medium. The resistivity value of rocks is inversely proportional to conductivity.

The relationship between soil resistivity and soil conductivity can be written in the form of an equation:

$$\rho = \frac{1}{\sigma} \quad (1)$$

Table 1. Rock resistivity values [16].

Material	Resistivity (Ωm)
Air	-
Phyrite	0.01 – 100
Quartz	500 – 80000
Calcite	$1 \times 10^{12} – 1 \times 10^{13}$
Rock salt	$30 – 1 \times 10^{13}$
Granite	200 – 10000
Andesite	$1.7 \times 10^{2} – 45 \times 10^{4}$
Basalt	200 – 10000
Limestone	500 – 10000
Sandstone	200 – 8000
Shales	20 – 2000
Sand	1 – 1000
Clay	1 – 100
Ground water	0.5 – 300
Magnetite	0.01 – 1000
Dry gravel	600 – 10000
Alluvium	10 – 800
Gravel	10 – 600

RESEARCH METHODS

The geoelectric method has been reported to have a high level of sensitivity for groundwater exploration [17]. In addition, the efficiency of the geoelectric resistivity method is able to map the subsurface layer providing more precise important information to characterize the aquifer layer, describe the depth of the bedrock, and determine resistivity values [18]. By estimating the resistivity price, rock porosity, and soil hydraulic conductivity, groundwater can be estimated qualitatively.

The Wenner configuration can provide a resistivity distribution map in the form of a two-dimensional subsurface image. The distance between the current electrode is three times the distance of the potential electrode, the potential distance to the sounding point is a/2, so the distance between the current electrode and the sounding point is 3a/2. The target depth that can be achieved is a/2 [16].

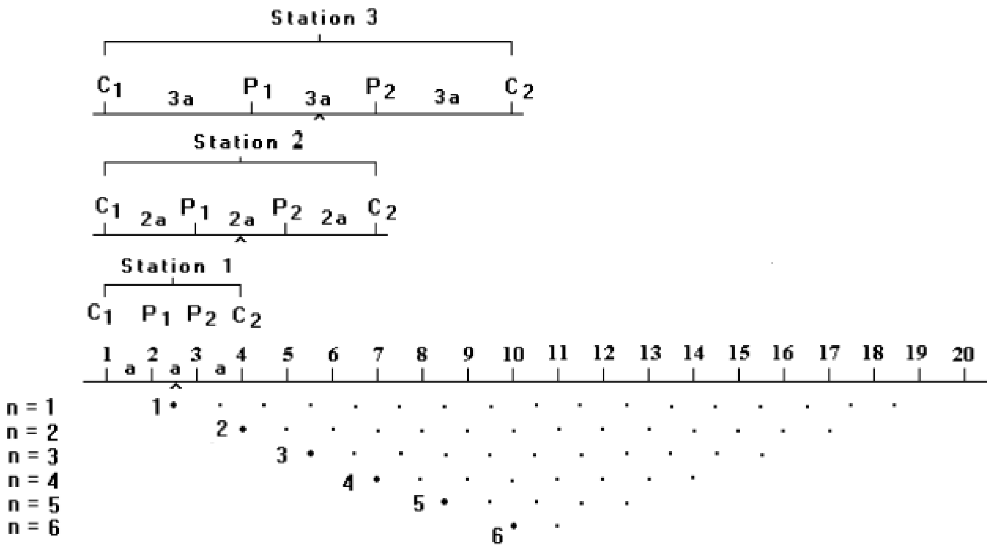

Figure 1. How to measure the Wenner configuration

RESULTS AND DISCUSSION

Data analysis and interpretation results based on field measurements using 2 tracks, each 300 meters long. Data collection in the field using the Wenner configuration geoelectric method at Gean de Green II Housing, Rimba Panjang Village, Tambang District, Kampar Regency. Field measurement data on track 1 were converted into apparent resistivity and 2D cross-section inversion results using Res2Dinv Software.

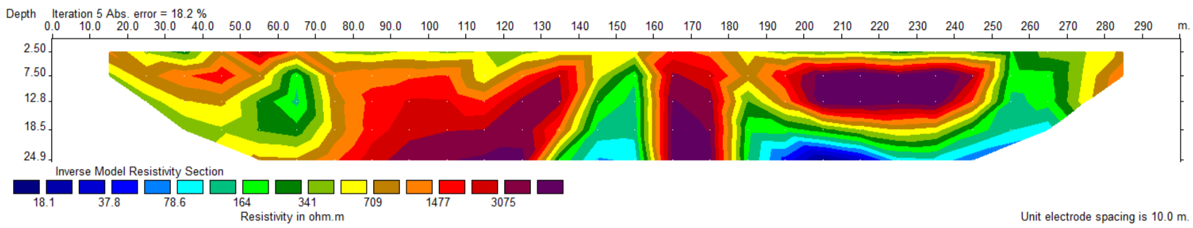

Figure 2. 2D cross-section inversion results for track 1.

Figure 2 above displays various layers with certain resistivity values according to the material in them. The results of calculations and data processing on track 1 with Res2Dinv Software using the Wenner method obtained an RMS-error value of 18.2% with a resistivity interval of (18.1 – 3075) Ωm and the depth of the layer displayed reached 24.9 meters. The results of the calculation and data processing on track 2 with Res2Dinv Software obtained an RMS-error value of 21.0% with a readable depth of 24.9 meters.

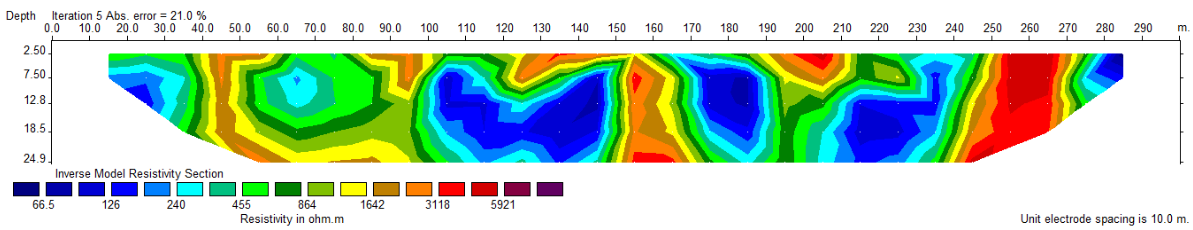

Figure 3. Results of 2D cross-section inversion of track 2.

The results of the 2D cross-section inversion of track 2 are shown in Figure 3 above with a resistivity interval ranging from (66.5 – 5921) Ωm. From the data processing carried out, it shows that the aquifer is located at a depth of 2.50 – 24.9 meters. Interpretation of track 1 on L1 with a depth of 2.5 – 12.8 meters is interpreted as shallow peat containing clay composition with a resistivity value ranging from (18.1 – 78.6) Ωm. L2 is light green in color and is suspected to be calcareous mudstone, with a resistivity value of (78.6 – 164) Ωm at a depth of 12.8 – 18.5 meters. L3 is dark green with a resistivity value of (164 – 341) Ωm is suspected to be a formation of coarse ash sandstone with a little clay at a depth of 24.9 meters. L4 is interpreted as the presence of claystone and sand at a depth of 7.50 – 18.5 meters with a resistivity value of (341 – 709) Ωm. L5 is brown to red in color, there is a composition of limestone, silt, and dry gravel at a depth of 15 meters with a resistivity value of (709 – 1477) Ωm. L6 is red to purple in color is suspected to be dry gravel material, and a little siltstone with a resistivity value of (1477 – 3075) Ωm at a depth of 24.9 meters.

Table 2. Results of L1 data processing.

Depth (m)	Resistivity (Ωm)	Material composition	Type of layer
2.5	66.5 – 240	Clay and tuffaceous sand	Aquitard
7.5	240 – 864	Claystone	Aquiclude
12.8	864 – 1642	Dra gravel	Aquifer
18.5	1642 – 3118	Dry gravel and sandstone	Aquifer
24.9	3118 – 5921	Dry gravel, limestone, and sandstone	Aquifer

The results of the path interpretation indicate that the potential aquifer is in a shallow area close to the surface at varying depths (see Tables 2 and 3). L1 with a depth of 2.5 meters is a medium peat layer containing fresh groundwater marked by dark blue to light blue with a resistivity value of (66.5 – 240) Ωm. L2 is green to turquoise with a resistivity value of (240 – 864) Ωm interpreted as a layer containing claystone at a depth of 7.50 meters.

Table 3. Results of L2 data processing.

Depth (m)	Resistivity (Ωm)	Material composition	Type of layer
2.5	66.5 – 240	Clay and tuffaceous sand	Aquitard
7.5	240 – 864	Claystone	Aquiclude
12.8	864 – 1642	Dra gravel	Aquifer
18.5	1642 – 3118	Dry gravel and sandstone	Aquifer
24.9	3118 – 5921	Dry gravel, limestone, and sandstone	Aquifer

L3 is a layer of clay, silt, and a little dry gravel found at a depth of 12.8 meters with a resistivity value of (864 – 1642) Ωm marked by a yellow to brown color. L4 is suspected of containing dry gravel and glauconite sandstone formations with a resistivity of (1642 – 3118) Ωm at a depth of 18.5 meters, marked by a brown to red color. The L5 assumption shows the presence of dry gravel, limestone and sandstone formations. Figures 2 and 3 show various layers with certain resistivity values based on the material or rocks below the peat soil surface as a geoelectric research site.

CONCLUSION

Based on the results of resistivity measurements, it is interpreted that for path 1 the resistivity value of the soil layer ranges from (18.1 – 3075) Ωm with a maximum depth of 24.9 meters, path 2 obtained a resistivity value of the soil layer ranging from (66.5 - 5921) Ωm with a maximum depth of 41.06 meters. Interpretation of lithology below the ground surface of Gean de Green II Housing, namely peat, clay, sandstone, limestone, dry gravel, saturated gravel, sandy clay, and sand.

The existence of aquifers refers to the formation of the geological sheet map and based on the results of data processing and 2D geoelectric cross-sectional images of the Wenner configuration, it is interpreted that on path 1 it was found at a depth of 15 meters, 24.9 meters and > 24.9 meters with a lithology composition of limestone, dry gravel, coarse sandstone, and siltstone. Route 2 found aquifer layers at depths of 12.8 meters, 18.5 meters and 24.9 meters with lithological compositions, namely dry gravel, sandstone and limestone which are very good at transmitting water.

REFERENCES

1. Juandi, M. & Ginting, E. N. (2021, October). The groundwater analysis using geoelectric method Wenner rules in Rejosari Village, Tenayan Raya Pekanbaru. *Journal of Physics: Conference Series*, **2049**(1), 012064.
2. Handwerger, A. L., Booth, A. M., Huang, M. H., & Fielding, E. J. (2021). Inferring the subsurface geometry and strength of slow-moving landslides using 3-D velocity measurements from the NASA/JPL UAVSAR. *Journal of Geophysical Research: Earth Surface*, **126**(3), e2020JF005898.
3. Singha, K., & Navarre-Sitchler, A. (2022). The importance of groundwater in critical zone science. *Groundwater*, **60**(1), 27–34.
4. Juandi, M. & Santoso, S. A. (2021). Analysis of groundwater infiltration using the schlumberger geoelectric method. *Journal of Physics: Conference Series*, **2049**(1), 012070.
5. Young, S. L., Frongillo, E. A., Jamaluddine, Z., Melgar-Quiñonez, H., Pérez-Escamilla, R., Ringler, C., & Rosinger, A. Y. (2021). Perspective: the importance of water security for ensuring food security, good nutrition, and well-being. *Advances in nutrition*, **12**(4), 1058–1073.
6. Sarker, B., Keya, K. N., Mahir, F. I., Nahiun, K. M., Shahida, S., & Khan, R. A. (2021). Surface and ground water pollution: causes and effects of urbanization and industrialization in South Asia. *Scientific Review*, **7**(3), 32–41.
7. Octalizar, M. R. (2021). Penentuan lapisan dan akuifer dengan kualitasnya menggunakan metode geolistrik dan geokimia konfigurasi Wenner di Desa Tarai Bangun Kecamatan Tambang Kabupaten Kampar. *FMIPA Universitas Riau*.
8. Enggarwati, D. A., Susilo, A., & Wardhana, D. D. (2015). Pendugaan akuifer serta pola alirannya dengan metode geolistrik daerah Pondok Pesantren Gontor 11 Solok–Sumatera Barat. *Physics Student Journal*. **2**(1), 549– 553.
9. Juandi, M. (2018). The interpretation of underground water physical parameters of housing in the region of asahan indah palm oil factory area Rokan Hulu District. *Open Journal of Modern Hydrology*, **8**(4), 119–125.
10. Wijaya, A. S. (2015). Aplikasi metode geolistrik resistivitas konfigurasi Wenner untuk menentukan struktur tanah di halaman belakang SCC ITS Surabaya. *Jurnal Fisika Indonesia*, **19**(55), 1–5.
11. Nuryanti, N. (2020). Identifikasi akuifer dangkal dengan menggunakan metode geolistrik konfigurasi Wenner dan hidrogeokimia di Desa Rimba Panjang. *FMIPA Universitas Riau*.
12. Juandi, M. (2017). Sustainability model for unconfined aquifers. *International Journal of Science and Applied Technology*, **1**(1).
13. Juandi, M. & Syahril, S. (2017). Empirical relationship between soil permeability and resistivity, and its application for determining the groundwater gross recharge in Marpoyan Damai, Pekanbaru, Indonesia. *Water Practice and Technology*, **12**(3), 660–666.
14. Vila-Concejo, A., Gallop, S. L., & Largier, J. L. (2020). Sandy beaches in estuaries and bays. *Sandy beach morphodynamics*, 343–362.

15. Driscoll, F. G. (1987). Groundwater and Wells, Johnson Division, second printing, St. *Paul, MN*.
16. Telford, W. M., Geldart, L. P., & Sheriff, R. E. (1990). *Applied geophysics*. Cambridge university press.
17. Lenkey, L., Hámori, Z., & Mihálffy, P. (2005). Investigating the hydrogeology of a water-supply area using direct-current vertical electrical soundings. *Geophysics*, **70**(4), 11–19.
18. Sultan, S. A. & Santos, F. A. M. (2008). Evaluating subsurface structures and stratigraphic units using 2D electrical and magnetic data at the area north Greater Cairo, Egypt. *International Journal of Applied Earth Observation and Geoinformation*, **10**(1), 56–67.