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Identification Of Soil Resistivity Distribution In Ekoriparian Leuwi Padjadjaran Area Using 2D Electrical Resistivity Method

Cevilla Amalia Prameswary[1], Fataya Tasya Donita[1], Muhammad Alkuansinta Rohman[1], Muhammad Raihan Saeful Ihsan[1], Eleonora Agustine[2]

[1]Study Program of Geophysics, Faculty of Mathematics and Natural Sciences, Universitas Padjadjaran, Jl. Raya Bandung-Sumedang Km. 21, Jatinangor, 45363
[2]Department of Geophysics, Faculty of Mathematics and Natural Sciences, Universitas Padjadjaran, Jl. Raya Bandung-Sumedang Km. 21, Jatinangor, 45363

Corresponding e-mail: eleonora.agustine@unpad.ac.id

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ABSTRACT. Research focused on the identification of soil resistivity distribution at the Ekoriparian Leuwi Padjadjaran area, University of Padjadjaran, Jatinangor, has been conducted using geoelectric resistivity method 2D with dipole - dipole configuration. Three survey lines were measured with the first and second lines being 2 meters long and the third line measuring 6 meters. Electrode spacing was set at 0.2 meters, with 10 electrodes on the first and second lines, and 30 electrodes on the third line. Data processing is done using the Res2Dinv software. The research results indicated that resistivity values in the range of 4.00 Ωm to 20.0 Ωm were interpreted as clay rocks, values from 20 Ωm to 200 Ωm were interpreted as silt rocks, and resistivity values in the range of 256 Ωm to 1024 Ωm were interpreted as sandy clay rocks. Based on the geology of the study area, the soil is a fine-grained soil, namely silt and sandy loam.

1. Introduction

Ekoriparian Leuwi Padjadjaran is one of the areas at Padjadjaran University, Jatinangor which is used as a runoff water retainer and implementation of water conservation program. Based on lithology, the Jatinangor area has young volcanic product rocks dominated by volcaniclastic rocks, young volcanic lava products dominated by lava forming Mount Geulis and sedimentary rocks deposited by Lake Bandung. Based on the Bandung Sheet Regional Engineering Geology Map compiled by Djadja and Hermawan (1996), Jatinangor area is classified as a unit of silt loam and sandy silt. The area is a residual soil formed through the weathering process of tuffaceous sandstone, conglomerate tuff, agglomerate, lapilli, and breccia (Muslim et al., 2015). Some of it comes from Mount Tangkuban Parahu and some from Mount Tampomas (Rukmana et al., 2020). Based on the regional geological map (Silitonga, 2003), the Padjadjaran University Jatinangor area is included in the Qyu geological formation which is the result of a young undecomposed andesitic-basaltic volcano with Quaternary age.

Soils in volcanic areas have a structure as volcanic deposits with fine grains (N. Khoirul, 2016). Soils that have fine grains tend to have a greater water absorption capacity compared to other soil types. The higher the percentage of fine grains in the soil, the higher the water content that can be absorbed by the soil (Farahnaz et al., 2018). Therefore, further identification is needed to determine the type of soil or rock that makes up the subsurface layer. One of the preliminary survey methods used to assess the subsurface soil layer is a geophysical survey, specifically the electrical resistivity method. An important parameter of resistivity is to know the physical subsurface of the earth, so that it can be categorized into the materials that exist in the subsurface (Wahyudi et al., 2021).

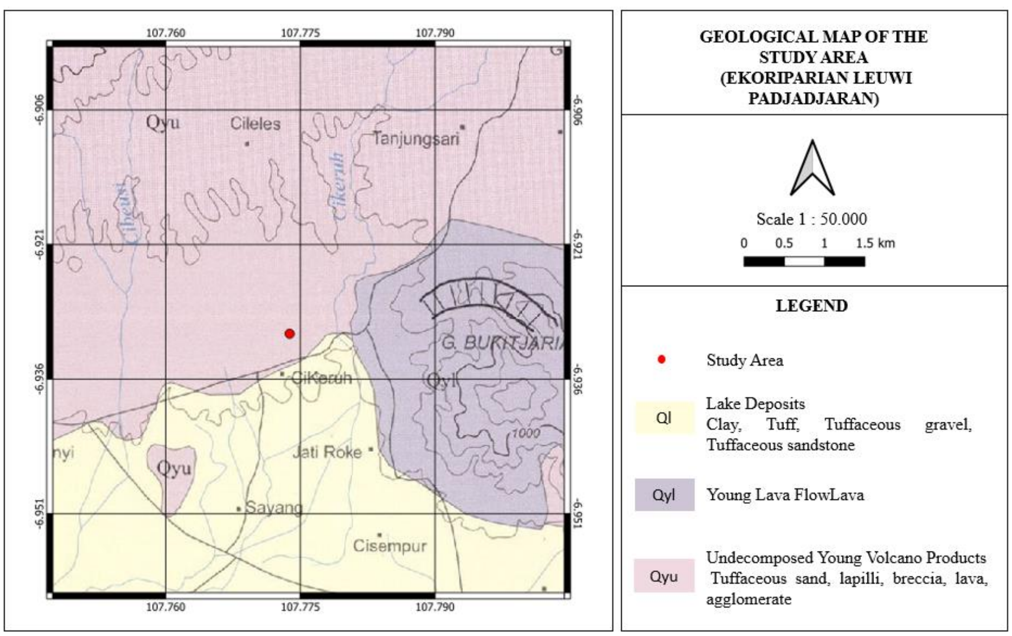

Figure 1. Geological Map of Ekoriparian Leuwi Padjadjaran (Modified from Silitonga, 2003)

The electrical resistivity method works with the basic principle of injecting electric current into the ground surface through current electrodes and potential electrodes. This method has been widely used in various studies to investigate subsurface conditions such as identification of rock lithology (Muhardi and Wahyudi, 2019), detection of groundwater (Rustadi et al., 2018), and so on. Research using the electrical resistivity method with dipole-dipole configuration can be used to identify rocks in the subsurface (Nurfalaq and Jumardi, 2019) and to investigate rock lithology (Pratama et al., 2019).

2. Research Methodology

The measurements were conducted at Ekoriparian Leuwi Padjadjaran area, Padjadjaran University, Jatinangor, Sumedang, in West Java, Indonesia. The measurements were carried out in the area Ekoriparian Leuwi Padjadjaran, especially at the edge of the Ekoriparian lake using the electrical resistivity method. This electrical resistivity method measurement uses the RMSS or Resistivity Meter Small Scale & Small Pin Electrode Marcapada instrument.

The electrical resistivity method uses the contrast of resistivity properties of mineral and rock layers below the surface as an intermediate medium to determine the geological properties that exist below the ground surface (Pratama et al., 2019). The electrical resistivity method is based on the principle of injecting electric current into the rock layer of the earth's crust through two current electrodes, namely at points C1 and C2. The injected electric current will evenly spread throughout the rock medium as shown in Figure 2. The electrical polarization that occurs within the surface is measured through the potential difference between two potential electrodes, located at points P1 and P2 (Halik & Widodo, 2008).

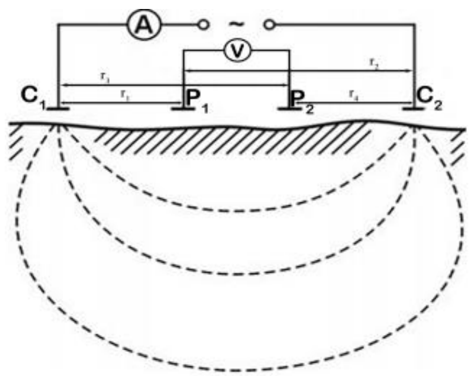

Figure 2. Electrode Arrangement (Kirsch, 2006)

Since potential has a scalar nature, the potential at a point arising from a double current electrode will be equal to the total potential generated by two single current electrodes. Therefore, the potential at point P1 due to the current flowing into electrodes C1 and C2 will have the same value (Baskara, 2020).

$$V_{P1} = \frac{I\rho}{2\pi}\left(\frac{1}{r1} - \frac{1}{r2}\right) \qquad (1)$$

The potential at point P2 is

$$V_{P2} = \frac{I\rho}{2\pi}\left(\frac{1}{r3} - \frac{1}{r4}\right) \qquad (2)$$

Therefore the potential difference between points P1 and P2 is

$$\Delta V = V_{P1} - V_{P2} \qquad (3)$$

$$\Delta V = \frac{I\rho}{2\pi}\left[\left(\frac{1}{a} - \frac{1}{2a}\right)\left(\frac{1}{2a} - \frac{1}{a}\right)\right] \qquad (4)$$

So that the apparent resistivity is calculated using the equation (Wahyudi et al., 2021)

$$\rho a = \frac{\Delta V}{I}\frac{2\pi}{\left[\left(\frac{1}{r1} - \frac{1}{r2}\right)\left(\frac{1}{r3} - \frac{1}{r4}\right)\right]} \qquad (5)$$

$$\rho a = k\,\frac{\Delta V}{I} \qquad (6)$$

With geometry factor (Wahyudi et al., 2021)

$$k = \frac{2\pi}{\left[\left(\frac{1}{r1} - \frac{1}{r2}\right)\left(\frac{1}{r3} - \frac{1}{r4}\right)\right]} \qquad (7)$$

Based on the measurement of electric current and potential difference, the resistivity value in the layer below the earth's surface can be calculated, so that the resistivity method can provide information about the electrical properties of materials in soil or rock layers (Mubarak et al., 2017).

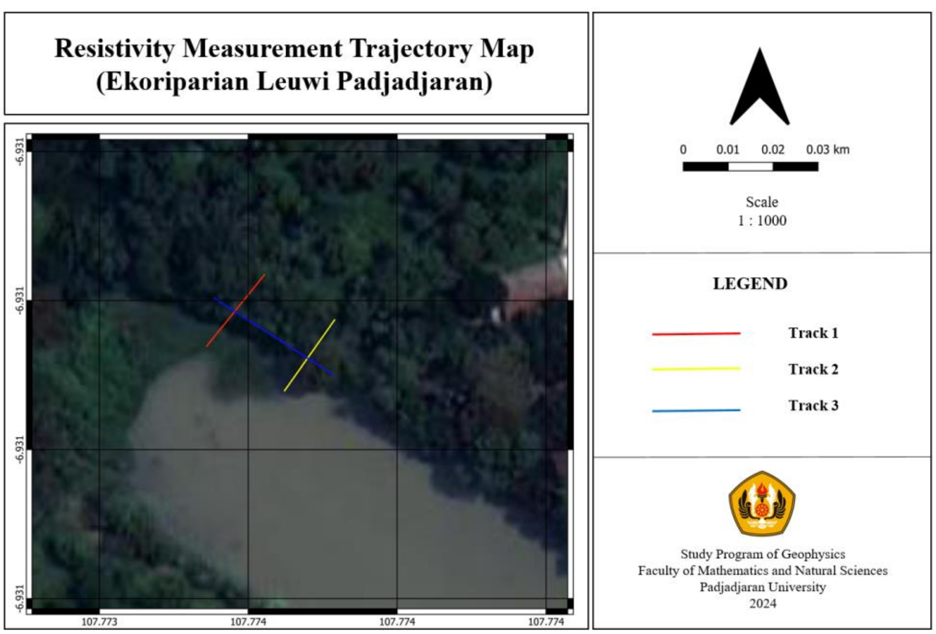

Figure 3. Map of Measurement Track

This electrical resistivity method measurement was carried out using three tracks, the first and second tracks were made vertically with the length of each track of 2 meters. Meanwhile, the third track is made horizontally cutting the first and second tracks with a track length of 6 meters. The spacing between electrodes is 0.2 meters and the number of electrodes in the first and second passes is 10 electrodes and the third pass is 30 electrodes. The measurement produces resistivity value data in the form of a 2-dimensional cross section that describes the subsurface state. The research methodology can be shown in Figure 4.

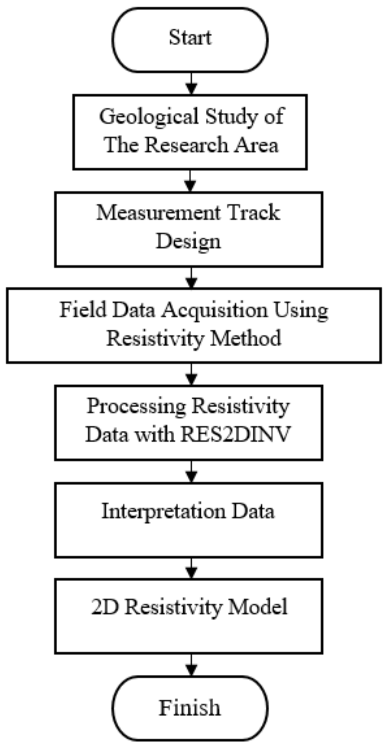

Figure 4. Flowchart of Research Methodology

Resistivity measurements were performed using the dipole-dipole configuration. The dipole - dipole configuration is widely used in resistivity surveys because it has a very low impact of electromagnetic effects, which arise due to the presence of potential and current circuits. The dipole - dipole configuration is effectively used to identify the bedrock of the earth's surface (Hamidah, 2016). This configuration has a shallower depth of investigation compared to the Wenner configuration.

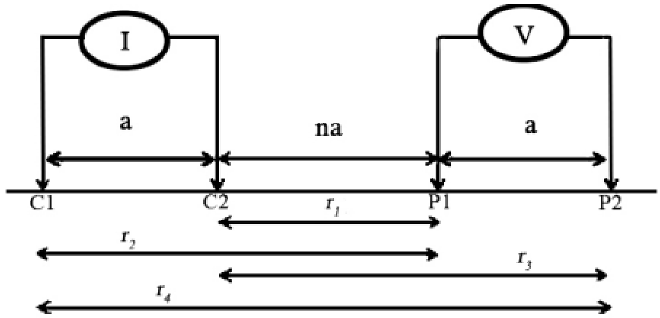

Figure 5. Arrangement of Dipole - Dipole Configuration (Loke, 1999)

The dipole - dipole configuration with two potential electrodes placed outside the current electrode. a is the distance between the two potential electrodes, while na is the distance between the current electrode and the inner potential electrode (c2 and P1), where n = 1, 2, 3.... (integer) (Figure 5). If n is greater, the depth of investigation will be greater. So that from equation (7) the geometry factor is obtained geometry factor for dipole-dipole configuration with the following equation :

$$k = \pi an\,(n+2)(n+1) \qquad (8)$$

k = Geometry Factor (m)

a = Smallest electrode distance (m)

n = Ratio factor between C2P1 and P1P2

Rocks are materials that have certain electrical conductivity and specific resistivity. The type of subsurface rock can be identified based on the resistivity value of the rock. The difference in resistivity value is caused by the electrical properties of the rock. Factors that affect the electrical properties of rocks include metallic and non-metallic minerals, solid electrolyte content, salt water content, differences in rock texture, differences in rock porosity, differences in rock permeability, and differences in temperature (Septyanto et al., 2019). The variations in rock resistivity values are :

Table 1. Rock Resistivity Value (Telford et al., 1990, Lowrie, 2007)

Material	Resistivity Value (Ωm)
Granite	4.5×10^3 s.d. 1.3×10^6
Sandstone	1 s.d. 6.4×10^8
Sand	1 s.d. 1000
Clay	1 s.d. 100
Sandy Loam	80 s.d. 1050
Silt	10 s.d. 200
Gravel	10^2 s.d. 10^4
Gabro	50 s.d. 10^7
Basalt	10 s.d. 1.3×10^7
Andesite	1.7×10^2 s.d. 4.5×10^4
Quartz Diorite	2×10^4 s.d. 2×10^6
Shale Stone	20 s.d. 1×10^3

3. Results and Discussion

Measurements were carried out using the electrical resistivity method with the RMSS instrument and applying the dipole - dipole configuration to determine changes in the resistivity of the subsurface rock layer by flowing electric current into the ground. The measurement results in the field are then processed using RES2DINV software which aims to produce a distribution of subsurface resistivity values in the form of 2D cross-sectional images. This method can provide a clearer visual picture of the subsurface layer.

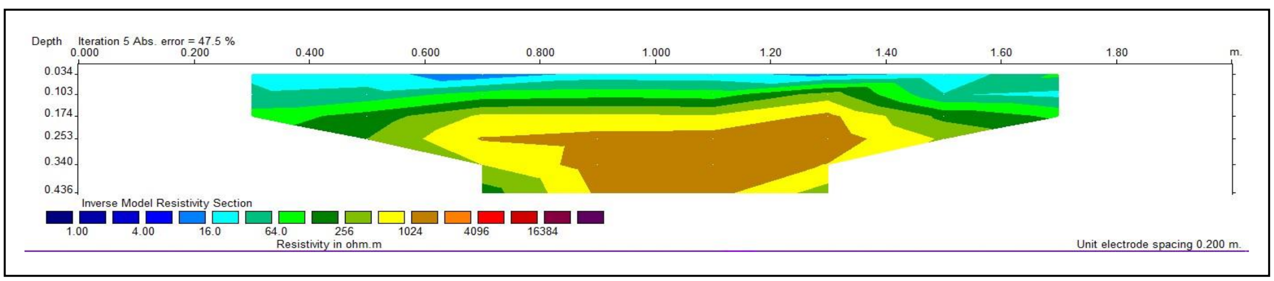

Figure 6. 2D Resistivity Model of Track 1

Track 1 is stretched vertically with a short stretch of track located at coordinates with longitude 0806389 and latitude 9232886. Based on the 2D cross section in Figure 6, a depth of 0.03 m to 0.43 m was obtained. The results of data processing show the presence of varying resistivity values, ranging from 4.00 Ωm to 1024 Ωm. Based on Table 2, the interpretation of the subsurface layer shows that the resistivity value range of 4.00 Ωm - 20.0 Ωm is interpreted as clay rock, resistivity value of 20 Ωm - 200 Ωm is interpreted as silt rock, resistivity value of 256 Ωm - 1024 Ωm is interpreted as sandy clay rock.

Table 2. Interpretation results of the subsurface layer in the first pass

Color Scale Indicator	Resistivity Value (Ωm)	Material
	4,00 Ωm – 20,0 Ωm	Clay
	20 Ωm – 200 Ωm	Silt
	256 Ωm – 1024 Ωm	Sandy Loam

Figure 7. Position of Track 1

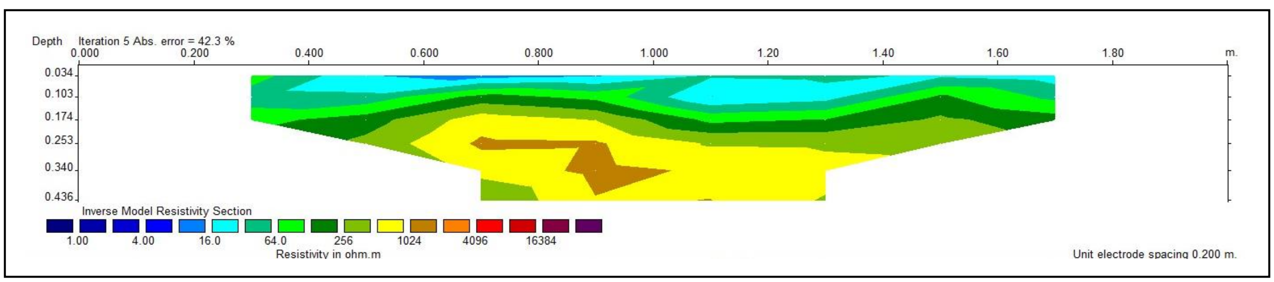

Figure 8. 2D Resistivity Model of Track 2

Track 2 is a vertically stretched track at coordinates with longitude 0785284 and latitude 9210291. Based on the 2D cross section in Figure 8, a depth of 0.03 m to 0.43 m was obtained. The results of data processing show the presence of varying resistivity values, ranging from 4.00 Ωm to 1024 Ωm. Based on Table 3, the interpretation of the subsurface layer shows that the resistivity value range of 4.00 Ωm - 20.0 Ωm is interpreted as clay rock, resistivity value of 20 Ωm - 200 Ωm is interpreted as silt rock, resistivity value of 256 Ωm - 1024 Ωm is interpreted as sandy clay rock.

Table 3. Interpretation results of the subsurface layer in the second pass

Color Scale Indicator	Resistivity Value (Ωm)	Material
	4,00 Ωm – 20,0 Ωm	Clay
	20 Ωm – 200 Ωm	Silt
	256 Ωm – 1024 Ωm	Sandy Loam

Figure 9. Position of Track 2

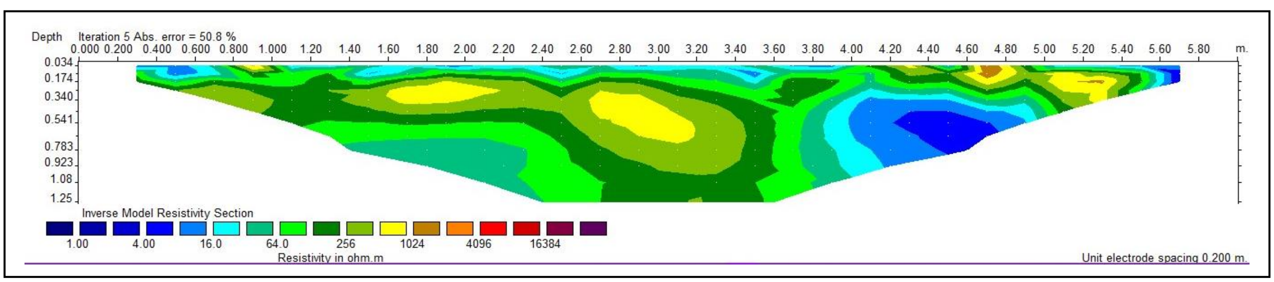

Figure 10. 2D Resistivity Model of Track 3

Track 3 is a horizontally stretched track as shown in Figure 11. Based on the 2D cross section in Figure 10, a depth of 0.034 m to 1.25 m was obtained. The results of data processing show that there are varying resistivity values, ranging from 4.00 Ωm to 1024 Ωm. Based on Table 4, the results of the interpretation of the subsurface layer show that the resistivity value range of 4.00 Ωm - 20.0 Ωm is interpreted as clay rock, resistivity value of 20 Ωm - 200 Ωm is interpreted as silt rock, resistivity value of 256 Ωm - 1024 Ωm is interpreted as sandy clay rock.

Table 4. Interpretation results of the subsurface layer in the third pass

Color Scale Indicator	Resistivity Value (Ωm)	Material
	4,00 Ωm – 20,0 Ωm	Clay
	20 Ωm – 200 Ωm	Silt
	256 Ωm – 1024 Ωm	Sandy Loam

Figure 11. Position of Track 3

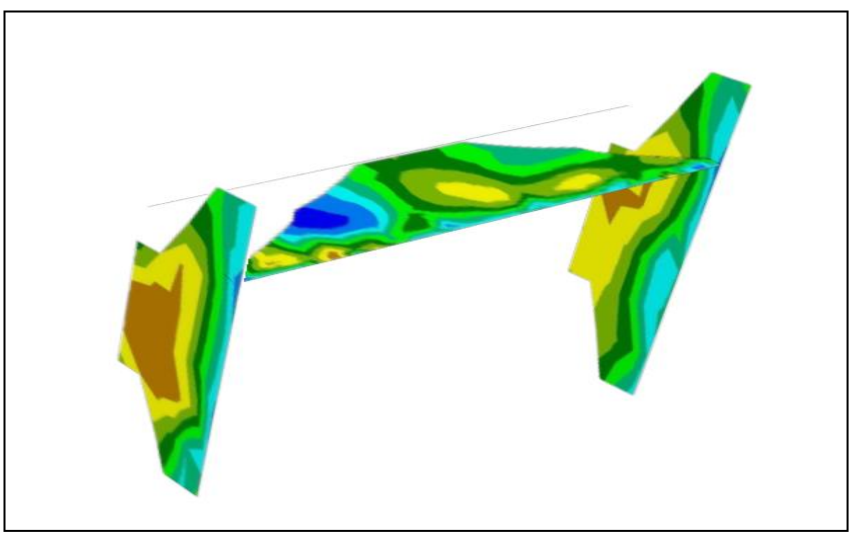

Figure 12. Combined Cross Section of 3 Tracks

Based on the cross-section results, there are significant errors and it can be indicated that there are some weaknesses in the process of making the measurement track. These include electrodes that were not installed properly and obstacles such as holes and poles around the measurement trajectory. In addition, the limited number of electrodes also had an impact on the quality of the cross-section results with considerable error and reachable depth. There are some notes that need to be considered regarding the state of the track when the measurement takes place, where there is a hole at a distance of 5 meters and there are poles near electrodes 22 and 23. In the combined results of all tracks (Figure 12), it shows that most of the rocks that make up the soil layer of the Ekoriparian Leuwi Padjadjaran area are silt and sandy loam. Loam has a very fine grain size of <0.002 mm. This fine grain nature causes clay to have low permeability and is cohesive, so clay has a fairly low resistivity value (Wahyudi et al., 2021). Silt is a sedimentary rock with grain size between 0.06 to 0.003 mm. The soils identified in the Ekoriparian Leuwi Padjadjaran area correlate with the geological map that classifies the Jatinangor area as partly silt and passive clay. Soils that have fine grains include soils with a mixture of clay and silt that are able to absorb larger volumes of water. One of the characteristics of clay minerals in fine-grained soils is the hydration ability where water particles surround the clay particles, causing the water content in the soil to tend to be high (Afif, 2016). The higher the water content in the soil, the lower the resistivity value (Irianto and Rahmawati, 2014). The existence of the Ekoriparian Leuwi Padjadjaran soil, which is still quite natural, has a low resistivity value, which shows the ability of this soil to absorb and retain water which can reduce the risk of flooding and maintain water quality in the Ekoriparian lake. Therefore, it is necessary to contribute to the maintenance of a balanced ecosystem in the Ekoriparian Leuwi Padjadjaran area.

4. Conclusion

Based on the research and data analysis that has been carried out, the interpretation results on the three tracks show a variation in resistivity values in the range of 4.00 Ωm to 1024 Ωm. Specifically, resistivity values between 4.00 Ωm to 20.0 Ωm are interpreted as clay rock, while resistivity values between 20 Ωm to 200 Ωm are interpreted as silt rock. Furthermore, resistivity values between 256 Ωm to 1024 Ωm are interpreted as sandy clay rock. This provides a deeper understanding of the types of rocks that can be identified based on the resistivity values at the research location. The resistivity values are associated with the geological map of the study area, so it can be concluded that the rocks that dominate the Ekoriparian Leuwi Padjadjaran area are silt and sandy loam layers. The relationship between the results of the interpretation of resistivity values and geological maps can provide a more comprehensive picture of the composition of rocks in the region.

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Involvement of the Author

EA provided the main concept for the research. CAP and MRSI were responsible for data collection. MAR processing of the data obtained and FTD conducting data analysis.

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