

Hydrostratigraphic Model Analysis Based on Rock Resistivity Data in the Purbalingga Regency Area, Central Java, Indonesia

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Abstract The availability of groundwater for irrigation in Purbalingga Regency, requires significant attention since the region has an extensive rice field, necessitating systematic groundwater exploration and the implementation of appropriate management strategies. A geoelectrical resistivity survey has been conducted to investigate groundwater resources and to construct a hydrostratigraphic model that facilitates the interpretation of hydrogeological conditions, including aquifer distribution, groundwater depth, and productive zones. Resistivity data were collected from 16 points distributed across the districts of Kalimanah, Purbalingga, Kemangkong, and Bukateja. The correlation of resistivity logs produced detailed hydrostratigraphic cross-sections, illustrating lithological variations, layer thicknesses, and aquifer distribution. Interpretation down to a depth of 200 m identified two major formations: the Alluvium Formation and the Terrace Formation. The Alluvium Formation, consisting of sandy clay, sand, and clayey sand, exhibits resistivity values ranging from 0.87 to 69.43 Ωm , whereas the Terrace Formation, composed of tuffaceous sandstone, sand, conglomerate, and tuff, with resistivity values between 7.81 and 38.09 Ωm . Hydrostratigraphic modeling indicates that aquifer productivity varies across the study area. Kalimanah District, dominated by low-resistivity deposits (0.87–8.55 Ωm), is interpreted as having the highest aquifer productivity, making it particularly suitable for the development of groundwater-based irrigation. This study introduces a resistivity-based interpretative approach to classify hydrostratigraphic characteristics by correlating resistivity values with local geological conditions.

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1. Introduction

Groundwater represents the largest freshwater reserve on Earth and is associated with diverse process across varying timescales, reflecting the internal dynamics of the Earth (Mishra & Dubey, 2023). It plays an important role in daily life, including for irrigation. Groundwater-based irrigation refers to the distribution of water from available sources to agricultural fields to meet crop requirements consistently, especially when surface water supply is insufficient to support normal crop growth (Lian et al., 2022). Strategic planning and well-designed development programs are essential to optimize the groundwater as an irrigation resource (Prayogo et al., 2022). Such efforts are especially critical in Purbalingga Regency, which comprises 18,755 hectares of rice fields and has produced 183,759 tons of rice in 2022 (Central Statistics Agency of Purbalingga Regency, 2023). A reliable groundwater-based irrigation system can help farmers mitigate the impacts of drought by ensuring a consistent water supply for their crops. This study contributes greatly in identifying the suitability of subsurface rocks based on their resistivity properties to obtain groundwater resources for irrigation purposes.

Purbalingga Regency, located on the Java Island, is predominantly an agricultural region where the majority of the population relies on farming as their primary livelihood. One of the major challenges in this area is the limited availability

of surface freshwater for agricultural irrigation, particularly during the dry season. Consequently, several villages in Purbalingga frequently experience drought conditions during this time. Groundwater-based irrigation, which supplies water to the land surface to compensate for rainfall shortages is therefore considered essential to sustaining crop growth and ensuring agricultural productivity (Worqlul et al., 2017). Providing freshwater for agricultural land can reduce soil temperature, ensure freshwater availability during the dry season, minimize soil degradation, and offer several other benefits (Dong et al., 2016). Therefore, groundwater-based irrigation is expected to be a reliable irrigation system for agricultural land during prolonged dry periods. The study area, located within the Purwokerto–Purbalingga basin, is considered to have significant potential for the development of groundwater-based irrigation. Density modeling derived from satellite gravity anomaly data reveals the presence of extensive alluvial deposits with density values ranging from 2.10 – 2.55 g/cm^3 (Sehah et al., 2024). These alluvial deposits can serve as substantial groundwater reservoirs within the basin. Figure 1 shows the location and boundaries of the Purwokerto–Purbalingga groundwater basin.

A groundwater basin is a concave-shaped region underlain by impermeable rocks that store substantial volumes of groundwater and supplies water to wells or other surface

manifestations (Onafeso et al., 2016). Within a groundwater basin, a series of layered alluvial aquifers typically occur with well-defined lateral boundaries. A basin is a three-dimensional system encompassing both the surface area and all subsurface freshwater resources (Demiroğlu, 2017). The study area is situated within the discharge zone of the Purwokerto–Purbalingga groundwater basin. The stratigraphy of this basin consists of the Alluvium Formation, lava deposits from Slamet Volcano, the Terrace Formation, the Ligung Formation, the clay member of the Ligung Formation, the Tapak Formation, and others (Djuri et al, 1996). Of this, the two formations most closely associated with the study area are the Alluvium Formation and the Terrace Formation. Both formations have the potential to host groundwater, commonly functioning as aquifers. The Terrace Formation, often referred to as paleo-alluvium, was formed from ancient alluvial deposits that underwent diagenesis and consolidation over a long geological period (Nikolinakou et al., 2021). This formation is considered to have lower groundwater storage capacity compared to the Alluvium Formation.

Research utilizing satellite gravity data is crucial for the planning and development of the Purwokerto–Purbalingga groundwater basin as a potential water source for irrigation. Following the initial investigation, groundwater resources in the alluvial deposits can be further explored using resistivity methods. Groundwater exploration has been conducted at several locations in Purbalingga Regency, as satellite gravity anomaly modeling alone does not provide sufficient spatial resolution for detailed groundwater investigations, particularly in identifying aquifer systems. In contrast, the Vertical Electrical Sounding (VES) method offers high-resolution vertical resistivity profiles that are directly sensitive to variations in lithology, moisture content, and the presence of groundwater. VES is a one-dimensional resistivity acquisition method in which resistivity data are collected exclusively along the vertical direction (Bahri et al., 2023). The aim of this study is to construct a hydrostratigraphic model of the study area based on resistivity data, thereby enabling interpretation of hydrogeological conditions, such as the position and depth of groundwater aquifers, as well as productive zones.

The resistivity method is widely recognized as an effective geophysical approach for groundwater exploration and subsurface structural characterization. This method utilizes the electrical properties of rocks and sediments (Paembonan et al., 2021), which vary according to lithology, porosity, saturation degree, and fluid conductivity, to provide indirect yet reliable information about subsurface conditions. The subsurface structure is generally composed of rock layers with varying resistivity and thickness. The measured resistivity values represent apparent resistivity rather than the true resistivity of the material. In each data measurement, the subsurface rock layer can be approximated as a homogeneous and isotropic medium (Nugraha et al., 2021), represented by the apparent resistivity (ρ_a). This value is calculated based on the electrical current (I), the measured voltage (ΔV), and a geometrical factor (K) determined by the electrode configuration employed, as expressed in Equation (1) (Telford et al, 1990).

$$\rho_a = K \frac{\Delta V}{I} \quad (1)$$

The true resistivity, in which the Earth is characterized by heterogeneous resistivity, is derived through forward and inverse modeling of the apparent resistivity data (Khalil & Santos, 2013). The rock resistivity values obtained from this modeling represent the true subsurface resistivity, reflecting the variations in the underlying rock formations.

A hydrostratigraphic model derived from rock resistivity data provides several advantages for interpreting aquifer systems. Previous studies have applied the resistivity method to characterize the aquifer model along the banks of the Serayu River in Sokawera Village, Somagede District, Banyumas, Indonesia (Sehah et al., 2021), and to investigate the hydrostratigraphy in the Lapindo mudflow disaster area (Chandrasasi et al., 2025). This approach offers a more detailed depiction of subsurface stratification, as rock resistivity is closely related to the physical properties and groundwater content of geological formations. Variations in subsurface

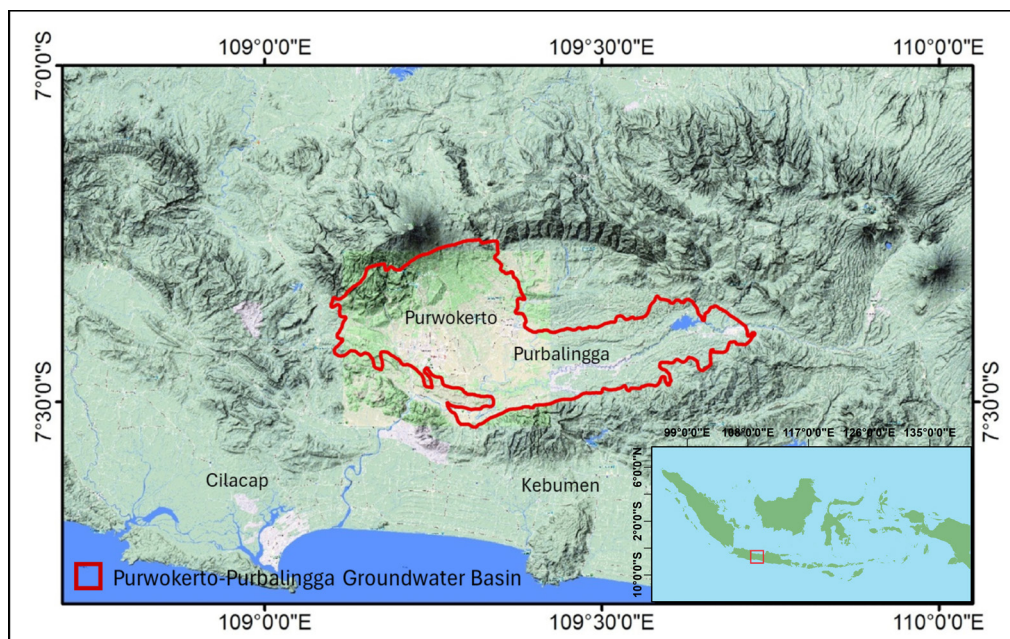


Figure 1. Location map of the Purwokerto-Purbalingga groundwater basin (Sehah et al., 2024).

resistivity values allow for more precise identification of boundaries between productive aquifers and impermeable rock layers (Thomas et al., 2025), thereby reducing the uncertainty of the mapping results. These advantages establish resistivity-based hydrostratigraphic modeling as an essential tool for groundwater exploration planning and sustainable resource management across diverse regions (Udosen et al., 2025). In the study area and elsewhere, the resistivity-based hydrostratigraphic model may represent a novel finding that significantly supports groundwater exploration strategies and utilization efforts for agricultural irrigation.

2. Methods

Location and Time of Study

Resistivity data acquisition was carried out in the study area within Purbalingga Regency, as illustrated in Figure 2. The dataset comprises 16 Vertical Electrical Sounding (VES) points: six in Kalimantan District, five in Purbalingga and Kemangkong Districts, and five in Bukateja District. The field survey and data collection were conducted from March to October 2024.

Research Equipment

In this study, field data acquisition was carried out using a Naniura resistivity meter, equipped with two pairs of current and potential electrodes, two 500 m roll cables for current, two 200 m roll cables for potential, batteries, data sheets, stationery, connectors, and a Global Positioning System (GPS). The resistivity meter is an electronic instrument designed to measure the resistivity of subsurface rocks by transmitting electric current into the ground through electrodes placed at regular intervals. Electrical resistivity, a fundamental physical property of materials, reflects their ability to resist electric current flow (Arygunartha et al., 2023). By employing this method, subsurface rock structures and lithological compositions can be well characterized, providing essential information for groundwater investigation, drilling, and natural resource exploration.

Research Procedure

Resistivity data acquisition was conducted using the VES technique. This method involves systematically increasing

the spacing between current and potential electrodes to obtain information on the vertical lithological composition of subsurface rocks based on their resistivity values (Bahri et al., 2023). Among various configurations, the Schlumberger array was employed as it provides higher resolution and requires less time compared to other configurations (Ahmed et al., 2022). In this array, the potential electrodes are positioned relatively close together while the current electrodes gradually expanded, this method provides high sensitivity to vertical variations in subsurface resistivity, thereby enabling more accurate identification of groundwater aquifers and the development of improved hydrostratigraphic models. In VES methods, the maximum current-electrode spacing ($AB/2$) determines the depth of investigation, where larger separations allow the current to penetrate deeper rock layers. Therefore, selecting an appropriate maximum $AB/2$ is crucial to ensure that the resistivity response adequately captures the intended subsurface information, including the targeted aquifer or deeper stratigraphic units.

The apparent resistivity values in Equation (1) do not represent true resistivity. Apparent resistivity corresponds to the resistivity of a hypothetical homogeneous medium that approximates the electrical response of a layered subsurface (Rolia & Sutjiningsih, 2018). The measured resistivity values are influenced by electrode spacing and subsurface heterogeneity, indicating that each subsurface rock layer possesses distinct resistivity characteristics. Using the VES method, data acquisition generates an apparent resistivity curve, which is then modeled to derive true resistivity values. The modeling process using Progress v3.0 produced a resistivity curve as a function of half-current electrode spacing, as well as resistivity logs with depth, as shown in Figure 3. These obtained resistivity logs are further interpreted to characterize lithology types and hydrogeological conditions at the research area, providing a vertical representation of rock stratigraphy (Sehah et al., 2021). The interpretation was carried out with reference to the geological information and the resistivity table (Telford et al., 1990). Based on these modeling and interpretation results, the distribution of groundwater aquifers within the Purwokerto-Purbalingga Basin, particularly across Kalimantan, Purbalingga, Kemangkong, and Bukateja districts, can be clearly delineated.

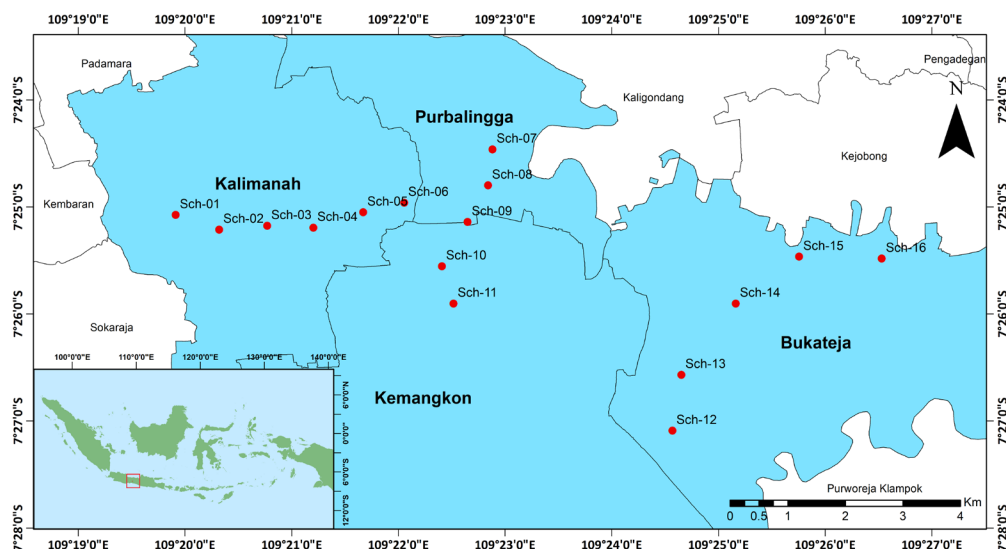


Figure 2. The distribution map of sounding points for resistivity data acquisition.

3. Results and Discussion

Results of Resistivity Data Processing

The long-term objective of this research is to support the development of a groundwater-based irrigation. In the short term, this study aims to construct a hydrostratigraphic model derived from resistivity data correlation, enabling the estimation of aquifer types, depths, and distributions within

the study area. Data processing, followed by forward and inversion modeling, generated resistivity logs as a function of depth at each sounding location. These true resistivity values were then interpreted to derive lithological and hydrogeological information by integrating local geological maps, rock resistivity tables, groundwater level data, topographic conditions, and other relevant data.

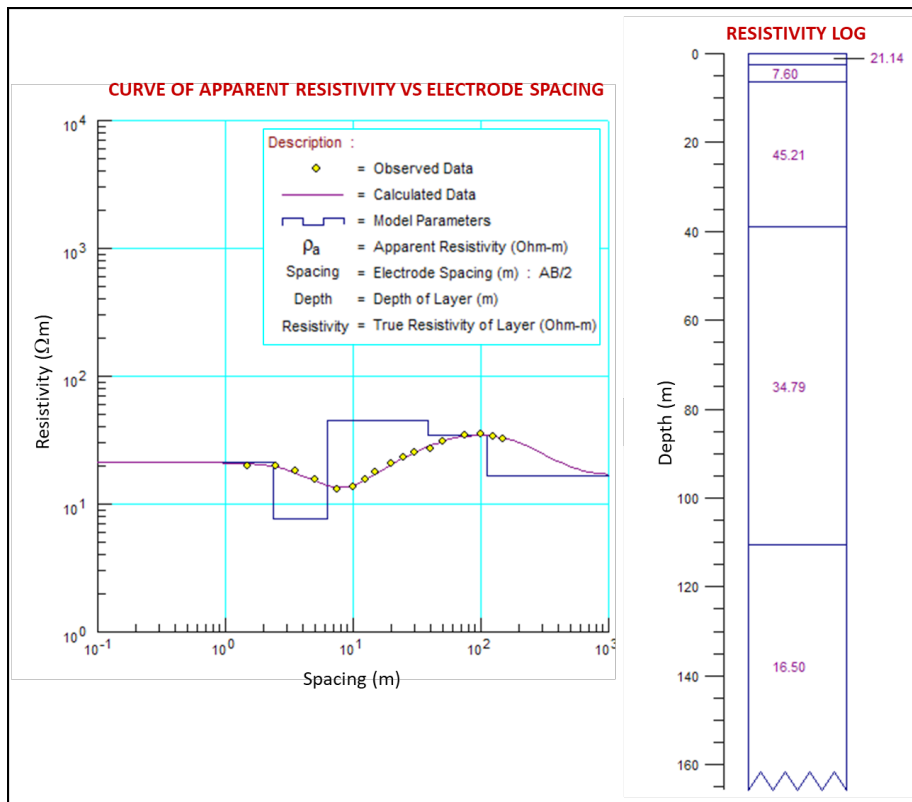


Figure 3. Example of resistivity curve and log resulting from modeling apparent resistivity data.

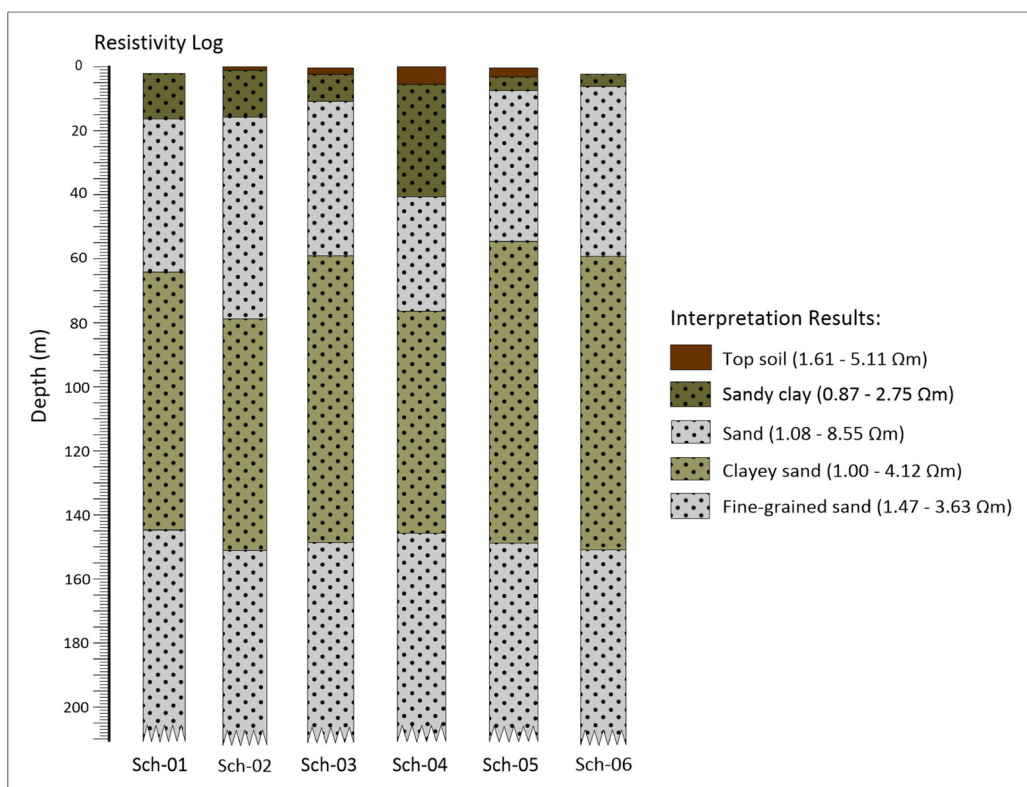


Figure 4. Results of modeling and interpretation of subsurface rock resistivity data in the Kalimantan District area.

Table 1. Results of lithological and hydrogeological interpretation of the subsurface rock resistivity data at sounding points in the Kalimantan District area

No.	Resistivity (Wm)	Depth (m)	Interpretation	
			Lithology	Hydrogeology
1	1.61 – 5.11	0 – 5.31	Top soil	Non aquifer
2	0.87 – 2.75	1.28 – 40.44	Sandy clay	Shallow aquifer
3	1.08 – 8.55	5.70 – 78.13	Sand	Intermediate aquifer
4	1.00 – 4.12	54.02 – 150.08	Clayey sand	Deep Aquifer
5	1.47 – 3.63	> 144.19	Fine-grained sand	Deep aquifer

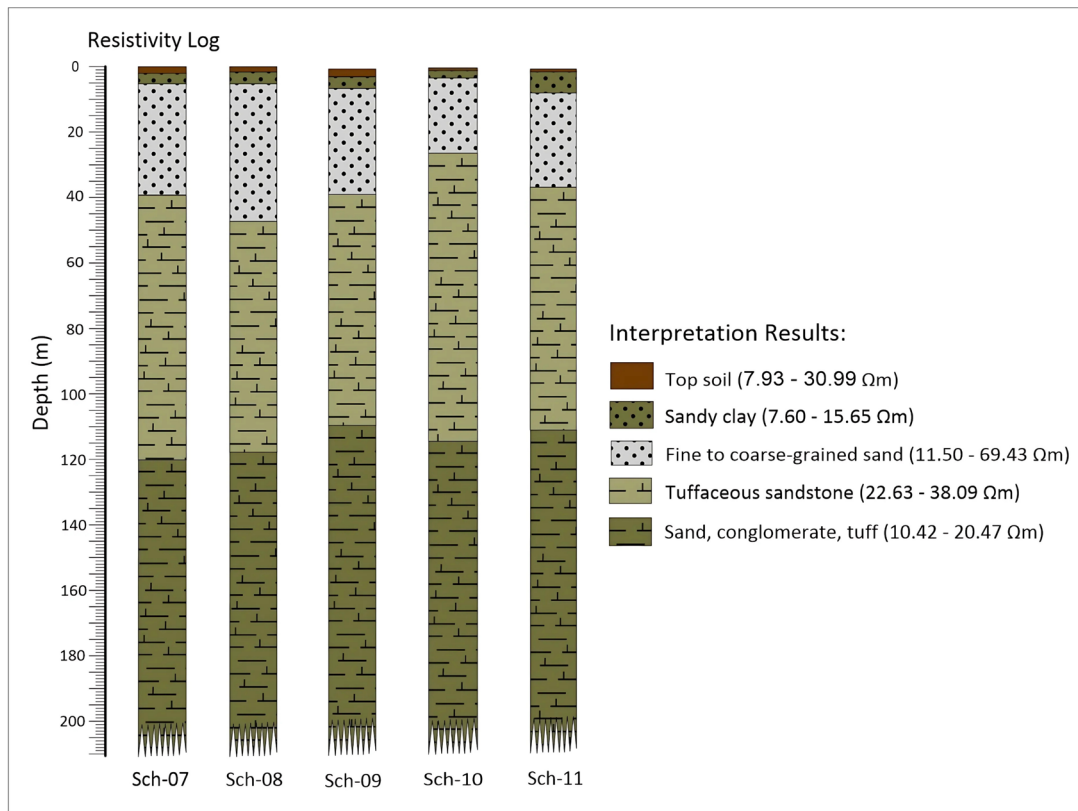


Figure 5. Results of modeling and interpretation of subsurface rock resistivity data in the Purbalingga and Kemangkkon District areas.

Table 2. Results of lithological and hydrogeological interpretation of the subsurface rock resistivity data at sounding points in the Purbalingga and Kemangkkon District areas

No.	Resistivity (Wm)	Depth (m)	Interpretation	
			Lithology	Hydrogeology
1	7.93 – 30.99	0 – 2.35	Top soil	Non aquifer
2	7.60 – 15.65	1.03 – 7.61	Sandy clay	Shallow aquifer
3	11.50 – 69.43	3.28 – 47.74	Fine to coarse-grained sand	Intermediate Aquifer
4	22.63 – 38.09	26.48 – 120.82	Tuffaceous sandstone	Aquitard
5	10.42 – 20.47	> 101.25	Sand, conglomerate, tuff	Deep aquifer

The resistivity modeling results from all sounding points distributed across Kalimantan District indicate low resistivity values ranging from 0.87 – 8.55 Ωm. The resistivity values modeled for Purbalingga and Kemangkkon Districts range between 7.60 – 69.43 Ωm, while those for Bukateja District range from 3.47 – 58.94 Ωm. The interpreted resistivity data

for these three areas are presented in the form of lithological logs, as shown in Figures 4, 5, and 6, whereas the lithological and hydrogeological interpretations are summarized in Tables 1, 2, and 3. The lithologic logs are vertical profiles illustrating the sequence and characteristics of rock layers from the surface to a certain depth, based on resistivity data interpretation.

The resistivity values of rocks such as sand, clay, silt, and other sedimentary materials generally exhibit a wide range because resistivity is influenced not only by the rock type but also by their associated physical and chemical conditions. Variations in water content, saturation level, and pore-water salinity are the primary factors that lead to significant differences in resistivity. In addition, parameters such as porosity, degree of compaction, grain size, and mineral composition also contribute to broadening the resistivity value range of rocks. More compacted materials tend to have smaller pore spaces, resulting in higher resistivity, whereas the presence of conductive minerals or clay layers can decrease resistivity. These combined physical factors result in the same rock types in the three study areas in Purbalingga regency to display highly variable resistivity values (Rubio *et al.*, 2025).

The hydrostratigraphic section model represents a crucial framework for understanding aquifer conditions and subsurface structures in a region. This model is constructed by correlating resistivity data obtained from geoelectric surveys (Udosen *et al.*, 2025) with local geological information. Low resistivity values generally indicate unconsolidated sediment rocks or water-saturated materials, whereas moderate to high resistivity values are typically associated with compact rocks, volcanic rocks, or relatively impermeable bedrock. Through lateral correlation among sounding points, the distribution

and thickness of aquifer layers can be mapped in greater detail, providing a subsurface stratigraphic profile that closely reflects the actual geological setting. The resulting hydrostratigraphic model also provides insights into aquifer continuity, the depth of saturated zones, and their potential (McKnight *et al.*, 2021). A comprehensive correlation of lithological logs across each study area has produced hydrostratigraphic cross-section models (Sehah *et al.*, 2021), as illustrated in Figures 7, 8, and 9.

The study area is situated within the Purwokerto-Purbalingga Groundwater Basin, which is composed of rocks ranging in age from the Tertiary to the Quaternary. The Tertiary formations, particularly the Halang Formation, are dominated by sandstone, claystone, and conglomerate (Djuri *et al.*, 1996), which serve as the basement rocks. Overlying these units are younger volcanic deposits derived from the activity of Slamet Volcano which cover much of the region and consist of andesitic lava, breccia, and tuff (Djuri *et al.*, 1996). The central part of the groundwater basin, including Kalimanah District (Table 1), is filled with Quaternary alluvial deposits of sand, silt, and clay (Djuri *et al.*, 1996), deposited by fluvial systems, primarily the Serayu River and its tributaries. Hydrogeologically, the combination of alluvial deposits and young volcanic materials forms productive aquifers that constitute the main groundwater resources in the Purbalingga region.

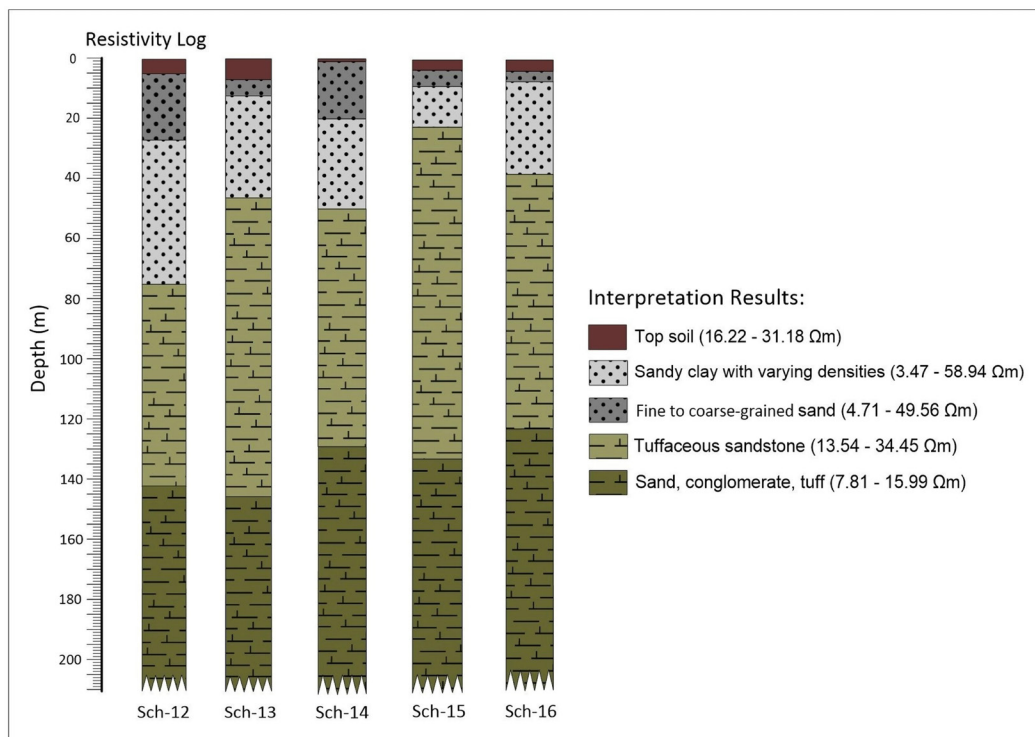


Figure 6. Results of modeling and interpretation of subsurface rock resistivity data in the Bukteja District area.

Table 3. Results of lithological and hydrogeological interpretation of the subsurface rock resistivity data at sounding points in the Bukateja District area

No.	Resistivity (Wm)	Depth (m)	Interpretation	
			Lithology	Hydrogeology
1	16.22 – 31.18	0 – 6.93	Top soil	Non aquifer
2	3.47 – 58.94	0.87 – 20.66	Sandy clay	Shallow aquifer
3	4.71 – 49.56	7.34 – 74.73	Fine to coarse-grained sand	Intermediate Aquifer
4	13.54 – 34.45	22.38 – 145.66	Tuffaceous sandstone	Aquitard
5	7.81 – 15.99	> 122.89	Sand, conglomerate, tuff	Deep aquifer

The resistivity values of rocks, as presented in Tables 1 to 3, exhibit a strong correlation with potential flow rates and groundwater storage capacity, as resistivity reflects key physical properties such as porosity and permeability (Fajana, 2020). Rocks or sediments with low resistivity typically possess moderate to high porosity and are water-saturated, allowing groundwater to flow more easily through interconnected pore spaces. This property enables resistivity values to serve as an initial indicator for identifying zones with potentially high groundwater flow rates, particularly in saturated sand or gravel deposits. Conversely, materials with high resistivity tend to be more compact, have low porosity, or contain minimal water, thus exhibiting limited flow capacity. In addition, resistivity is closely related to groundwater storage capacity. Layers with relatively low resistivity often contain larger volumes of water because their pores are fully saturated, making them effective

aquifer zones capable of storing groundwater (Dietrich et al. 2018) Therefore, resistivity values not only help identify the presence of groundwater but also provide insights into the ability of geological layers to store and transmit water. This correlation underscores the importance of geoelectrical methods as a key tool for aquifer mapping and evaluating groundwater resource potential.

Analysis and Discussion

The modeling and interpretation of resistivity data across all locations in the Kalimantan District area revealed low resistivity values ranging from 0.87 – 8.55 Ωm (Figure 7). This range is commonly associated with alluvial deposits, such as sand, clay, and silt (Razak & Muftaza, 2022). Low resistivity values suggest that subsurface materials possess a high capacity to conduct electrical current. This condition is influenced

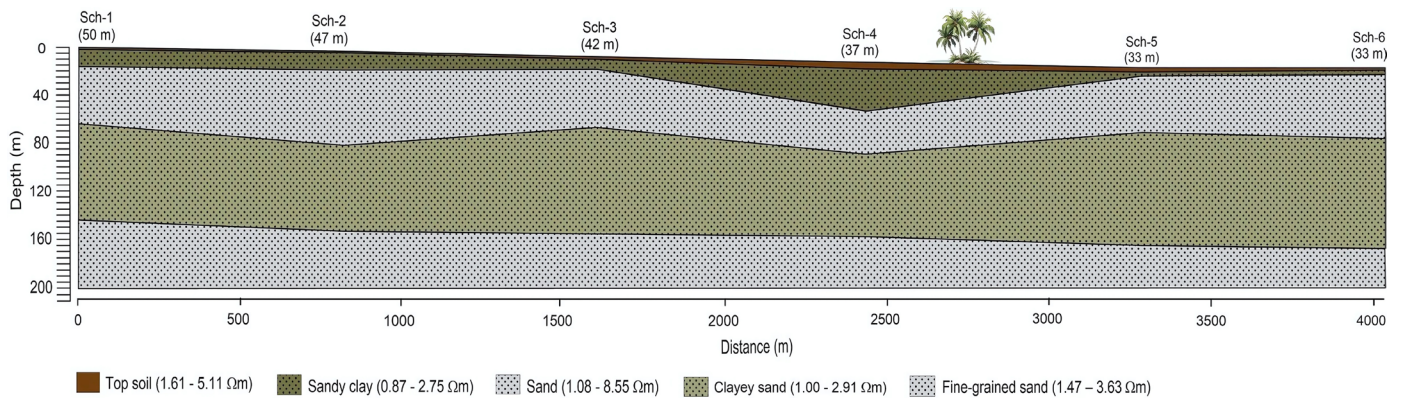


Figure 7. Hydrostratigraphical cross-section model for the Kalimantan District area based on resistivity data.

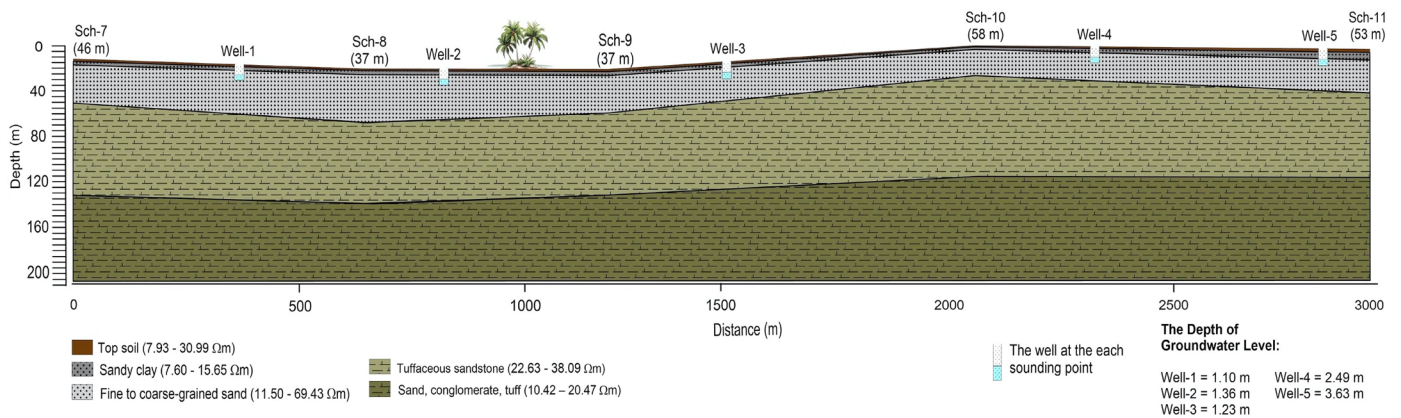


Figure 8. Hydrostratigraphical cross-section model for the Purbalingga and Kemangkön District areas based on resistivity data.

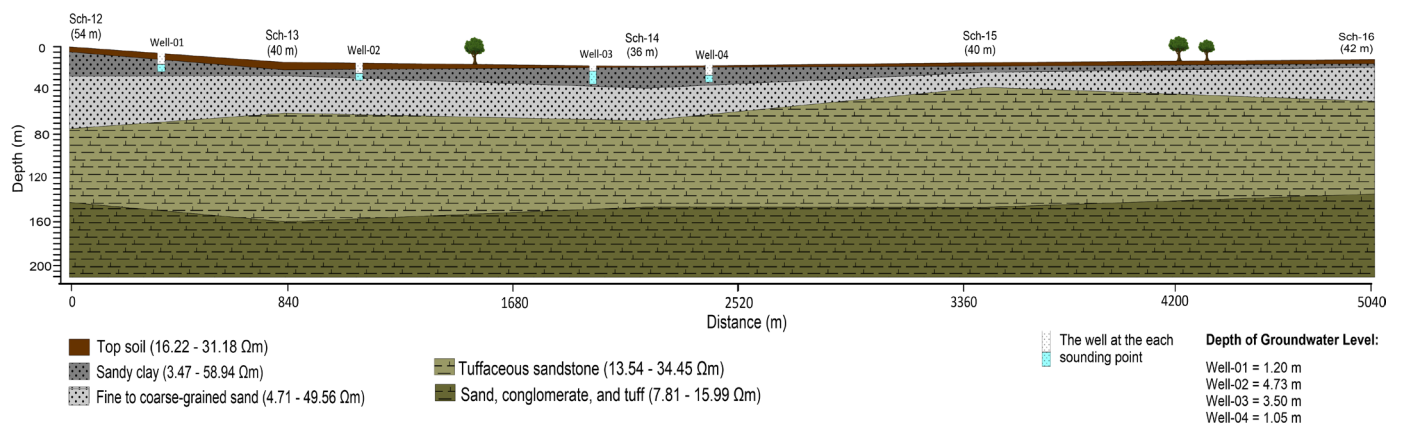


Figure 9. Hydrostratigraphical cross-section model for the Bukateja District area based on resistivity data.

by several factors, particularly mineral composition, which interact with groundwater to produce ions that enhance conductivity (Gomaa, 2020). Accordingly, zones characterized by low resistivity are typically interpreted as water-saturated layers, indicating the presence of abundant groundwater. Previous investigations have confirmed that the study area lies in the central part of the Purwokerto-Purbalingga groundwater basin, which is predominantly composed of alluvial deposits (Sehah *et al.*, 2024). The hydrostratigraphic model of the study area (Figure 7) and its interpretation (Table 1) indicate that the Kalimanah District constitutes a productive groundwater aquifer zone. The lithological units characterized by low resistivity generally consist of materials or rocks with moderate to high porosity and permeability that are saturated with groundwater, thus efficiently forming potential aquifer systems within the research area (Udosen *et al.*, 2025). Meanwhile, the gentle topography promotes lateral groundwater flow toward the central basin (around the study area), thus enhancing groundwater availability in the region.

Modeling and interpretation of resistivity data in Purbalingga and Kemangkön Districts identified five subsurface rock layers with resistivity values ranging from 7.60 – 69.43 Ωm . The alluvial deposits in the study area exhibit considerable variability in grain size. This is particularly evident in the third layer, which has resistivity values between 11.50 – 69.43 Ωm and is interpreted as fine-to coarse-grained sand. Fine-grained sand contains more grains of sand than coarse-grained sand, and when these sediments interact with water, they tend to be conductive (Kolay *et al.*, 2016). Such porous materials are commonly saturated with groundwater, saline solutions, or other ion-bearing fluids, in which the ions enhance current flow through ionic conduction. In the study area, the Terrace Formation functions both as an aquitard and as a deep aquifer. An aquitard is a subsurface unit that restricts groundwater movement between aquifers (De Smedt, 2023). The hydrostratigraphic model (Figure 8) and resistivity interpretation results (Table 2) suggest that productive groundwater zones in the study area are likely present within both shallow and deep aquifer layers.

Bukateja District, located on the easternmost part of Purbalingga Regency, lies at the edge of the Purwokerto-Purbalingga Basin. The modeling and interpretation results indicate that the Alluvium Formation exhibits resistivity values ranging from 3.47 – 58.94 Ωm with depths reaching up to 74.73 m, whereas the Terrace Formation shows resistivity values between 7.81 and 34.45 Ωm at depths exceeding 22.38 m. The shallow aquifer is composed of clay, silt, and sand with a relatively wide resistivity range of 3.47 – 58.94 Ωm , reflecting variations in subsurface rock properties such as porosity and grain size, which significantly influence bulk electric resistivity. Similarly, the intermediate aquifer, primarily consisting of sand with resistivity values between 4.71 – 49.56 Ωm , is inferred to exhibit variability in grain size or density. Fine-grained loose sand typically displays lower resistivity, whereas coarser deposits generally have higher values (Barustan *et al.*, 2021). In most cases, coarse-grained sediments tend to accumulate along the basin edges. This is evident in the resistivity data for Bukateja District, which predominantly indicates higher rock resistivity values. Although the availability of shallow groundwater in this area remains relatively adequate, Figure 9 and Table 3 show that its productivity is lower than that of the previously examined regions, such as Kalimanah and Purbalingga.

The study area, situated in the central part of the Purwokerto–Purbalingga Groundwater Basin, is characterized by a lowland landscape surrounded by highlands, mountains, and hills, including Slamet Volcano (Ramadhan, 2020). The topographic conditions indicate that groundwater flows from areas with higher elevations to lower, predominantly from the northwest to the southeast and the northeast to the southwest across Purbalingga Regency, thereby recharging the aquifers within the region. Hydrostratigraphical models reveal the absence of impermeable layers throughout the study area, enabling a significant portion of groundwater from shallow aquifers to percolate into intermediate and deep aquifers, while part of the flow continues toward lower elevations in the central basin. Although groundwater tends to converge toward the basin center, shallow aquifer resources remain abundant along the basin margins. Groundwater levels recorded from several wells across the study area, particularly in Purbalingga, Kemangkön, and Bukateja Districts, are presented in Figures 8 and 9.

The interpretation of resistivity data down to a depth of 200 m throughout the study area indicates the presence of two main formations: the Alluvium Formation and the Terrace Formation. The Alluvium Formation is composed of sandy clay, sand, and clayey sand with low resistivity values (0.87 – 69.43 Ωm). Meanwhile the Terrace Formation consists of tuffaceous sandstone, sand, conglomerate, and tuff (Djuri *et al.*, 1996) with moderate resistivity values (7.81 – 38.09 Ωm). Hydrostratigraphic modeling across the study area reveals variations in hydrogeology conditions. In particular, the Kalimanah District area is predominantly characterized by low-resistivity rocks (0.87 – 8.55 Ωm), interpreted as water-saturated alluvial deposits with high potential, making this area highly suitable for the development of groundwater-based irrigation program. The novelty of this study lies in the application of a resistivity-based interpretive approach to analyze and classify the hydrostratigraphic characteristics of the study area through the integration of resistivity data with local geological conditions. This method not only provides a more accurate depiction of aquifer distribution and quality but also establishes a scientific foundation for developing groundwater resource management strategies, thereby supporting efforts to enhance global food security, including in Purbalingga Regency.

Understanding the hydrostratigraphic framework of an area is fundamental for assessing groundwater potential and its sustainable utilization (Cianflone *et al.*, 2021). The results of hydrostratigraphic modeling provide insights into the vertical and lateral distribution of aquifers and aquitards, including their thickness, porosity, permeability, and hydraulic connectivity. Such information is essential to determine groundwater storage capacity, recharge and discharge areas, which collectively control the availability and productivity of aquifers. In agricultural regions, particularly those that rely heavily on groundwater resources, a detailed hydrostratigraphical model characterization enables more accurate estimation of groundwater availability and supports the design of effective groundwater extraction strategies. Moreover, reliable hydrostratigraphic models provide a scientific basis for optimizing groundwater use in irrigation systems, ensuring sufficient water supply for crop production while minimizing the risks of overexploitation and aquifer degradation (Elsaidy *et al.*, 2025). Consequently, integrating hydrostratigraphic analysis with groundwater management

practices represents a critical stage toward achieving water security and promoting sustainable agricultural development.

This study has several limitations primarily due to the insufficient number of resistivity data points in each area, which prevented a comprehensive reconstruction of subsurface information. In addition, the absence of geological drilling data posed a constraint on conducting direct lithological calibration, causing the resistivity interpretation to rely more heavily on geophysical modeling. The lack of pumping test results further restricted the study's ability to evaluate key aquifer hydraulic parameters, such as transmissivity, hydraulic conductivity, and groundwater recovery capacity. To enhance the quality of future research, it is recommended that resistivity surveys be conducted with a greater number of measurement points and a more evenly distributed spatial coverage, enabling higher-resolution subsurface modeling and allowing for the accurate development of isopach maps. Geological investigations are also needed, particularly to supplement drilling data for obtaining definitive lithological information, as well as pumping test data to quantitatively characterize the hydraulic properties of the aquifer.

4. Conclusion

This study addresses the hydrostratigraphic information gap in Purbalingga Regency, which has long been constrained by the limited availability of drilling data and subsurface surveys. Using resistivity-based modeling, this research has successfully developed a hydrostratigraphic model that delineates the vertical and lateral structure of the aquifers in the districts of Kalimanah, Purbalingga, Kemangkong, and Bukateja. Two lithological units were identified are the Alluvium Formation, characterized by low resistivity values (0.87–69.43 Ωm), and the Terrace Formation, which exhibits moderate resistivity values (7.81–38.09 Ωm). Overall, the study area represents a productive groundwater zone; however, the Kalimanah District, with its distinctly low resistivity values (0.87–8.55 Ωm) and its location near the central part of the Purwokerto–Purbalingga Basin, is estimated to be the most productive groundwater zone.

The hydrostratigraphic model also reveals the absence of significant impermeable layers, suggesting connectivity between aquifer layers through recharge processes from shallow aquifers to intermediate and deeper aquifers. Integrating resistivity data with local geological conditions provides a significant scientific contribution by offering a better and more comprehensive hydrostratigraphic model. The findings not only clarify the aquifer framework and its productivity potential but also offer a strong scientific basis for sustainable groundwater resource management. This approach reinforces the strategic role of hydrostratigraphic modeling in supporting water security, groundwater-based agricultural irrigation development, and the mitigation of drought-related disaster risks within the region.

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