IDENTIFICATION OF AQUIFERS USING THE GEO-ELECTRIC RESISTIVITY METHOD AND GEO-CHEMICAL ANALYSIS IN THE KARST AREA OF SOUTH MALANG, INDONESIA

Fian Fakhruddin[1], Adi Susilo[1,2], Alamsyah M. Juwono[1], Erwan Hermawan[3], Farizky Hisyam[1]

[1]Department of Physic, Faculty of Mathematics and Natural Sciences, Brawijaya University, Malang, 65145, Indonesia.
[2]Research Study of Geosciences and Hazard Mitigation, Brawijaya University, Malang, 65145, Indonesia.
[3]Research Centre for Process Industry Technology and Manufacturing, National Research and Innovation Agency, Puspiptek Gd. 720, Tangerang Selatan, 15314, Indonesia.
e-mail: fianfakhruddin10@gmail.com

Abstract. Communities residing in karst regions commonly encounter challenges related to the availability of clean water. The southern part of Malang, characterized by extensive karst formations, is no exception. This study aims to identify aquifer zones and perform geochemical analysis for water feasibility around the Ar-Roudloh Islamic Boarding School, an area with limited access to clean water. The geoelectrical method employing the Schlumberger configuration, along with geochemical testing, was utilized across five survey lines measuring 300 meters each, positioned in the northern and eastern sectors of the study area. The findings indicate that deep aquifer zones are located within calcareous sandstone layers, exhibiting favorable porosity and resistivity values (5–90 Ωm). These aquifers follow a conduit flow system, particularly evident at points T3, T4 (62–110 m), T2 (23–65 m), and T5 (15–60 m). Shallow aquifers were detected at T1–T4 (4–26 m). Geochemical results revealed that water at point T4 is unsuitable for consumption, exceeding acceptable color parameter limits (15 TCU).

Keywords: Aquifer, Geochemical, Geoelectric, Schlumberger configuration

INTRODUCTION

Clean water is a primary need to support human sustainability, an unlimited and sustainable need that must be met at all times. Humans create different ways of using water to support different human activities. One of the water sources used to meet the need for clean water is groundwater, as it has several advantages over surface water (Mostacedo and Marasovic, 2022). The demand for drinking water is increasing due to various factors such as population growth, increased urbanisation, industrial growth, economic development and improved living standards (Ikhsan, 2024). Sidodadi Village is a village located in the karst region of Gedangan District, Malang Regency. This village is one of the villages affected by the severe drought that continues to spread in the southern region of Malang. The residents of Sidodadi village have difficulty finding groundwater sources to meet their daily needs. Various efforts have been made by the local government, including drilling groundwater wells to a depth of more than 100 m. On the other hand, the well water pump is unable to pump the well water to the surface, so this research is a follow-up to these efforts (Puspita, 2022).

The hydrogeological condition of karst areas has its own peculiarities, namely the distribution of groundwater potential is mostly far below the ground surface, with about 10% of underground water sources being stored in karst areas. This is due to the formation process of karst subsurface geomorphology, which is dominated by the process of water dissolution (Fiorese, 2025). Soluble rocks consist of limestone, halite, conglomerate, dolomite and gypsum, where rainwater that falls and enters the pores of karst rocks causes a dissolution process, this process creates underground passages and caves that are filled with water(Zerga, 2024).

Lack of water is a major problem in karst areas, making it difficult to find water sources. Surface water flows are very rare in this region, and groundwater collects in zones that form extensive underground passages or caves. These characteristics mean that the karst zone has huge underground water reserves (Sahrina, 2020).

Previous research conducted by Susilo (2021) on aquifer analysis in Sidodadi village, Gedangan subdistrict, Malang district, provided information on the potential of underground aquifer zones in the study area using geoelectric methods; the research did not include geochemical analysis. The aquifer zone in the study area is located in the calcareous sandstone in the form of passages and underground caves.

Human activities such as mining, agriculture, livestock and tourism can affect the quality of groundwater, so an analysis is needed to understand the quality of groundwater in the study area (Lagade, 2024). Geoelectric

DOI : http://dx.doi.org/10.12962/j25023659.v11i1.3085

Artikel Masuk : 17-03-2024 Artikel Diulas 19-03-2024 Artikel Diterima : 29-04-2025

survey is a geophysical survey that is an active survey but environmentally friendly. Geoelectric surveys are widely used for various purposes, namely soil structure surveys for construction, metal mineral surveys for mining and aquifer stratum surveys for groundwater exploitation. The advantage of this method is that it can be used for shallow exploration, which is non-destructive (Prabhu, 2018). Geochemical analysis of water is carried out to determine various characteristics such as odour, amount of dissolved solids, colour, turbidity, temperature, iron, nitrate, nitrite, manganese, pH and hardness. This analysis was carried out to determine the viability of the water in the study area. The analysis method was carried out by means of a single sampling, but in triplicate using a Uv Vis spectrophotometer and a Hach 2800 spectrophotometer (Wattimanela, 2021). The purpose of this research is to identify aquifer zones with resistivity geoelectric method and geochemical analysis of water for drinking feasibility, as an effort to provide clean and potable drinking water sources for the residents of Sidodadi village.

RESEARCH METHOD

This research was conducted on 17 February 2024 in Sidodadi Village. The purpose of this research is to identify aquifer zones using the schlumberger configuration geoelectric method and geochemical analysis. The geoelectric point was located between two residents' wells, namely the north well of the Islamic boarding school and the east well of the Islamic boarding school. Data acquisition was carried out using a resistivity meter, this tool is one of the tools often used in geophysical surveys, and can determine changes in the specific resistance of rock stratums below the surface.

Geochemical analysis was carried out using a uv vis spectrophotometer and a hach 2800 spectrophotometer. Well water samples were subjected to geochemical tests, the results of which can determine the impact of environmental influences and the potential of water resources and the feasibility of drinking water.

The resistivity value is a physical property of each rock that can be obtained using geoelectric methods. The Schlumberger configuration is able to determine the variation of rock resistivity with depth vertically (one-dimensional) and has the advantage of detecting inhomogeneity of rock stratums at the surface by comparing resistivity values (Rahmawati, 2024). This study uses five geoelectric points with each stretch having a length of 300 metres.

Spectrophotometer is a device that measures absorbance by passing light of a specific wavelength through a glass or quartz object called a cuvette, some of the light is absorbed and the rest is transmitted, and the absorbance of the absorbed light is proportional to the concentration of the solution in the cuvette. The advantage of a spectrophotometer is that the wavelength of the polychromatic light is more accurately selected because the spectrophotometer is equipped with a monochromator, such as a prism, grating, or optical slit, to produce more sensitive and accurate results (Salsabiila, 2024).

DOI : http://dx.doi.org/10.12962/j25023659.v11i1.3085

Artikel Masuk : 17-03-2024 Artikel Diulas 19-03-2024 Artikel Diterima : 29-04-2025

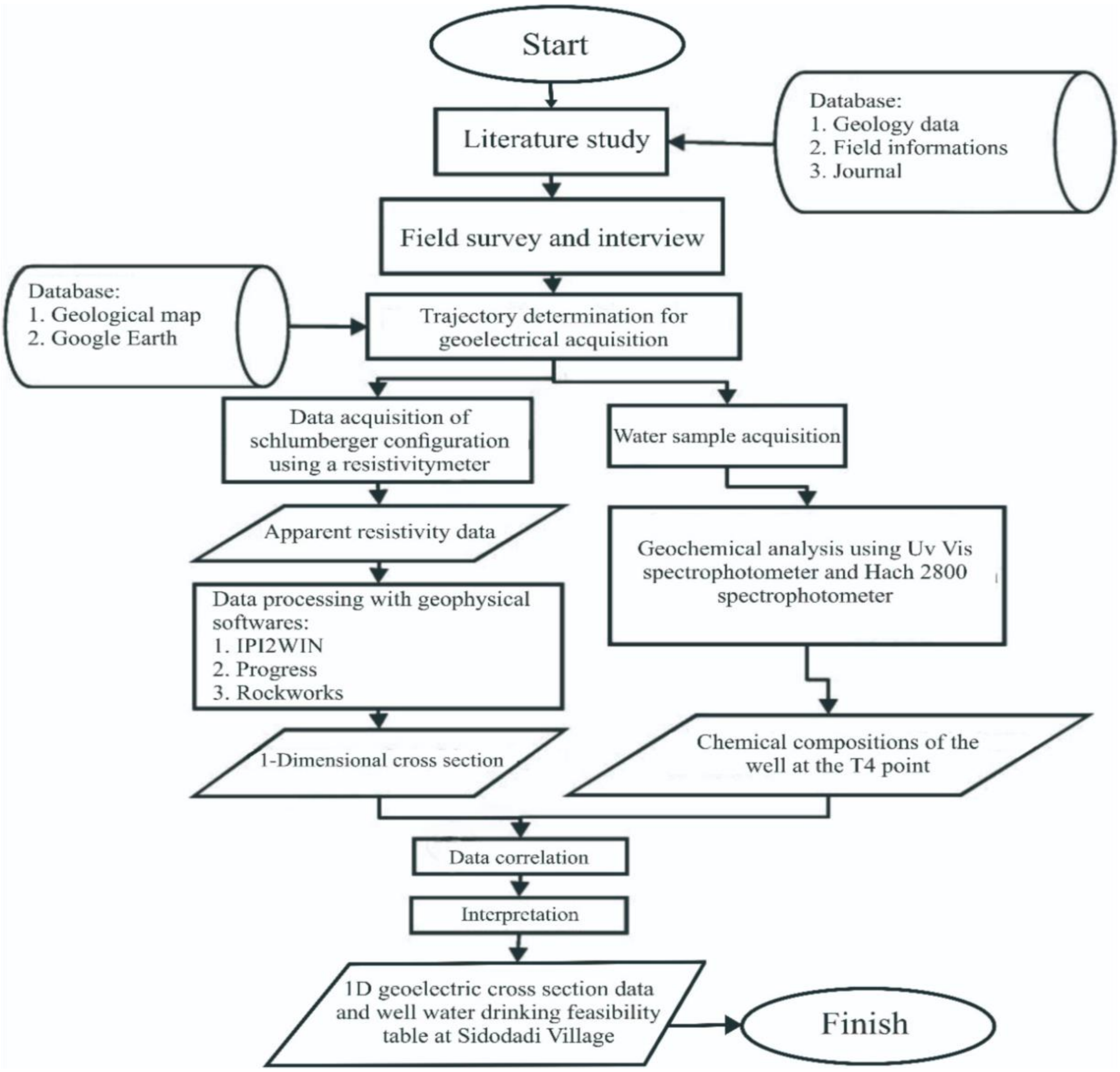

Figure 1. Research flow chart

Research Location

The research was conducted near the Ar-roudloh Islamic boarding school located in Sidodadi village, Gedangan district, Malang regency. The coordinates are at latitude 8°19'55.84"S and longitude 112°39'30.03". The location of the research area is easily accessible by motorbikes.

According to the geological map (Figure 2), the research site is located in the Nampol Formation. This formation consists of stratums of tuffaceous or calcarous sandstone, black claystone , sandy marl and limestone. The Nampol Formation has a Tmn code shown in yellow, the Tm code indicates that this formation was formed in the Miocene period about 5-23 million years ago, the rocks of this period are dirty limestone with white patches, the limestone is smooth and very compact (Iqbal, 2022).

DOI : http://dx.doi.org/10.12962/j25023659.v11i1.3085

Artikel Masuk : 17-03-2024 Artikel Diulas 19-03-2024 Artikel Diterima : 29-04-2025

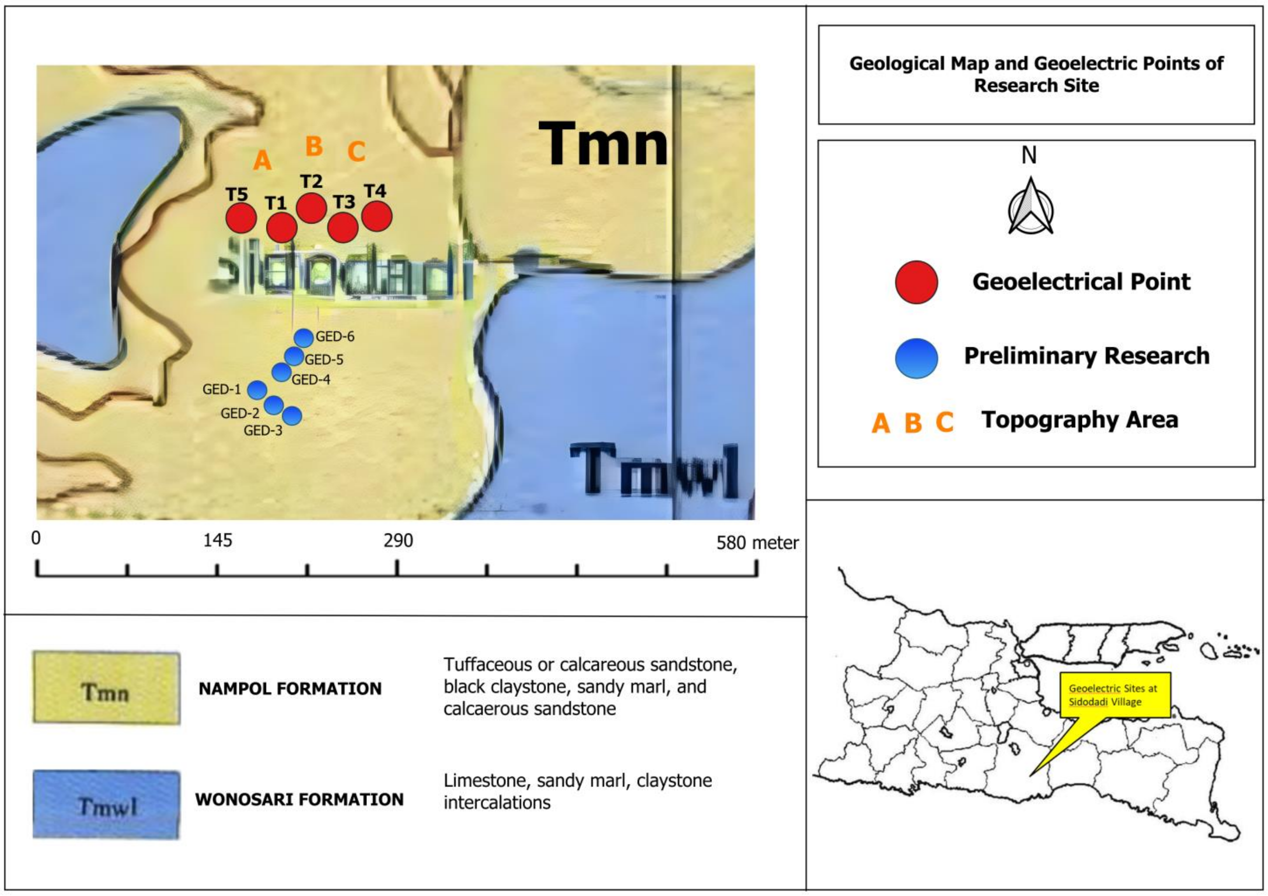

Figure 2. Geological map of the research area.

Data Acquisition

Direct current is applied to the ground through electrodes placed at a certain distance and strain, the output is a different value of resistivity at each datum point, the principle of direct current emphasises the measurement of the value of resistivity, which represents the material resistance to the flow of electric current. The resistivity value obtained is recorded on a paper log which is a field curve, the data can be interpreted using various geophysical applications (Widodo, 2023).

Five Vertical Electrical Sounding (VES) or geoelectric points spread from the northern well of the Pesantren to the eastern well of the Pesantren can be seen in Figure 4. The Schlumberger configuration is used in this study because it has advantages in depth measurement or VES, the Schlumberger configuration has several advantages, namely in data retrieval is more efficient and optimal in reducing errors and is very suitable for identifying aquifer zones below the ground surface which have different resistivity values in each rock stratum (Kalaivanan, 2019).

DOI : http://dx.doi.org/10.12962/j25023659.v11i1.3085

Artikel Masuk : 17-03-2024 Artikel Diulas 19-03-2024 Artikel Diterima : 29-04-2025

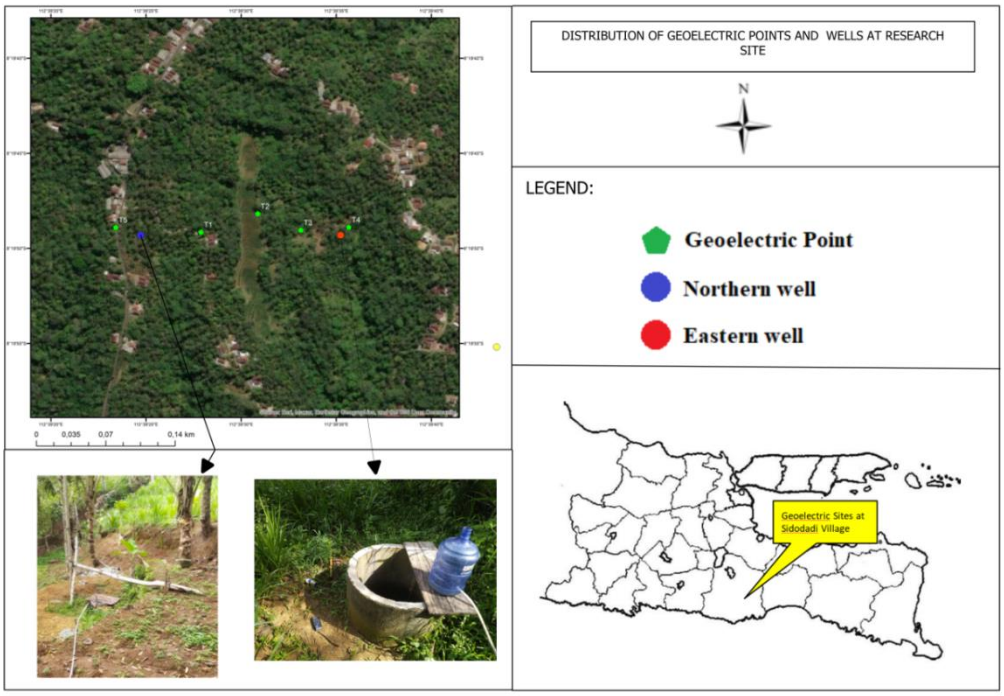

Figure 3. Location of the geoelectric points used for research.

Data Processing

Geophysic Data Processing

Field measured resistivity is apparent resistivity, the assumption that the earth has isotropic homogeneous properties is the basis of resistivity geoelectrics, in reality however, the earth is made up of stratums with different resistivity values. The apparent resistivity can be expressed by the following calculation (Latupapua, 2023).

$$\rho_a = k\frac{\Delta v}{I} \quad (1)$$

k is a geometry factor influenced by the configuration used and the electrode spacing, the geometry factor of the Schlumberger configuration is expressed by the following calculation (J.O, 2019) :

$$k = \pi(\frac{a^2 - b^2}{2b}) \quad (2)$$

Δv is the potential difference between P1 and P2 and I is the current (A), ρ_a is the apparent resistivity (Ωm), a is the current electrode distance A-B (m), b is the voltage electrode distance M-N (m).

The geoelectric data of the apparent resistivity obtained from the data acquisition are processed with the geophysical application such as IPI2win, Progress and Rockworks. IPI2win is the application used to process the apparent resistivity data. Progress application is used for data inversion. Rockworks application is used to interpret resistivity log data in two or three dimensions.

Geochemical Data Processing

Geochemical analysis of water samples was conducted on the eastern well of the Islamic boarding school (point T4), as this well is utilised by local residents for daily needs, while the northern well of the Islamic boarding school is only used by one household. The geochemical analysis employed UV vis spectrophotometer and Hach 2800 spectrophotometer. The data was collected on one occasion, and the analysis process was repeated three times (from one data sample, three tests were carried out to determine the average value). The results of the data analysis will provide the physical and chemical parameters of the water from well point T4.

Geophysic and Geochemical Data Interpretation

Each rock has different electrical conductivity and resistivity values, the same rock does not necessarily have the same resistivity value. Different types of rock can have the same resistivity value. This is due to several factors that affect the resistivity value, including: rock conditions, composition of fluid objects in the rock, porosity, pressure and mineral composition (Kahraman and Öğretici, 2024).

DOI : http://dx.doi.org/10.12962/j25023659.v11i1.3085
Artikel Masuk : 17-03-2024 Artikel Diulas 19-03-2024 Artikel Diterima : 29-04-2025

Rock resistivity value is required to interpolate data from all VES points. This value can be an aid in the interpretation of the two-dimensional underground rock structure with different color indicators on each rock stratum. Hydrogeochemical processes that cause groundwater contamination, such as the dissolution of substances, ionic changes, and biochemical reactions (Durrani, 2025). Geochemical analysis shows the parameters and standards of drinking water suitability, namely the standards of the Indonesian Minister of Health Regulation No. 2 of 2023. With these data it is possible to correlate the value of the chemical content with the lithological conditions of the research area.

Preliminary Research Result

Preliminary research have demonstrated the presence of a water storage/permeable stratum comprising a stratum of sandstone and calcarous sandstone/claystone. The depth of the aquifer at each point is as follows:

- GED-1: The shallow aquifer is 4.4 to 17.7 meters deep, and the deep aquifer is 25 to 48.5 meters deep.
- GED-2: Depth 38 - 125 meters is deep aquifer
- GED-3: depths of 12.3 - 20.2 meters is shallow aquifer and 33 - 122 meters is deep aquifer
- GED-4: depth 6.1 - 11.9 meters is shallow aquifer and 52 - 122 meters is deep aquifer
- GED-5: depth 5.6 - 12 meters is shallow aquifer and 46 - 124 meters is deep aquifer
- GED-6: depth 2.5 - 14.8 meters is shallow aquifer and 76 - 123 meters is deep aquifer

The strategic position for exploitation (drilling) is indicated by GED 2 and GED-3 points (Figure 7), which are located at a depth of 33 to 125 meters.

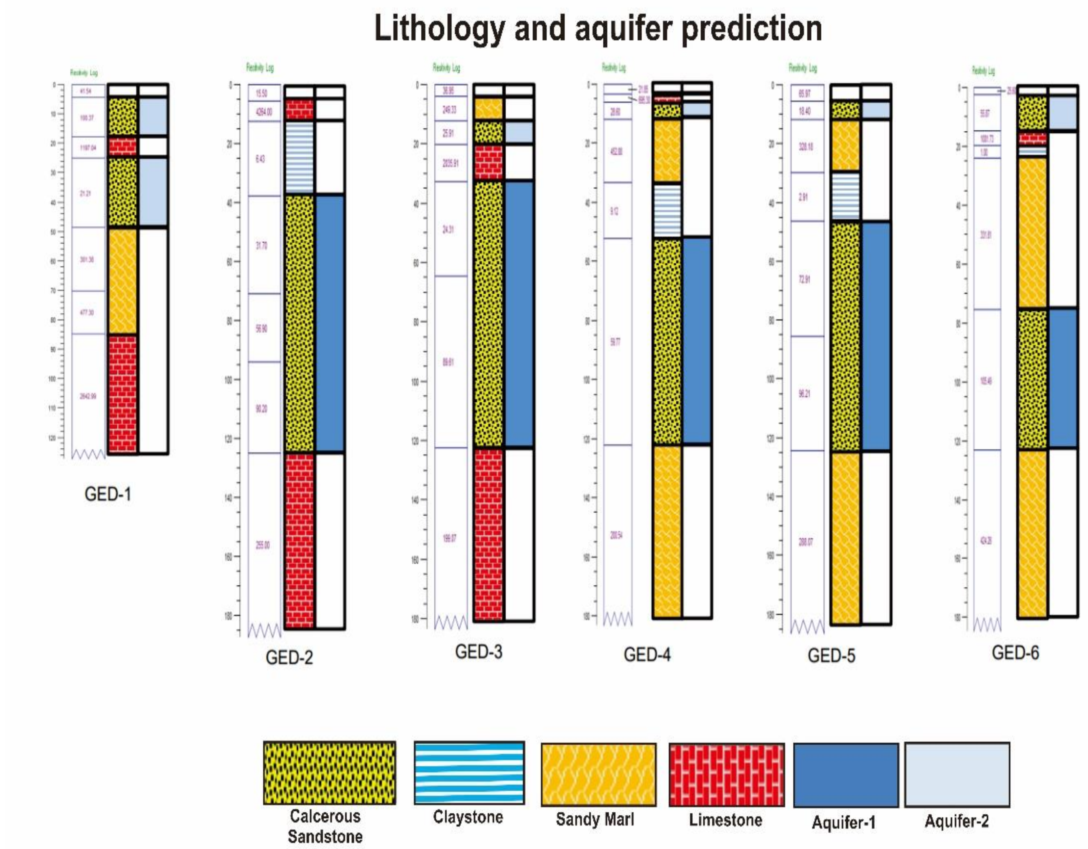

Figure 4. Lithological Interpretation and groundwater prediction results from previous research (Susilo, 2021).

RESULT AND DISCUSSION

Interpretation of data aqcuisition results at the research area

Based on the results of acquisition and processing geoelectric data of Sidodadi Village, Gedangan District, Malang Regency, there are five types of rock stratums that make up the lithology of the rocks in the research area, including soil, claystone, calcarous sandstone, sandy marl and limestone. Limestone and sandy marl,

DOI : http://dx.doi.org/10.12962/j25023659.v11i1.3085

Artikel Masuk : 17-03-2024 Artikel Diulas 19-03-2024 Artikel Diterima : 29-04-2025

which are impermeable, become a barrier stratum for water infiltration (Amin, 2024), Meanwhile, the calcareous sandstone and claystone layers are permeable, making them an aquifer zone (A. Sivasakthi and TJPRC, 2018).

The data obtained from the inversion modeling present a pseudo-resistivity curve, depth values (in meters), and resistivity values at each depth. These data can be utilized to aid in the interpretation of rock lithology in the study area, represented through a 1 Dimensional model that illustrates resistivity values at varying depths.

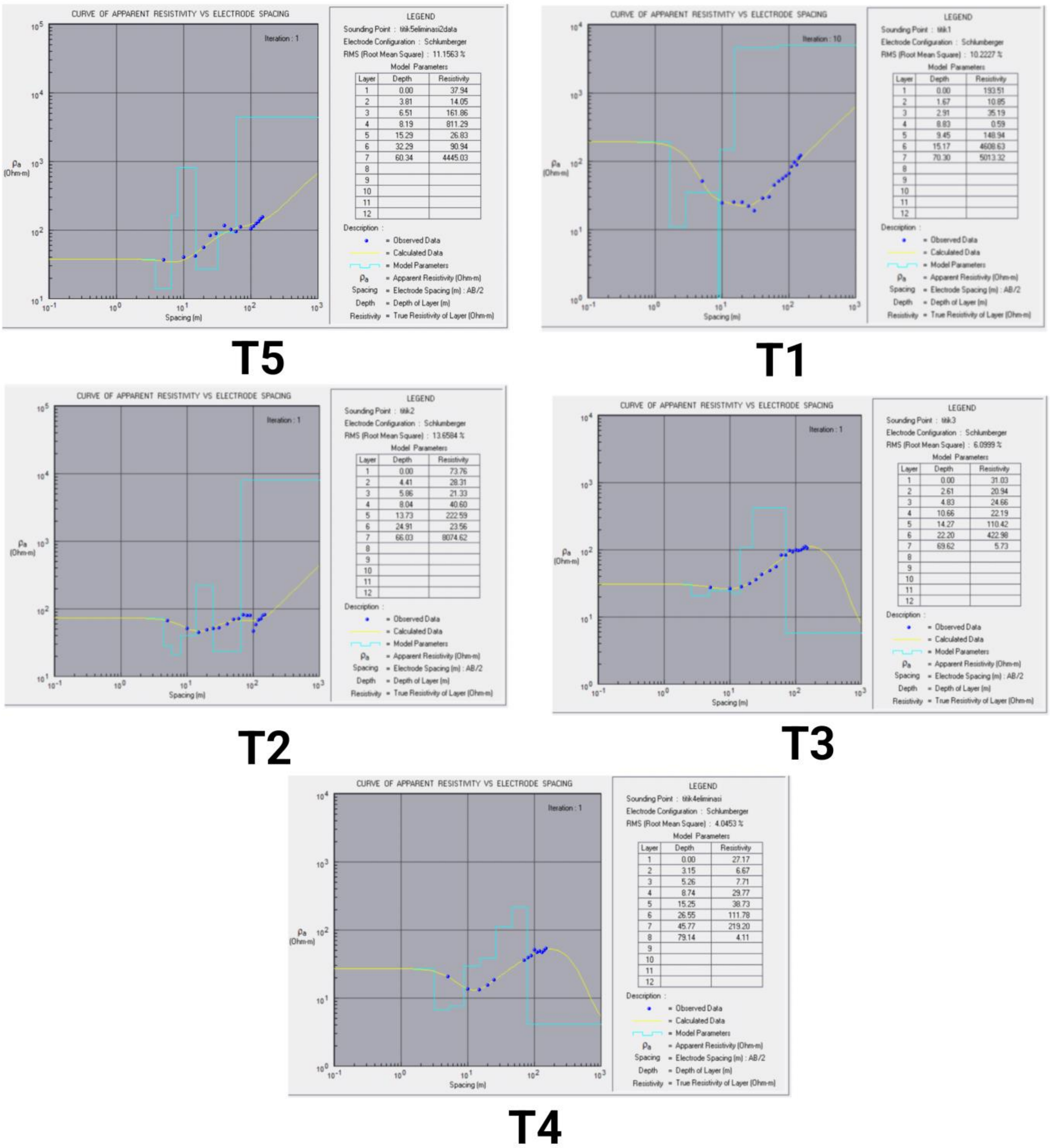

Figure 5. Invers Modeling Result

DOI : http://dx.doi.org/10.12962/j25023659.v11i1.3085

Artikel Masuk : 17-03-2024 Artikel Diulas 19-03-2024 Artikel Diterima : 29-04-2025

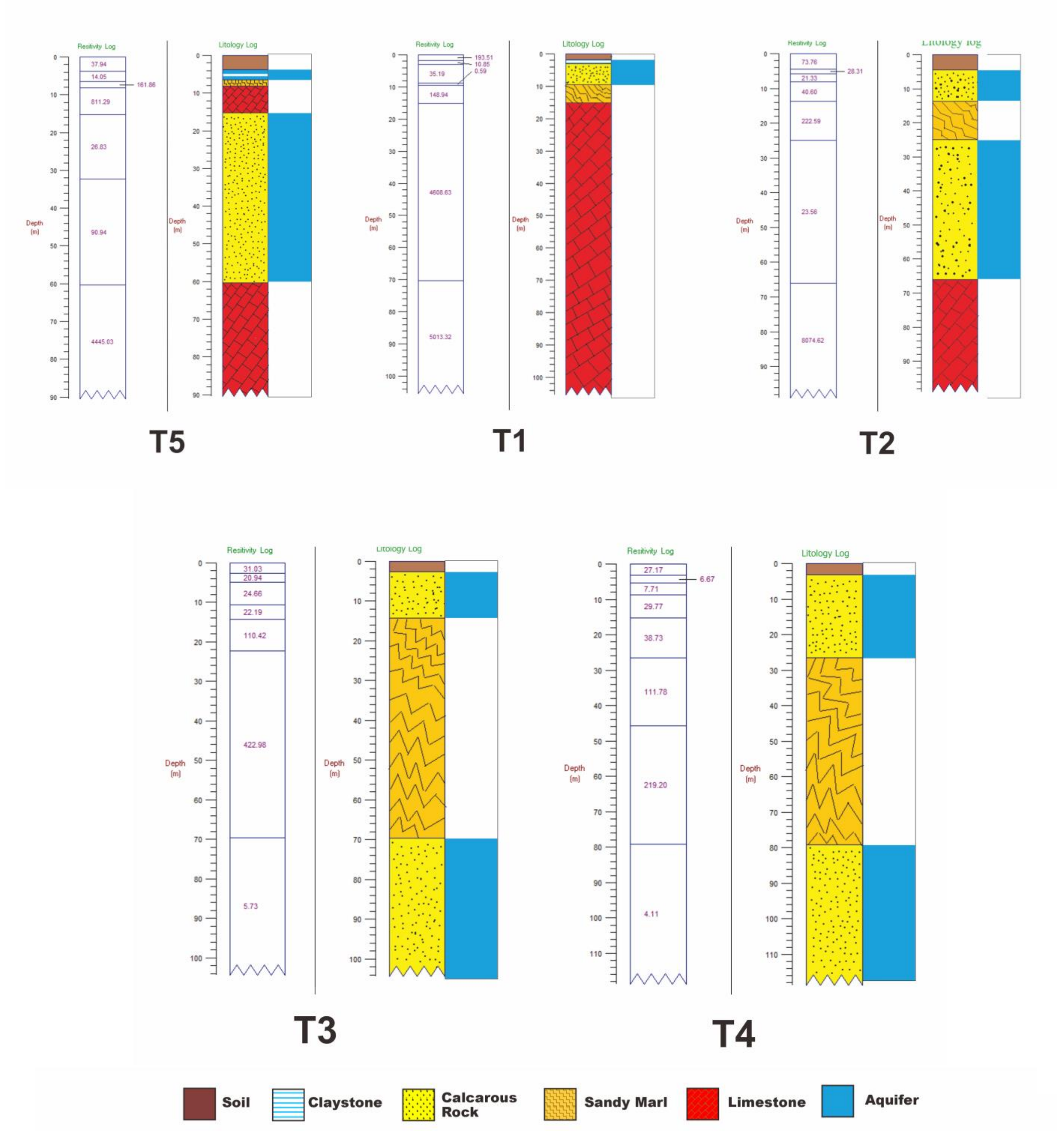

Figure 6. Lithological interpretation and groundwater prediction results

Observation points revealed the presence of both shallow and deep aquifer layers, except at point T1, where only a shallow aquifer was identified. This is attributed to the dominance of thick limestone layers in that area. The resistivity values of the aquifer layers range from 1-110 Ωm and are associated with calcareous sandstone formations. The identified depth are 90-114 meters across all points.

VES points in the research area are interpolated. The aim is to better understand the correlation of all VES points. The Rockworks application creates a two-dimensional cross section of the subsurface at the VES point by following the interpolated line.

DOI : http://dx.doi.org/10.12962/j25023659.v11i1.3085

Artikel Masuk : 17-03-2024 Artikel Diulas 19-03-2024 Artikel Diterima : 29-04-2025

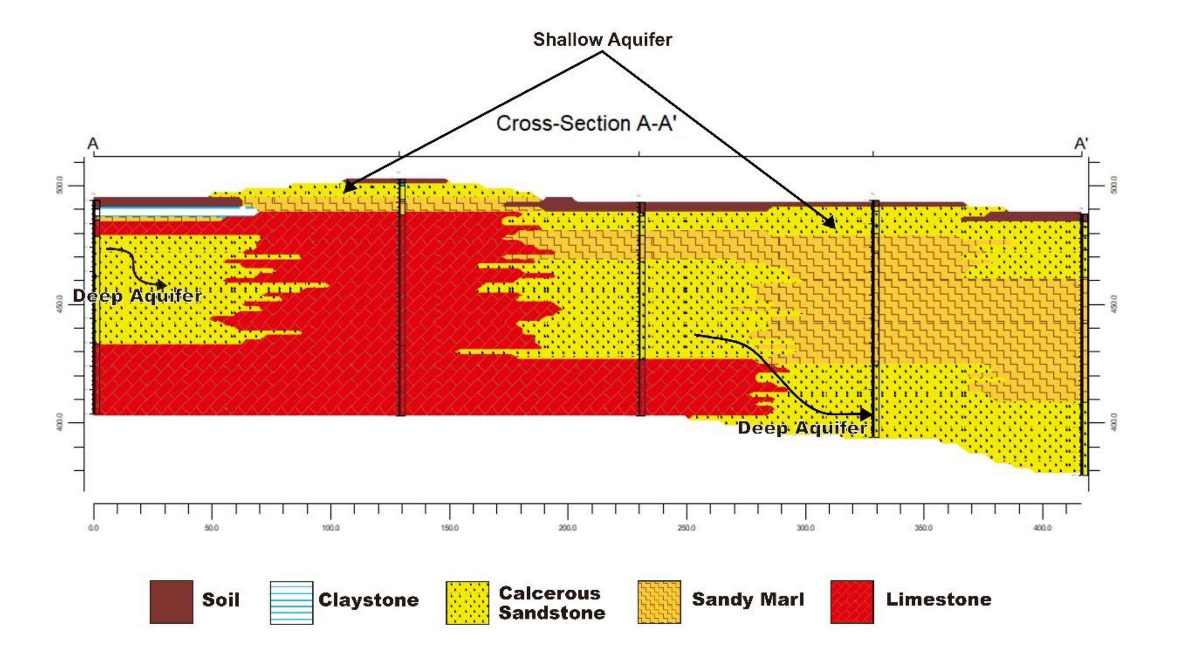

Figure 7. Interpolation result of all VES points or section A-A'.

The cross section A-A' shown in Figure 6 are based on T5,T1,T2,T3,T4 points rescpectively and indicated by a thick black vertical line, it is an interpolation of the resistivity values between the points T5, T1, T2, T3, and T4 from the north to the east of Islamic boarding school. Cross section A is at point T5 and cross section A' is at point T4. Resistivity interpolation results from 4 Ωm to 8074 Ωm show a fairly uniform pattern. The cross section A-A' shows the distribution pattern of the limestone at T5 and for T1 and T2 distributed both at the surface and far below the surface, T1 has the highest number of limestone stratums starting from a depth of 15 meters up to 100 meters, this stratum forms a dividing point between the zone around T5 with T2, T3 and T4.

The calcarous sandstone is distributed throughout the site, but at T1 the distribution is only near the surface. At T2, T3, and T4 it is distributed at depths of 4 to 28 meters. At T5 it is distributed at depths of 15 to 60 meters. Sandy marl can be seen at all points, at points T5, T1 and T2 are distributed near the surface while for points T3 and T4 the sandy marl stratum is distributed at a considerable depth with a range of 10 meters to 70 meters. The deep aquifer zone is a zone whose upper and lower stratums consist of impermeable rock stratums with a resistivity value of 1 - 100 Ωm (Roth, 2024), it is located at depths of 62 meters to 110 meters in the calcarous sandstone stratum at T3 and T4, T2 with a depth ranging from 23 meters to 65 meters and T5 with a depth ranging from 15 meters to 60 meters. Shallow or unconfined aquifers are located at points T1, T2, T3, and T4 ranging in depth from 4 meters to 28 meters, point T4 is the location of eastern Islamic boarding school well with the 4 meters depth.

The availability of groundwater is influenced by the geological conditions of the research area, namely rock lithology refers to the type and physical properties of the rocks, rock structure explains the characteristics of the rocks that will affect the quantity of aquifers, while rock porosity explains the ability of rocks to store and release water (Juwono, 2024).

The hydrogeological condition based on the Kediri sheet map shows that the research site is in the aquifer zone with flow through cavity or conduit, fractures and channels. The aquifer condition is classified as high to medium productive aquifer. Groundwater flow is confined to the cavity zone, dissolution channels and springs. Geologically, the site is located in the Nampol Formation, which is composed of calcarous sandstones, black claystone, sandy marl and limestone.

Geochemical Analysis

Well water samples that have been geochemically analysed show several parameters of clean water suitable for consumption in accordance with the rules of the Indonesian Minister of Health Regulation No. 2 of 2023, the results of which can be seen in the table below:

DOI : http://dx.doi.org/10.12962/j25023659.v11i1.3085

Artikel Masuk : 17-03-2024 Artikel Diulas 19-03-2024 Artikel Diterima : 29-04-2025

Table 1. Geochemical analysis results.

No	Parameter	Unit	Result	Legal Standard according to Indonesian Health Minister No.2 of 2023
	A. PHYSIC			
1	Odor	-	Odorless	Odorless
2	Amount of Total Dissolved Solids	mg/L	64	< 300
3	Colour	TCU	15	10
4	Turbidity	NTU	2.86	< 3
5	Temperature	°C	27	Air temperature ±3°C
	B. CHEMICAL			
1	Iron	mg/L	0.08	0.2
2	Nitrate (as NO_3)	mg/L	0.97	20
3	Nitrite (as NO_2)	mg/L	0.01	3
4	Manganase	mg/L	0.01	0.1
5	pH	-	6.9	6.5 – 8.5
	C. CHEMICAL			**Old Standard**
1	Hardness	Mg/L	30	500

Based on the results of the laboratory analysis of the chemical content of the residents' well water at point T4, it can be concluded that the well water is not suitable for consumption. This is because the water colour parameter has a very high value of 15 TCU. TCU is a unit for quantitative measurement of water colour and stands for True Colour Unit. In addition, the well water at this point had a significant level of turbidity, approaching the maximum limit with a value of 2.86 NTU. Turbidity levels affect the colour of the water as turbidity and colour parameters are directly proportional.

The lithology of the T4 point area, extending from a depth of 4 meters to 28 meters, comprises a stratum of calcarous sandstone, which functions as a shallow aquifer zone. Calcarous sandstone is defined as a type of rock that contains lime and exhibits specific levels of hardness. These characteristics can be elucidated through a detailed geochemical analysis.

Summary of preliminary and current research

The correlation of the two data sets yielded insights into the stratification of rock types within the research area at each topographic point. The groupings are separated by lithological boundary lines, as illustrated in Figure 8. The area encompassing Area A and the preceding research site is characterized by a topography of limestone hills, composed of calcarous sandstone, claystone, sandy marl, and limestone. Area A is composed of impermeable limestone, which provides information about the subsurface aquifer passages that are confined by impermeable rock stratums in the limestone hill. Area C is characterized by a confined aquifer zone, which is distinguished by a notably extensive aquifer passage, accompanied by an unconfined aquifer zone that is evident at the surface. Area B is characterized by a topography of valleys and rice fields, demarcating the boundary between Area A and C (Figure 2). The area exhibits a geologic composition of calcarous sandstone, sandy marl, and limestone.

Preliminary and current research data provide information on the potential of aquifers that are relatively close in depth to each other. The presence of shallow aquifer zones are found at depths ranging from 2.5 to 4 meters to 12 to 26 meters. Similarly, the existence of potential deep aquifer zones has been determined at depths between 15 and 33 meters to 70 and 123 meters. The extensive array of meters indicates the presence of substantial subterranean passages or caves beneath the research site's surface. The subsurface area is characterized by a conduit water flow system, a phenomenon that has the capacity to store substantial quantities of water reserves (Fandel, 2022).

CONCLUSION AND SUGGESTION

This research concludes that the deep aquifer potential is fairly evenly distributed at all points except T1. The deep aquifer zone is located in a stratum of calcarous sandstone that exhibits optimal porosity and resistivity values ranging from 1-110 Ωm. The stratum of calcarous sandstone within the deep aquifer zone is

DOI : http://dx.doi.org/10.12962/j25023659.v11i1.3085

Artikel Masuk : 17-03-2024 Artikel Diulas 19-03-2024 Artikel Diterima : 29-04-2025

typically found at a depth of 15-110 meters, it confining rocks are limestone with resistivities of 500 Ωm and higher and sandy marl with resistivities of 110-500 Ωm. Potential of shallow aquifer zones are distributed throughout the research site points and located in the calcarous sandstone stratum near the surface with resistivity values of 1-110 Ωm and at depths of 4-26 meters. At point T4, there is a shallow aquifer ranging from a depth of 3.15 meters to 26 meters, it is eastern well located to the east of the islamic boarding school, which is the main source of water for local residents. The well to the north of the Islamic boarding school is about 10 meters deep, it is located near point T5 and is used by only one household. At point T5, there is a shallow aquifer zone with the depth of 15 meters, the difference is due to the 5 meters elevation difference between points T5 and the northern well of the Islamic boarding school. The strategic position for exploitation (drilling) is at points T3 and T4, which are located at a depth of 69–110 meters. These two points are characterized by a notably extensive aquifer zone, suggesting the potential for substantial underground water reserves.

Water originating from the shallow aquifer zone at point T4 is not suitable for consumption due to its proximity to the surface, which renders it susceptible to contamination by substances resulting from hydrogeochemical processes near the surface. The findings of the geochemical analysis indicate that the water in this zone has a water value of 15 TCU. The value exceeds the standard limit stipulated in Indonesian Minister of Health Regulation No. 2 of 2023.

Based on the geo-electric measurements and modeling that have been carried out, it is expected that additional points should be added in order to reach a wider area of wells for the villagers of Sidodadi.

BIBLIOGRAPHY

A. Sivasakthi, A.S., TJPRC, (2018). A Study on Oil Field Sandstone through Porosity and Permeability Parameters. Int. J. Mech. Prod. Eng. Res. Dev. 8, 61–66. https://doi.org/10.24247/ijmperdoct20188

Amin, A.K., Ahmed, K.M., Baban, E.N., (2024). Application of seismic refraction tomography for determining ground water potential zone in the Qularaisi area, Sulaimaniyah city, NE Iraq. Contrib. Geophys. Geod. 54, 345–369. https://doi.org/10.31577/congeo.2024.54.4.3

Durrani, T.S., Akhtar, M.M., Kakar, K.U., Khan, M.N., Muhammad, F., Khan, M., Habibullah, H., Khan, C., (2025). Geochemical evolution, geostatistical mapping and machine learning predictive modeling of groundwater fluoride: a case study of western Balochistan, Quetta. Environ. Geochem. Health 47, 32. https://doi.org/10.1007/s10653-024-02335-2

Fandel, C., Miville, F., Ferré, T., Goldscheider, N., Renard, P., (2022). The stochastic simulation of karst conduit network structure using anisotropic fast marching, and its application to a geologically complex alpine karst system. Hydrogeol. J. 30, 927–946. https://doi.org/10.1007/s10040-022-02464-x

Fiorese, G.D., Balacco, G., Bruno, G., Nikolaidis, N., (2025). Hydrogeological modelling of a coastal karst aquifer using an integrated SWAT-MODFLOW approach. Environ. Model. Softw. 183, 106249. https://doi.org/10.1016/j.envsoft.2024.106249

Ikhsan, J., Nursetiawan, Hairani, A., Wijaya, D.D., Mohd Arif Zainol, M.R., Ibrahim, M.S.I.B., (2024). Geoelectric application for groundwater source search as an effort to meet water needs in kaliapak hamlet Kulon Progo. BIO Web Conf. 137, 03006. https://doi.org/10.1051/bioconf/202413703006

Iqbal Hidayat, F., Yogi, A., Sabra, E., Ramli, T., Firdaus, M., Mersil Saleh, H., Ghia Arviallyn, G., Setyo Wibowo, A., (2022). Source Rock Characterization of the Eocene-Miocene, Central Deep, North East Java Basin. J. Geol. Dan Sumberd. Miner. 23, 163–176. https://doi.org/10.33332/jgsm.geologi.v23i3.697

J.O, A., M.D, D., D, A., E.E, S., (2019). Comparative Assessment of half Schlumberger Configuration as an Alternative Method to the Conventional Schlumberger Configuration at Trade Centre, Mani-Nissi Village, Kaduna, Nigeria. Int. J. Appl. Phys. 6, 51–56. https://doi.org/10.14445/23500301/IJAP-V6I3P109

Juwono, A.M., Susilo, A., Hasan, M.F.R., Yunika, N.A., Annabil, A.A., Mujtaba, M.W.H., Haniyyah, S., (2024). Investigation of Groundwater Sources In Banyol Hamlet Malang Regency Using The Geoelectrical Resistivity Method To Overcome Drought Strategy. Indones. Phys. Rev. 7, 240–248. https://doi.org/10.29303/ipr.v7i2.320

Kahraman, S., Öğretici, E., (2024). Prediction of physico-mechanical rock characteristics from electrical resistivity tests. J. South. Afr. Inst. Min. Metall. 124, 361–368. https://doi.org/10.17159/2411-9717/3191/2024

DOI : http://dx.doi.org/10.12962/j25023659.v11i1.3085

Artikel Masuk : 17-03-2024 Artikel Diulas 19-03-2024 Artikel Diterima : 29-04-2025

Kalaivanan, K., Gurugnanam, B., Suresh, M., Karung Phaisonreng Kom, Kumaravel, S., (2019). Geoelectrical resistivity investigation for hydrogeology conditions and groundwater potential zone mapping of Kodavanar sub-basin, southern India. Sustain. Water Resour. Manag. 5, 1281–1301. https://doi.org/10.1007/s40899-019-00305-6

Lagade, V.M., Taware, S.S., Lagade, S.V., (2024). Water quality assessment of Dudhganga river using water quality index and anthropogenic activities. J. Water Clim. Change 15, 4237–4253. https://doi.org/10.2166/wcc.2024.716

Latupapua, A.I., Tahapary, F.D., Soplanit, R., (2023). The Estimation of Resistivity of Poka Alluvial Plain Material by Geoelectric Method with Wenner-Schlumberger Configuration. Int. J. Multidiscip. Appl. Bus. Educ. Res. 4, 3116–3122. https://doi.org/10.11594/ijmaber.04.09.05

Mostacedo-Marasovic, S.-J., Mott, B.C., White, H., Forbes, C.T., (2022). Towards water literacy: an interdisciplinary analysis of standards for teaching and learning about humans and Water. Discip. Interdiscip. Sci. Educ. Res. 4, 25. https://doi.org/10.1186/s43031-022-00065-y

Prabhu, K., (2018). Geoelectrical Resistivity Survey for Groundwater Potential – A Case Study of Nandi River Basin, Tamil Nasu, India. Appl. Ecol. Environ. Res. 16, 1961–1972. https://doi.org/10.15666/aeer/1602_19611972

Puspita, M.B., Aprilia, F., Sunaryo, S., Putro, T., Anggraeni, D., Latifa, R., (2022). Sosialisasi Potensi Air Bawah Tanah (ABT) sebagai Upaya Pencegahan Kekeringan di Desa Jabung, Kabupaten Malang. J. Abdi Masy. Indones. 2, 1417–1422. https://doi.org/10.54082/jamsi.440

Rahmawati, Z., Niyartama, T.F., Wibowo, N.B., Andi, A., (2024). Identification of Landslide Prone Areas with Schlumberger Configuration Geoelectric Method, Kalongan Village, East Ungaran in 2023. Adv. Sustain. Sci. Eng. Technol. 6, 0240208. https://doi.org/10.26877/asset.v6i2.18163

Roth, N., Zhu, T., Gao, Y., (2024). Characterizing Liquid Water in Deep Martian Aquifers: A Seismo-Electric Approach. J. Geophys. Res. Planets 129, e2024JE008292. https://doi.org/10.1029/2024JE008292

Sahrina, A., Fitrianti, D., Suprianto, A., Labib, M.A., (2020). Potential and Challenges of Karst Water Resources in Sumbermanjing Wetan District of Malang Regency. IOP Conf. Ser. Earth Environ. Sci. 412, 012032. https://doi.org/10.1088/1755-1315/412/1/012032

Salsabiila, F., Rahmawati, L.N., Kholidah, H.M., Shidiq, A.S., (2024). Portable and Inexpensive Blue LED based UV-Vis Spectrophotometer with Smartphone Detector as a Chemistry Learning Innovation. Int. J. Pedagogy Teach. Educ. 7, 119. https://doi.org/10.20961/ijpte.v7i2.87950

Wattimanela, J., Haryanto, A.D., Hutabarat, J., Gentana, D., (2021). Karakteristik Geokimia Air Panas Dan Perkiraan Temperatur Reservoar Panas Bumi Daerah Suli 5.

Widodo, W., (2023). DC Resistivity and Electromagnetic Induction Techniques for Soil Characterization in the Agriculture Land (Case Study in Cidadap, West Bandung, West Java). J. Environ. Eng. Geophys. 28, 197–208. https://doi.org/10.32389/JEEG23-004

Zerga, B., (2024). Karst topography: Formation, processes, characteristics, landforms, degradation and restoration: A systematic review. Watershed Ecol. Environ. 6, 252–269. https://doi.org/10.1016/j.wsee.2024.10.003

DOI : http://dx.doi.org/10.12962/j25023659.v11i1.3085

Artikel Masuk : 17-03-2024 Artikel Diulas 19-03-2024 Artikel Diterima : 29-04-2025