# Geoelectric application for groundwater source search as an effort to meet water needs in kaliapak hamlet Kulon Progo

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**Abstract.** The government through the Public Works Office launched Pamsimas (Community-Based Drinking Water and Sanitation Supply) program to realize 100% safe access to drinking water. However, this program is still unable to serve the community's overall water needs. To prevent clean water crises, the community independently formed clean water management groups, one of which is the Tirto Lestari Clean Water Group located in Kaliapak Hamlet, Banjarsari, Samigaluh, Kulon Progo. The main problem that occurs in this group is the lack of water discharge so that the water supply system is not able to serve the needs of users optimally. The solution to this problem is to find potential sources of new groundwater and the construction of intake infrastructure. This research is focused on finding potential new water sources with geoelectric methods. Based on the results of this study, it shows that there is groundwater potential that can be used to meet clean water needs. The conclusion is that there is groundwater potential that can be used as a new source for the Pamsimas of Tirto Lestari group.

## 1 Introduction

In 2017, 785 million people, or 11% of the world's population, still lacked access to basic water services, which include water derived from cleaner sources and collection times less than thirty minutes [1-3]. Most of them live in rural areas without access to basic utilities, demonstrating the disparity in water services between rural and urban areas. To make matters worse, water shortages are also thought to be spreading quickly over the planet[4]. Indonesia is still having trouble making basic water services more accessible. A 2017 Joint Monitoring Programme (JMP) study from WHO and UNICEF states that 90% of Indonesian households have access to at least basic water services. In terms of the disparity between urban and rural

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areas, 95% of urban households and 82% of rural households, respectively, have access to basic water services [3]. Over the years 2000–2017, there was a notable rise in rural areas (16%) compared to urban areas (5% increase) in the percentage of people with access to basic water services. To increase water coverage and sanitation services, particularly in suburban and rural regions, the Government of Indonesia and the World Bank launched the "Community-Based Water Supply and Sanitation Program (PAMSIMAS)" in 2007[5].

For areas that cannot be reached by PDAMs, groundwater is a mainstay in meeting daily water needs. The availability of groundwater in each region varies greatly depending on the available groundwater basins. Samigaluh District, Kulon Progo Regency is included in an area with reserves that are very vulnerable to utilization [6]. The annual groundwater discharge is around 1.5 million $m^3$/year, which is the smallest compared to other areas in Kulon Progo as shown in Table 1. This causes residents in Samigaluh District to find it difficult to obtain water.

**Table 1.** Calculation of Groundwater Reserves (CAT) Menoreh [6]

| **No** | **Sub District** | **Major Aquifers** | | | |
|---|---|---|---|---|---|
| | | **Cross-sectional Length (m)** | **Transmissivity ($cm^3$/day)** | **Hydraulics Ramps (i)** | **Discharge ($m^3$/year)** |
| 1 | Samigaluh | 8.891 | 13 | 0.037 | 1.560.948 |
| 2 | Kalibawang | 12.500 | 9 | 0.037 | 1.519.313 |
| 3 | Girimulyo | 9.700 | 14 | 0.074 | 3.667.958 |
| 4 | Nanggulan | 10.583 | 181 | 0.014 | 9.788.323 |
| 5 | Pengasih | 5.554 | 171 | 0.042 | 11.846.108 |
| 6 | Kokap | 13.122 | 9 | 0.040 | 1.742.333 |
| 7 | Sentolo | 7.024 | 500 | 0.004 | 4.488.375 |
| 8 | Temon | 2.556 | 260 | 0.012 | 2.962.815 |
| 9 | Wates | 590 | 492 | 0.047 | 4.931.286 |
| 10 | Panjatan | 2.800 | 495 | 0.011 | 5.608.537 |
| 11 | Lendah | 8.021 | 500 | 0.006 | 8.773.344 |
| Total | | | | | 56.889.340 |

To realize 100% safe access to drinking water, the Government through the Public Works Office launched the Pamsimas program (Community-Based Drinking Water and Sanitation Supply) [7-12]. The implementation of the Pamsimas Program in 2008-2012 has succeeded in increasing the number of rural and suburban poor who can access drinking water services through community empowerment efforts. This community empowerment is able to increase community participation as a strategic partner of the Regional Government and Government in providing and improving the quality of drinking water services. Until the end of 2018 this program has been implemented in 16,785 villages throughout Indonesia and has served 1260,135 house connections with water meters and 612,257 without water meters [13]. However, the Village Water Supply System (SPAM (Drinking Water Supply System) that was built turned out to be only 84.4% functioning properly, the rest were not functioning optimally. In addition, this program is still unable to serve the community's overall water needs. There are still some areas that are not covered by the Pamsimas SPAM network. This makes the area prone to clean water crises in the dry season [14]. Areas included in the high level of vulnerability are the northern part of Kulon Progo, including Samigaluh District [15].

# 2 Methodology

## 2.1 Geoelectric Method

One of the geophysical techniques is the geoelectric approach, whose basic idea is to investigate how electricity moves through the earth and how to find it on its surface. This covers the measurement of potentials, currents, and electromagnetic fields that arise from artificial current injection into the earth as well as naturally occurring ones. These geophysical techniques include resistivity (type resistance), magneto telluric, self-potential, electromagnetic, telluric current, and IP (Induced Polarization). The resistivity method, often known as the kind of resistance, is the most widely utilized of the numerous geophysical techniques employed in geoelectric.

To create a potential difference, electric current is injected into the earth using two current electrodes in the resistivity method. Additionally, two potential electrodes are used to measure the potential difference that arises. The fluctuation in the resistance value of the layer type below the sounding point can be ascertained using the findings of the measurements of the current and potential difference for each electrode distance. This approach works better and is appropriate for surface-level research. As a result, this approach is rarely employed for oil exploration and is more frequently used in engineering geology applications including determining bedrock basement depth, locating water aquifers, and geothermal research.

For resistivity measurement, measurements can be made in the laboratory or measurements in the field. For measurements in the laboratory, the resistivity value can be determined using **Ohm's Law**, namely $V = I R$ and then $\varrho = A. \Delta V / I. L$, which applies when electric current I passes through a cylindrical material with a cross-sectional area A and length L and causes a potential difference $\Delta V$ between the ends. For measurements in the field, it can be done by measuring indirectly by injecting electric current into the ground through 2 points (electrodes) on the surface and measuring the potential difference that arises between 2 other points on the surface as Figure 1.

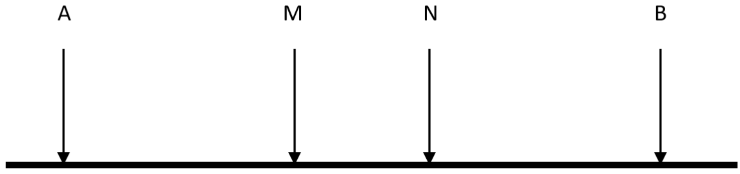


**Fig. 1.** Electrode arrays for resistivity measurement in the field

Information:

A and B : Current electrodes
M and N : Electrode potential

Based on the location (configuration) of potential electrodes and current electrodes, several types of resistance resistivity methods are known, including:

1. Schlumberger configuration
2. Wenner configuration
3. Dipole-dipole configuration
4. Wenner-Schlumberger configuration

Based on the purpose of investigation, geoelectric methods of type resistance can be divided into two major groups, namely:

1. The resistivity *mapping* method is a resistivity method that aims to study the resistivity variations of the subsurface layer laterally (horizontally). The method is measurement with a fixed current and voltage / potential electrode distance, while the measuring point is moved / shifted horizontally. Commonly used electrode configurations are Wenner, Dipole-dipole and Wenner-Schlumberger configurations. For current developments, mapping methods can be done to map variations in the resistivity of rock layers vertically which is often called resistivity *Imaging/pseudo section*.
2. Sounding resistivity method *is* a resistivity method that aims to study rock variations vertically or depth. This method is done by changing the distance of the current and voltage electrodes with a fixed measuring point. A frequently used configuration is the Schlumberger configuration. Where the distance of the expanse of the current electrode is proportional to the depth of the detected rock layer.

### 2.2 Equipment

The equipment used in this geoelectric survey is a set of OYO Resistivity meter McOHM EL-2119 consisting of:

1. 1 from unit Resistocracymeter OYO
2. 4 cable rollers @ 100 meters
3. 2-meter rollers 50 meters
4. 4 electrode
5. GPS
6. Power supply
7. Support equipment (hammer, stationery, HT etc)

### 2.3 Electrode Configuration

Based on the survey objectives and track conditions, the geoelectric configuration used is the Wenner-Schlumberger configuration with an electrode interval of 4 meters, a track length of 60 meters and a multiple value of n from 1 to 7. With the length of the track and the value of multiples, it is expected to be able to know the subsurface structure to a depth below 10 meters.

### 2.4 Survey Location

The field yard area of Banjarsari village, Samigaluh District, Kulon Progo Regency, Yogyakarta Special Province is where the geoelectric survey is being conducted. Here is a table of survey locations (Table 2).

**Table 2.** Coordinates of the survey location (Midpoint of the Track)

| No | Location Name | S | E | Height (m) |
|---|---|---|---|---|
| 1 | Trajectory 1 | 7° 41’ 20.23” | 110° 9’ 10.62” | 676.9 |


**Fig. 2.** Geoelectric survey track map in Samigaluh

## 2.5 Data Processing

Geoelectric Resistivity data processing using *RES2DINV software* version 3.54. This *software* works based on the principle or method of Non-Linear Least-Squares Optimisation which is used for the inversion process to calculate resistivity values. Here is an initial look at the RES2DINV as shown in Figure 3.

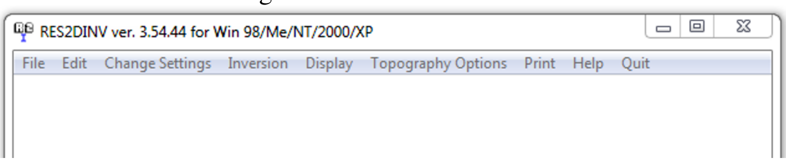


**Fig. 3.** Initial view of RES2DINV Software

And here is an example of the results of modelling RES2DINV as shown in Figure 4.

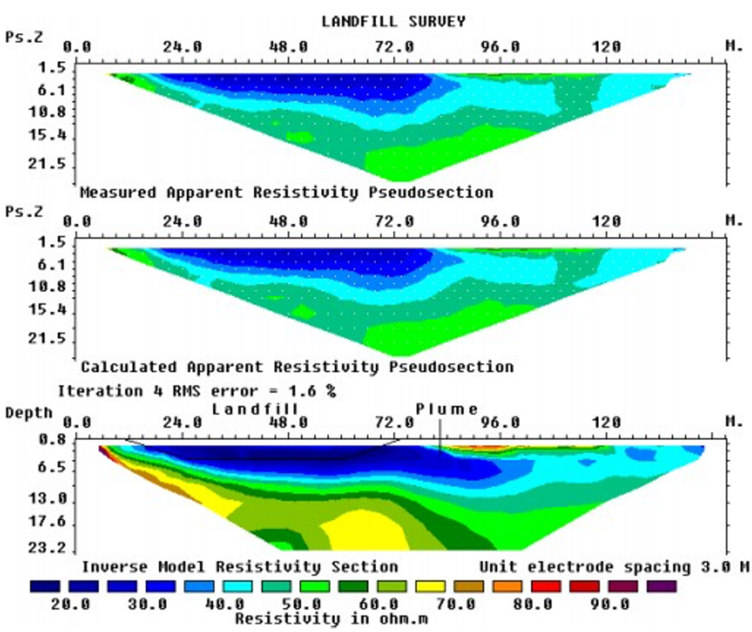


**Fig. 4.** (a) Resistivity gauge, (b) Apparent resistivity and (c) Modelinversion

Resistivity values for some rock types is shown in Figure 5.

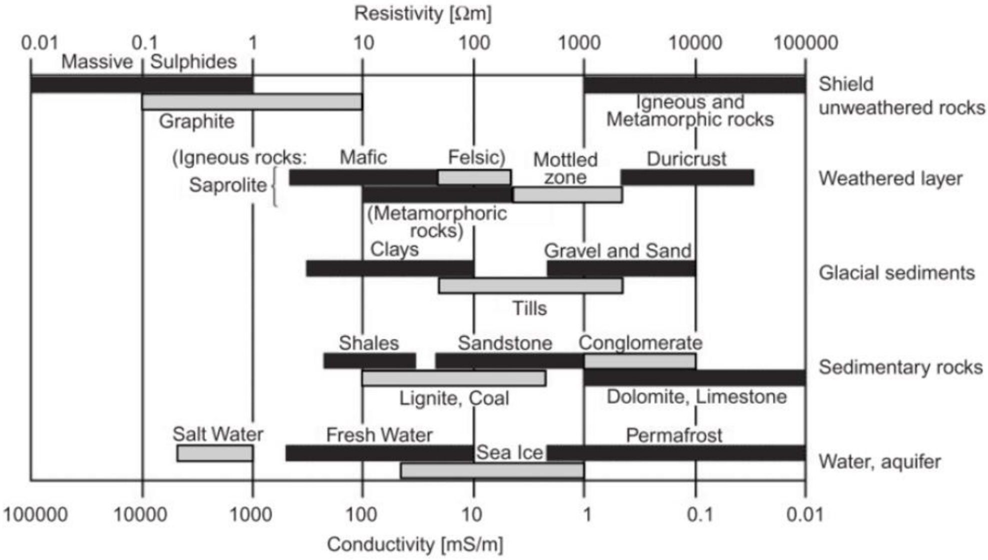


**Fig. 5.** Rock resistivity value [16]

## 3 Results and Discussion

Interpretation of geoelectric data cross-sectional modelling data is carried out based on the resistivity values obtained and geological information around the study site. The following are the results of the discussion for geoelectric measuring trajectories, as shown in Figure 6 and Figure 7.

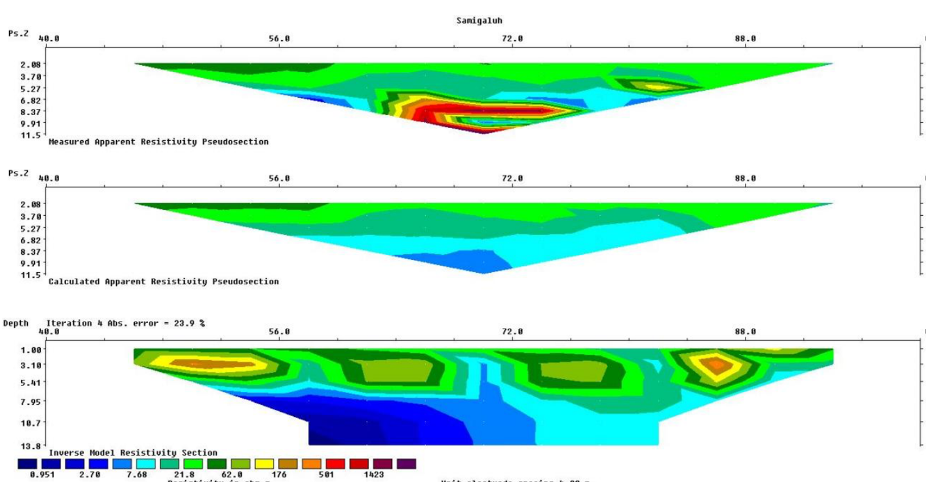


**Fig. 6.** Results of data processing path 1 (before topography is entered)

https://doi.org/10.1051/bioconf/202413703006

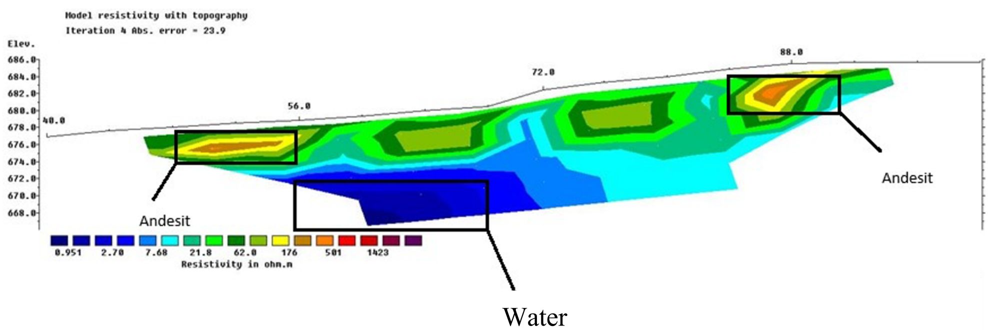


**Fig. 7.** Results of data processing track 1 (after entering topography)

This time, the Wenner Schlumberger configuration was employed for the geoelectric measurements, with a stretch length of 60 meters and an electrode interval of 4 meters. These measurements yielded resistivity values ranging from 0.9 Ωm to 1500 Ωm and a depth of up to 12.5 meters; the modeling error value was 23.9%. The starting point for measurements is the 40th meter, and the finishing point is the 100th meter. On an inclined plane ranging in height from 676.5 meters to 686 meters, measurements were taken. The geology of the measuring site is taken into consideration when interpreting the processing results.

A geological deposit made up of andesite breccia, tuff, lapilli tuff, and andesite lava is referred to as the measuring area in geology. A layer of clay with resistivity ranging from 21 to 30 Ωm is present on the upper surface, while a layer of breccia with resistivity between 30 and 100 Ωm is present underneath.

There is a layer of light blue-colored sand clay with a resistivity of 10–20 Ωm beneath the breccia's surface. There is groundwater with a resistivity range of 0.9 to 3.5 Ωm in a section of 56 to 72 meters, at a depth of 4.5 meters below the surface. An andesite layer with a resistivity value of 100–200 Ωm can be found at 50 and 88 meters, respectively, indicating a hard rock type.

## 4 Conclusions

Based on geoelectric surveys that have been carried out at the site, it is obtained that Subsurface structure lithology in the survey area is dominated by breccia, andesite, and sandloam. Groundwater may be present at positions of 50 meters to 72 meters with a depth of 4.5 meters to 12 meters. The study's findings indicate that there may be groundwater available to meet the demand for clean water. The upshot is that groundwater has the potential to be a new source of energy

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