Identification of aquifer potential in Karanganyar City by using vertical electrical sounding method

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Abstract. The identification of aquifer was done by using Vertical Electrical Sounding (VES) method. This research aims to identify potential and depth of the aquifers. The locations of surveys are at ten points, namely TS1 (Alastuwo), TS2 (Wonorejo), TS3 (Kaling), TS4 (Kaling), TS5 (Buran), TS6 (Wonolopo), TS7 (Buran), TS8 (Ngijo), TS9 (Jati), and TS10 (Suruhkalang) where all located in Karanganyar regency. The survey path is about 500-600 meters length which can penetrate current to 100 – 200 meters in depth. The measurement was done by using OYO Mc OHM-EL Model 2119C. Geoelectrical data analysis was processed using Progress version 3.0 Software. The interpretation result shows that the locations of research area are included in Lawu-volcano rock formation which is breccias, lava, and tuff as the constituents. We found that unconfined aquifer in all of locations with different depth and confined aquifer just 7 locations start from 25.04 meters.

1. Introduction
Water is a basic need as a source of human livelihood of daily activities. Therefore, the water used shall be in accordance with the feasibility standard. The amount of water needed to drink per person on average is 2.5 liters/day. Population growth is incomparable with availability of water and clean water is difficult to find. To overcome these problems, need to find water sources to meet the needs in the dry season. One of the water sources is groundwater. Groundwater is water that is below the earth's surface. To get groundwater can be drilled. However, prior to drilling, submarine identification is required in the aquifer layer. Aquifers are the arrangement of rocks that can store and drain water. Aquifers can be searched by knowing the resistance value of each layer of rock. Groundwater can be found by geophysical method such as Vertical Electrical Sounding.

Vertical Electrical Sounding is a geophysical method that studies an electrical trait within the earth. The use of this method has already been carried out by previous researchers, such as the estimation of groundwater potential [1], VES survey and magnetic for fault characteristics in Ethiopia [2], Understanding of the structural controls on groundwater flow in the Mojave Desert, California [3], Improved measurements of the apparent resistivity for small depths in Vertical Electrical Soundings [4] and many another research [5-10]. This VES is good for knowing the subsurface condition is aware of the resistance value of each layer [11]. This method is based on the concept that the earth has only one layer. But in reality, the earth consists of several layers.
2. Methods

Research has been conducted in September 2016 and April 2017. There are 10 points of data collection with track length 500 - 600 meters. The research sites are located in three sub-districts in Karanganyar city, Kebakkramat (Alastuwo and Wonorejo Villages), Jaten (Jati and Suruhkalang Villages) and Tasikmadu (Kaling Village, Buran, Ngijo and Wonolopo) that shows at Figure 1.

![Figure 1. Research locations](image1.png)

Data acquisition used Vertical Electrical Sounding method with Schlumberger configuration. Schlumberger configuration is suitable for deep penetration in water search (Figure 2).

![Figure 2. Schlumberger configuration](image2.png)

In the Schlumberger configuration the displacement of the electrode at the current electrode and the potential electrode will move when the resulting potential value is small. Equipment used in this research is OYO 2119C McOMH-EL. The data obtained in the field is a false resistivity value, because at the time of data retrieval of the earth is considered only one layer. But the reality of the earth consists of several layers. Data processing is done by using Progress software version 3 for 1 dimension.
3. Result and discussion

The data processing method uses curve matching method. This method compares or matches between field measurement data and master curve data in order to obtain an errata between field data and model data as small as possible. By using this method, it will be known resistivity values and the depth of each layered rocks. The following is shown the result of processing data which have been plotted in double log graph (Figure 3). Y axis is resistivity and X axis is distance of current electrodes [12].

![Figure 3. Inversion result in TS1 site](image-url)
| No | Depth (m) | Thickness (m) | Resistivity (Ωm) | Lithology | Note         |
|----|-----------|---------------|------------------|-----------|--------------|
| 1  | 0 – 2.19  | 2.19          | 15.80            | Top Soil  | Top Soil     |
| 2  | 2.19 – 8.22 | 6.03         | 12.08            | Top Soil  | Top Soil     |
| 3  | 8.22 – 10.91 | 2.69        | 3.18             | Clay      | Confining Bed|
| 4  | 10.95 – 30.12 | 19.21       | 49.43            | Sand      | Unconfined Aquifer |
| 5  | 30.12 – 56.98 | 26.86       | 4.85             | Clay Sand | Confining Bed |
| 6  | 56.98 – 85.86 | 28.88       | 7.85             | Clay Sand | Confining Bed |
| 7  | 85.86     | 23.21         |                  | Sand      | Confined Aquifer |
| 1  | 0 – 1.05  | 1.05          | 10.74            | Top Soil  | Top Soil     |
| 2  | 1.05 – 3.23 | 2.18        | 5.23             | Clay Sand | Confining Bed |
| 3  | 3.23 – 11.23 | 8.00        | 5.98             | Clay Sand | Confining Bed |
| 4  | 11.23 – 30.62 | 19.39       | 19.13            | Sand      | Unconfined Aquifer |
| 5  | 30.62 – 43.84 | 13.22       | 32.14            | Sand      | Unconfined Aquifer |
| 6  | 43.84 – 68.07 | 24.23       | 15.25            | Clay Sand | Confining Bed |
| 7  | 68.07 – 114.62 | 46.55      | 3.34             | Clay      | Confining Bed |
| 8  | 114.62    | 0.50          |                  | Clay      | Confining Bed |
| 1  | 0 – 0.49  | 0.49          | 3.57             | Top Soil  | Top Soil     |
| 2  | 0.49 – 9.50 | 9.01        | 46.43            | Sand      | Unconfined Aquifer |
| 3  | 9.50 – 52.86 | 43.36       | 16.73            | Sand      | Unconfined Aquifer |
| 4  | 52.86 – 102.19 | 49.33      | 18.75            | Sand      | Unconfined Aquifer |
| 5  | 102.19 – 154.79 | 52.60      | 9.56             | Clay Sand | Confining Bed |
| 6  | 154.79 – 203.13 | 48.34      | 28.20            | Sand      | Confined Aquifer |
| 7  | 203.13    | 8.72          |                  | Clay Sand | Confining Bed |
| 1  | 0 – 1.16  | 1.16          | 49.81            | Top Soil  | Top Soil     |
| 2  | 1.16 – 6.14 | 4.98        | 28.41            | Sand      | Unconfined Aquifer |
| 3  | 6.14 – 15.68 | 9.54        | 37.75            | Sand      | Unconfined Aquifer |
| 4  | 15.68 – 25.63 | 9.95        | 31.81            | Sand      | Unconfined Aquifer |
| 5  | 25.63 – 78.85 | 53.22       | 71.28            | Breccia   | Unconfined Aquifer |
| 6  | 78.85 – 107.78 | 28.93      | 28.96            | Sand      | Unconfined Aquifer |
| 7  | 107.78    | 17.25         |                  | Sand      | Unconfined Aquifer |
| 1  | 0 – 1.24  | 1.24          | 22.45            | Top Soil  | Top Soil     |
| 2  | 0.98 – 3.38 | 2.4         | 8.43             | Clay Sand | Confining Bed |
| 3  | 3.38 – 10.93 | 7.55        | 22.61            | Sand      | Unconfined Aquifer |
| 4  | 10.93 – 27.74 | 16.81       | 8.94             | Clay Sand | Confining Bed |
| 5  | 27.74 – 82.33 | 54.59       | 27.22            | Sand      | Confined Aquifer |
| 6  | 82.33     | 4.26          |                  | Clay Sand | Confining Bed |
| 1  | 0 – 0.72  | 0.72          | 31.76            | Top Soil  | Top Soil     |
| 2  | 0.72 – 1.15 | 0.43        | 6.87             | Clay Sand | Confining Bed |
| 3  | 1.15 – 3.47 | 2.32        | 37.37            | Sand      | Unconfined Aquifer |
| 4  | 3.47 – 17.92 | 14.45       | 31.84            | Sand      | Unconfined Aquifer |
| 5  | 17.92 – 63.65 | 45.73       | 78.21            | Breccia   | Unconfined Aquifer |
| 6  | 63.65 – 84.07 | 20.42       | 14.78            | Clay Sand | Confining Bed |
| 7  | 84.07     | 7.99          |                  | Clay Sand | Confining Bed |
| 1  | 0 – 1.90  | 1.90          | 21.10            | Top Soil  | Top Soil     |
| 2  | 1.9 – 12.12 | 10.22       | 49.07            | Sand      | Unconfined Aquifer |
| 3  | 12.12 – 25.04 | 12.92       | 14.88            | Clay Sand | Confining Bed |
| 4  | 25.04 – 106.59 | 81.55       | 51.61            | Breccia   | Confined Aquifer |
| 5  | 106.59    | 20.50         |                  | Sand      | Confined Aquifer |
The results of this study can be used as a reference for all locations with different depth and We have some conclusions that the potential of aquifer varies in each location, unconfined aquifer in all of locations with different depth and confined aquifer just 7 locations start from 25.04 meters. The results of this study can be used as a reference for drilling as an effort to meet water needs in the dry season.
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