Vertical Electrical Sounding Survey to Determine Groundwater Potential in Sekaran, Gunungpati, Semarang, Indonesia

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Abstract: A research to figure out the location and extent of groundwater distribution in western Sekaran administrative village using resistivity method in Schlumberger configuration has been carried out. Data were taken using S-Field resistivity meter from 5 locations stretching 160 to 300 m each. Those data were then processed using Microsoft Excel, Progress, and Rockwork. Two types of aquifers were found; unconfined and confined. This finding agrees with groundwater condition in the research area, according to the Central Java Map of Groundwater Basin (CAT). This research area belongs to the Ungaran CAT region with two aquifer types of unconfined and confined. Unconfined aquifer is located 18-28 m deep in the sand and pebble layer, while confined aquifer is located at more than 77 m depth in the tuffaceous sand layer. In order to see the extent of groundwater distribution, the data were then modeled in 3D.

1 INTRODUCTION

One of the most urgent issues the world is dealing with is the ever increasing number of its population that will directly raise the demand for water (Balia & Viezzoli, 2015). According to UNEP (United Nations Environment Program, 2012), more than two billion people will be in great demand for water by 2050 (Yousif & Sracek, 2016). The problem is that surface water cannot meet this demand. Hence, more groundwater supply is required (Expo et al., 2016). Groundwater is very important as it is the main source of water for both industrial and domestic needs (Kazakis et al., 2017) such as water for consumption. Groundwater can be found in the pores of sedimentary rocks, in the crevices of hard rocks, and in karst caves.

This is also in issue Sekaran as there are more people and hence, the need for water (Jayanti et al., 2012). Sekaran administrative village is a water catchment area. However, rapid developments cause more water to directly flow on the surface that less water comes down to the catchment are beneath the ground (Agustina et al., 2012). Based on Figure 1, Sekaran administrative village is in the border between CAT Ungaran and non-CAT areas.

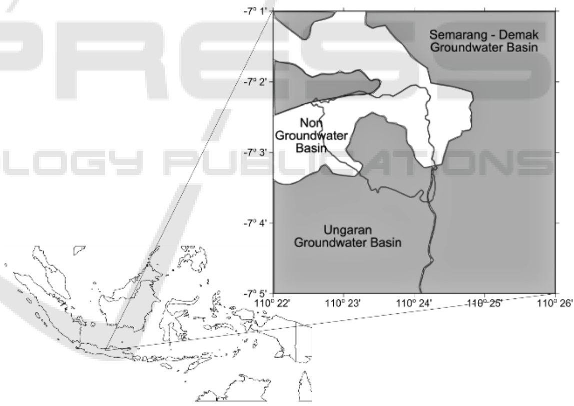

Figure 1: Central Java Groundwater Basin Map (Setiadi, 2003).

Nowadays, the use of geophysical methods to explore groundwater is on the increase. The use of vertical electrical sounding to detect groundwater is very popular due to its simplicity (Abdullahi et al., 2014) and ease of data interpretation (Adelusi et al., 2014). Sounding using geophysical methods involves the measurements of physical characteristics of the surface of the Earth to gather information about its underground structure and composition. (Strelec et al. 2017). Geoelectric method is often used to probe groundwater, location of faults, mineral exploration, and archeological research (Reynold, 1997). Resistivity is one of the geoelectric methods in

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geophysics. This method is very effective for groundwater exploration, especially to estimate the thickness of a water body (Khalil and Santos, 2013).

Geoelectric probing is based on the fact that different materials have different resistivity. Resistivity is one the rock characteristics. That is its ability to be passed by electrical current. In this method, electric current is injected into the Earth via two current electrodes, and then potential difference between the two potential electrodes is measured (Supriyadi et al., 2017).

In Schlumberger configuration, two electrodes are positioned symmetrically along a straight line as depicted in Figure 2., the Current Electrodes (AB) are outside, whereas the Potential Electrodes (MN) are inside. In order to change the depth range of measurement, the current electrodes are moved outside, while the potential electrodes are left where they are (Obiajulu et al., 2016).

Figure 2: Scheme of electrodes in Schlumberger configuration (Loke. 1999).

The Earth is assumed to be homogeneously isotropic. But in reality, it consists of layers with different resistivity values. Therefore, measured resistivity values are not only from one layer, but stem from many different layers. (Syaifuddin et al. 2018). Measured resistivity of medium values can be calculated using Equation (1) as follows:

$$\rho = K\frac{\Delta V}{I} \qquad (1)$$

With the value of geometric factor (K) that can be calculated using Equation (2) as follows:

$$K = \frac{\left(\frac{AB}{2}\right)^2 - \left(\frac{MN}{2}\right)^2}{MN} \qquad (2)$$

2 METHOD

Data were taken manually using type S-Field resistivity meter in the western part of Sekaran administrative village from 21 - 24 April 2017. Research location and the lines are given in Figure 3.

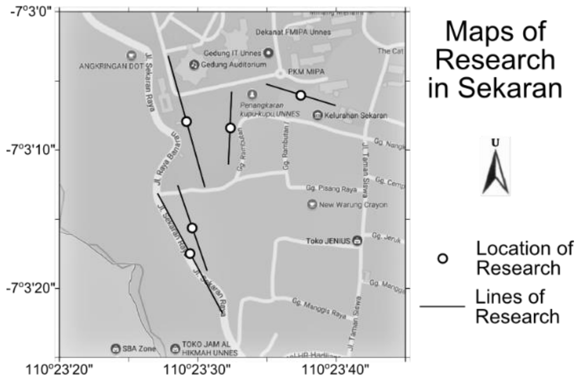

Figure 3: Map of research location and lines.

Measurement of VES geoelectric data made use of the Schlumberger configuration. Measurements were carried out in five different locations spanning 160 - 300 m each. Data were measured manually in line with the Schlumberger configuration. Data taken include self-potential (SP), current (I_{AB}) and potential difference (V_{MN}). Data of measurement positions and line directions were also taken.

Those data were then processed using Microsoft Excel to obtain apparent resistivity. The software Progress was then used to gain 1D image of the data. Differences in resistivity values were then used for identification, along with basic knowledge of resistivity aspects such as geological conditions, as to interpret the subsurface condition of the surface area. Once interpretation was conducted successfully, data were then further processed using Rockwork to get the subsurface 3D image.

3 RESULT AND DISCUSSION

Plotting of research location shows that the research was carried out on top of the Kaligetas formation. This formation consists of volcanic breccia, lava flow, tuff rock, tuffaceous sandstone, and clay. Breccia and lava flow with intermittent lava and fine to coarse tuff rocks. Underneath this formation is clay and tuffaceous sandstone. There are also weathered volcanic rocks that often come in massive bulks (Thanden et al., 1996).

Field data processing and matching with the regional geological condition of Sekaran administrative village show that the subsurface condition of Sekaran is as can be seen in Table 1 and Figure 4. Two types of aquifers were detected; unconfined and confined. The unconfined aquifer is located between 17.75 m to 41.41 m deep with layer thickness of between 6.26 m to 19.48 m. Meanwhile, the confined aquifer is at a depth of more than 76.6 m. This particular layer is categorized as confined as on top of it is a layer of clay. Those results reveal that VES geoelectric method is very good for the detection of groundwater potential and its thickness.

Table 1: Depths, Resistivity Values, and Type of Rock Layers.

No.	Depth (meter)	Resistivity (Ohm m)	Type
1	0.00	16.71	Top Soil
	10.02	59.31	Sand and Pebble
	21.93	3.02	Sand and Water
	41.41	115.65	Breccia
2	0.00	20.78	Top Soil
	11.88	63.01	Sand and Pebble
	17.75	4.24	Sand and Water
	24.54	146.36	Breccia
3	0.00	79.95	Backfill Soil
	0.68	47.19	Top Soil
	19.88	5.08	Sand and Water
	28.46	163.08	Breccia
	74.03	10.24	Clay
4	0.00	36.05	Backfill Soil
	3.94	30.20	Top Soil
	28.38	7.86	Sand and Water
	37.76	196.14	Breccia
	73.60	10.01	Clay
	78.60	3.02	Sand and Water
5	0.00	77.81	Backfill Soil
	1.04	41.03	Top Soil
	19.02	8.38	Sand and Water
	25.28	115.14	Breccia
	66.53	10.11	Clay
	76.60	2.88	Sand and Water

Based on the geological map, results of this research are in line with the geological condition of Sekaran area. They are well-proven as there are layers of breccia and lava flow, with clay and tuffaceous sand underneath them. Furthermore, the finding of two aquifers that matches the CAT map of Sekaran area is also in support of them. There are two types of aquifers were found; unconfined and confined.

Other than those, data interpretation revealed two types of sand layers; dry sand and pebble, and wet sand and pebble with water content. Even though the two layers are of the same rock type, they have starkly contrasting resistivity values. Resistivity value for the dry sand and pebble layer is up to 60 - 65 ohm.m, whereas that of the wet sand and pebble reaches 3 - 8 ohm.m. This difference in resistivity value is due to the electrolytic properties of conductive rocks. Higher resistivity values of sand and pebble and lower resistivity values of water cause the current to flow with the help of fluid (water) ions in the crevices of sand and pebble (Fallah-Safari et al., 2013).

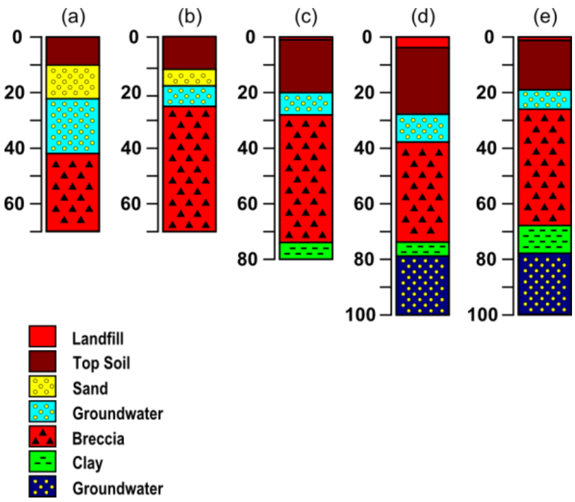

Figure 4: The 1D image of Sekaran subsurface condition consisting of depths and rock types.

In order to help interpret the extent of groundwater distribution, 3 modeling was conducted, with the help of Rockworks, as can be seen in Figure 5.

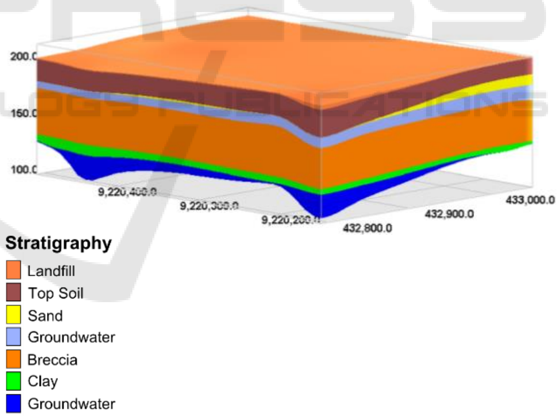

Figure 5: Map of research location and lines.

Based on Figure 5 in its western part reveals two aquifers of unconfined and confined types. The surface of groundwater, which is a unconfined aquifer, is seen to be of the same depth from the ground surface. This unconfined aquifer consists of sand.

Meanwhile, the confined aquifer below is also of equal depth from the ground surface and extents evenly. This confined aquifer lies underneath a layer of breccia and lava flow, as well as clay. It consists of tuffaceous sand at 77 m depth.

However, seen from the eastern side, there is only one aquifer found, the unconfined aquifer. The confined aquifer cannot be detected from this side as it is not easy to get maximum extent of the research line. The eastern part of Sekaran area is filled with housing complexes that does not allow long range extension of geoelectric wires.

This side also witnesses an unfilled sandy unconfined aquifer, or at least only passed by water. This is perhaps due to extensive use of groundwater by the people living nearby. The numerous living quarters and buildings, and also roads also prevent water catchment.

It can be seen in Figure 5 that there are two types of groundwater aquifer in Sekaran administrative village. Both aquifers extends evenly to all areas in Sekaran administrative village with different depths. The depth of unconfined aquifer is between 17.75 m to 28.46 m, while the depth of confined aquifer is at more than 76.60 m.

4 CONCLUSIONS

Results show that there are two types of groundwater aquifer in Sekaran administrative village. Both aquifers extends evenly at different depths. The depth of the unconfined aquifer is between 18 m to 28 m, whereas the depth of the confined aquifer is at more than 77 m.

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