Groundwater potential prediction by using geoelectricity method a case study in Simpang Lima and around it

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Abstract. Water is an important natural resource, which is available both on surface as well as in recharge zone of weathered layer and in various other suitable water reservoir formations/structures below the surface. The study was conducted in Semarang City, Indonesian. Simpang Lima area were chosen since they have geology record of thick alluvium. The condition of Simpang Lima and around it which currently has developed into the main business area in Semarang City. This is marked by the presence like hotels, super market, that is more than one. This condition certainly requires a supply of water for various purposes that support economic efforts in the region. During this time the water needs are met by drilling wells and used as much as possible without taking into account the impact of water utilization. This study aims to determine the zones that have the potential existence of groundwater. The method used is Geoelectric method with Shlumberger configuration in 7 distributed spatial point. The results showed that there is a potential groundwater in eastern Pekunden, Erlanga, behind The Hotel Horizon, and Simpang Lima. Groundwater is found successively at an average depth of 15 meters under earth’s surface.

1. Introduction
Water is a unique property of the Earth and very important to every living organism [1]. Water is found in many places in the world including oceans, rivers, lakes, polar ice, rain, and groundwater. In addition to the volumes represented by oceans and polar ice, groundwater is another most significant source. Groundwater makes up only 0.61% of the total distribution of the world water supply and is approximately 50 to 70 times more plentiful than surface water.

The role of geophysical methods in Groundwater is to understand the hidden subsurface hydrogeological conditions adequately and accurately. The basis of any geophysical method is measuring a contrast between physical properties of the target and the environs [2].

The study was conducted in Semarang City, Indonesian. Simpang Lima area were chosen since they have geology record of thick alluvium in Figure 3. The coordinate location in Simpang Lima Semarang is 6,9905 °S and 110,4230 °E.

At this time, condition of groundwater potential and human consumption to supply the water is not balance. This can be seen from groundwater lost absorption data is 5,281,564 m³. An use of groundwater for domestic purposes. Most human generally requires about 2.5 litres of water everyday which justify the average amount of water used domestically each day by every person is around 190 litres. Generally, industries require approximately one third of the public water supply, with the remainder being used in the home. Thus the total per capital day use is around 300 litres per day [3].
In this research, systematic planning and managing for groundwater potential prediction using modern techniques is implemented for the proper utilization, protection and management of this vital resource [4]. A good appreciation of geology is fundamental in any groundwater development program since the geology determines where, how, and what quantity and quality of available groundwater [5].

Geophysical methods provide an efficient tool for characterizing subsurface geology and hydrology. The geophysical method used in this study measured the electrical resistivity using the Horizontal Electrical Mapping, employing the Schlumberger electrode configuration [6].

2. Methods
Geophysical methods provide an efficient tool for characterizing subsurface geology and hydrology [6]. Geological and geophysical surveys were conducted in the study area to identify the groundwater potentials of the area. The geological survey was aimed at identifying and mapping the geomorphological and geological features, mainly landform units and lithologic units exposed in the study area. For geophysical investigation, the electrical resistivity survey is an effective method for groundwater investigation. For geophysical investigation, the electrical resistivity survey is an effective method for groundwater investigation. This method is a geophysical approach based on conductivity/resistivity contrast which is used to determine the conductivity/resistivity distribution of the Earth materials in the subsurface, so that this method is very suitable for identifying lithological units and variations within lithological units as well as for groundwater and aquifer studies [7]. In addition, this geophysical method is also a popular method due to its low cost, simple operation, and efficiency in areas with low contrasting resistivity [8].

The principle of the resistivity method is to inject electrical current into the earth through the current electrodes (a pair of electrodes) and a response is received in the form of a potential difference is measured via two electrodes potential. From the measurement results of current and electric potential difference, can be obtained by variation of electrical resistivity in the layer below the measuring point [9]. The multi-electrode resistivity survey was carried out by using an S Field resistivity meter. This system is connected to 16 stainless steel electrodes, which were laid out on a straight line with a constant spacing via a multi-core cable in Figure 1. The Schlumberger configuration was used in this research in Figure 2. The resistivity survey was conducted with an electrode spacing of 10 m which gives a spread length of about 150 m with the deepest penetration of about 50 m. Seven survey lines were selected for this study by considering the morphology in Figure 2.

![Figure 1. Structure Schlumberger electrode](image-url)
3. Result and Discussion
The geoelectrical survey helps in determining or concluding the conditions of the groundwater occurrence in the study area. To achieve this goal, the method of electrical resistance, which is one of the most important geophysical methods used to search for groundwater reservoirs, was used. The most important characteristics of this method is to determine the geometric dimensions of these groundwater reservoirs in terms of the thicknesses and depths of the water-bearing layers, from the earth’s surface and the lithological contrast in the horizontal and vertical direction and the expected water salinity [10].

Suspected subsurface water can be identified using the geoelectricity measurement. The presence of subsurface water can indicate the potential for subsidence somewhere. This will occur when groundwater is exploited continuously making the basin is empty and can’t sustain higher levels.

At location 1 to location 7 or resitivitas resistivity values ranged from 0.250 - 24.4 \( \Omega \)m. In these circumstances are divided into three categories or tiers. The first level is a low resistivity with a resistivity value 0250-1 \( \Omega \)m were indicated as the aquifer (has a blue indicator range). The second level is moderate resistivity with the resistivity values 1-10 \( \Omega \)m were indicated as a layer of silt. and the third level is a high resistivity with \( \geq 10 \) \( \Omega \)m resistivity value which is indicated as a layer of sand.

3.1 Location 1
In accordance with the reference value of resistivity in if seen in Figure 3 at location 1, the presence of groundwater is at a depth of 15 meters down with an unknown width. This position is in the 70 to 130 meters of the data depth range. The final limit of depth can’t be known because of the limitations of the tools used. However, it can be estimated that the depth of the basin is more than 53 meters below the surface and the length limit is more than 130 meters from the expanse of the data.
3.2 Location 2
In accordance with the reference value of resistivity, when seen in Figure 4 location 2, the presence of groundwater level on site 2 average is at a depth of 15 meters below the surface. At this cross section there are two groundwater basins. The first basin has a water level at a depth of 15 meters. This position is at 20 to 60 meters from the expanse of the data. While the depth of ±15 meters in position 15 - 30 meters below the surface. The second basin lies at meters 65 to 130 from the expanse of the data. This second baseline deadline is unknown. Ground water on the second winds is at a depth of 15 meters below the surface. The depth of the basin is also not known to the end limit. However, it can be estimated that the depth of the second basin is more than 53 meters below the surface and the length limit is more than 130 meters from the expanse of the data.

![Figure 4](image4.png)

Figure 4. The results of geoelectric data processing using software Res2Dinv at location 2

3.3 Location 3
In accordance with the reference value of resistivity, if seen in Figure 5 location 3, the presence of groundwater level is at a depth of 15 meters from the soil surface. The depth of the basin at this location is unknown. When viewed in Figure 16 the position of the basin is in meters to 70 to 130 of the expanse of data and has not known the final limit. However, it can be estimated that the depth of the basin at this location is more than 53 meters below the surface and the length limit is more than 130 meters from the data retrieval range.

![Figure 5](image5.png)

Figure 5. The results of geoelectric data processing using software Res2Dinv at location 3

3.4 Location 4
In accordance with the reference value of resistivity, if seen in Figure 6 location 4 the existence of groundwater is at a depth of 10 meters. This position is in the 70th meter to an unknown extent. Similarly, the depth of the groundwater basin at this position is not yet known to the limit. It can be estimated that the depth of this basin is more than 53 meters below the surface and the boundary length of this basin is more than 130 meters from the expanse of the data. However, there is a difference in meters to 33 to 60 meters from the range of data retrieval. According to field observations on the area is a seepage area (the soil slightly wet). So that area has a low resistivity value.
3.5 Location 5
In accordance with the reference value of resistivity, if seen in Figure 7 location 5, the presence of groundwater level is at a depth of 10 meters below the surface. There are 2 groundwater checks at 60 to 80 meters and 90 to 120 meters from the expanse range. The depth of the first basin is at a depth of 10 to 30 meters below the surface. While the depth on the second basin is estimated from meters 15 to 30 meters below the soil surface.

3.6 Location 6
In accordance with the reference value of resistivity, if seen in Figure 8 location 6, the presence of groundwater level is at a depth of about 15 meters below the surface. With an estimated depth of more than 50 meters below the surface. The position of this basin is spread evenly across the expanse of data but with different depth of basin.

3.7 Location 7
In accordance with the reference value of resistivity, when seen in Figure 9 location 7, the groundwater level is at a depth of 50 meters below the surface. This position is in the 80th meter until the deadline is unknown. The depth of the basin is also not known the final limit, but its depth is estimated to reach more than 54 meters from the ground. The resistivity value of 0.250 - 1 Ωm indicated as groundwater in Figure 11 has a range of dark blue indicator, while the indicator with light blue color is estimated to be a layer of sand and water.
Figure 9. The results of geoelectric data processing using software Res2Dinv at location 7

4. Conclusion
Based on geoelectric measurements, conclusions can be drawn at the measurement sites. They indicate the potential for groundwater found consecutively at an average depth of 15 meters below the soil surface. Such correlations as mentioned above then suggest the great possibility of potential subsidence in the region. However, there are few constraints that it is technically difficult to apply Geoelectric methods in Simpang Lima and surrounding areas to obtain information at depths more than 50 m. The reason is the difficulty of spreading the cable more than 150 m because there is no place or land for that purpose.

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