One-dimensional data analysis for aquifer layer in Pancuma Village, Tojo Una-Una, Central Sulawesi

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\textbf{Abstrak.} The need for water resources continues to increase from year to year to meet various needs. The availability of water resources is increasingly limited due to seawater intrusion or water pollution. Pancuma Village is one of the coastal areas where it is necessary to study the potential of groundwater, especially during the dry season. One way to determine the presence of the groundwater aquifer layer is by using the resistivity method. This method is an effective geophysical method for shallow exploration so that it can be used to determine the structure beneath the earth's surface. The configuration used in this study is the Schlumberger configuration. Research in Pancuma Village aims to determine the subsurface stratigraphy of the study area based on the resistivity value and to determine the distribution of groundwater aquifers in the study area. The results obtained from this study are that there are four types of subsurface layers in the study area, namely topsoil, claystone, iron sand, and alternating sandstone with conglomerates which are the aquifer layer in the study area. The resistivity value estimated at the aquifer layer ranges from 119 $\Omega$m - 529 $\Omega$m with a thickness of up to 45 meters.

1. Introduction
Water is one of the most important natural resources [1]. Without water, the life of animals, plants, and humans will be discontinued. Water is being widely used for human living in many sectors such as consumption, transportation and agriculture [2]. The increase in demand for water resource happens from year to year. However, because of the seawater intrusion and water pollution, water resource availability is becoming decreased. Pancuma Village is one of the coastal areas which needs a potential groundwater assessment to fulfil daily life needs, especially in the dry season. Seawater intrusion is usually happened in the coastal area, making the availability of clean water to become limited. The limited availability of water resource is also caused by the increase in water pollution due to the high number of populations. This condition resulted in the increase of household wastes, resulting the increase of water pollution and clean water needs [3]. In order to fulfil the needs of clean water permanently, it is necessary to take anticipatory action to obtain information on the potential of groundwater aquifers that may be developed. Groundwater is water which is found in the soil layer or rocks below the soil surface. Groundwater is stored in water-collecting layers called aquifers. The aquifer layer is a layer of gravel or sand that can store and release sufficient amounts of water [4].

One way to determine the presence of the groundwater aquifer layer is by using the resistivity method. Resistivity can be determined by using Ohm's Law. In general, Ohm's Law states that the amount of electric current ($I$) which is flowing along a conductor will be directly proportional to the
potential difference or voltage \( (V) \) given and inversely proportional to the resistivity \( (R) \). The equation is written as follows [5]:

\[
V = I \cdot R
\]  

(1)

The resistivity method is a geophysical method which is effectively used for shallow exploration to determine the structure below the earth's surface. The resistivity method utilizes an electric current that is injected under the earth's surface through two current electrodes. The potential difference that occurs is measured by two potential electrodes. The measurement results of current and potential differences at each measurement point are then calculated to obtain the variation in the resistivity value of each layer below the measuring point. The apparent resistivity is calculated using the following equation [6]:

\[
\rho_a = \frac{\Delta V}{I} K
\]  

(2)

By knowing the earth’s electrical properties, the information about the earth’s subsurface layer can be obtained. The results of resistivity measurement method can produce a one-dimensional (1D) cross-section model of earth’s subsurface resistivity. The configuration used in this research is the Schlumberger configuration. The advantage of this configuration is able to obtain the resistivity value for each vertical layer. This configuration also has the deepest range compared to other configurations while being more effective for exploration of groundwater aquifer layers [7].

Research related to this paper was done by Virman in 2016 [8] in order to map the aquifer layer of Tanah Hitam, Abepura. The research used the geoelectrical resistivity method with Schlumberger configuration. The obtained resistivity value obtained is about 4,34 \( \Omega m \) – 30,1 \( \Omega m \). The aquifer was found as a sand layer in the depth of 40 to 60 meters. Sand layer acts as an aquifer layer because it has a good porosity making it able to store and drain water.

![Figure 1. The geology of the research location](image-url)
As mentioned by Simanjuntak [9], there are some rock formations in the research location, specifically Bongka Formation, Ultramafic Complex, Salodik Formation, Alluvium and Coastal Sediment. Previously, a geoelectrical method has been used to determine the distribution of iron sand in Pancuma Village [10]. The research resulted that there are four known subsurface layers in the location. They are top soil as the upper layer, claystone in the bongka formation, sand rock as an aquifer layer in ultramafic complex, and conglomerate in the bongka formation.

2. Methods
The research is done in Pancuma Village, Tojo Una-Una, Central Sulawesi. There are four measurement points with a distance of 200 meters.

![Research location](image)

**Figure 2.** Research location

The data acquisition is made by using geoelectrical method with Schlumberger configuration. The distance between C1, C2, and P1, P2 electrode is 200 meters, respectively. The electrode is placed at those designated locations. The centre of each measurement track is determined using GPS. Then, the current is injected through the electrodes to the earth’s subsurface. Data for every measurement points are collected as a potential difference, current, and resistivity. The data then summarized into *Schlumberger* configuration table, which has geometry factor value and the distance of the current electrode (AB/2) and the potential electrode (MN/2).

![Schlumberger Configuration](image)

**Figure 3.** *Schlumberger* Configuration
For Schlumberger configuration, the relation between the apparent resistivity and the geometry factor is written as the following equation [11]:

$$\rho_a = \frac{\pi}{2l} \left( \frac{L^2 - l^2}{l} \right) \left( \frac{\Delta V}{I} \right)$$  \hspace{1cm} (3)

The research is conducted by processing the secondary data which contains the value of AB/2, MN/2, current, potential difference and apparent resistivity. After the apparent resistivity value is obtained, the resistivity value is generated by using curve approach to the field data result to obtain the layer thickness [10].

The 1D cross section is generated using the obtained value of resistivity and layer thickness. The generation of 1D cross section is done by correlating the data processing result which consists of information (resistivity, depth, and thickness) and basic knowledge of rock resistivity aspect like geological data to determine the presence or absence of research targets.

3. Results and Discussion

![Figure 4. 1D cross-section for the first measurement point](image-url)
The result of 1D cross-section, which is obtained at the first measurement point [Figure 4] shows that there is a potential of aquifer in the form of sand rock in the depth of 11.3 m – 50.6 m with a resistivity value of 70.4 Ωm. Sand rock layer has good porosity and permeability respectively for storing water and draining water. Therefore, sand rock as earth’s subsurface layer is good to be the aquifer layer.

![Figure 5. 1D cross section for the second measurement point](image)

The measurement on the second measurement point [Figure 5] resulted that there is a shallow aquifer layer and a deep aquifer layer. Those aquifer layers consist of sand rocks. The shallow aquifer layer is located in the depth of 5.48 m – 11.3 m with resistivity value of 51.6 Ωm, while the deep aquifer layer is located in the depth of 39.8 m – 64.4 m with resistivity value of 64.4 Ωm. Based on the constituent layer, the type of aquifer in the research location is a confined aquifer with a layer thickness of up to 24.6 meters.

The value of resistivity on the third measurement point [Figure 6] is 54.8 Ωm. It is estimated that the aquifer layer is sand rocks layer. The aquifer layer is located in the depth of 4.58 m – 6.7 m with 2.12 m of thickness. It is a shallow aquifer layer. Aquifer layer is also found at the third measurement point with a resistivity value of 51.6 Ωm in the depth of 32.6 m – 64.4 m and 31.8 m of thickness. Based on
the constituent layers, the type of aquifer at the third measurement point is a confined aquifer because there are aquitard layers which are located above and below the aquifer layer.

![Figure 6](image)

**Figure 6.** 1D cross-section for the third measurement point

Based on the measurement of the fourth measurement point [Figure 7], sand rocks layer is estimated to be the deep aquifer layer with resistivity value of 80.9 Ωm, 39.9 m of thickness, in the depth of 5.62 m – 45.5 m under the earth’s surface. Aquifer layer at the fourth measurement point is the thickest aquifer layer than the aquifer layers at the other measurement points.

The first, second, third and fourth measurement point is located at an altitude of 123, 270, 487 and 487 m.a.s.l., respectively. Based on the analysis results and supported by geological sheet map, it is known that the aquifer layer is become thinner from west to east. It is presumably because of the thinning of certain rocks layer in its sedimentary basin, undergoes changes in depositional facies, a misalignment that forms an angle with the above rocks, or shifting of rock layers due to tectonic forces that cause faults or fractures.
4. Conclusion
Earth’s subsurface layers in the research location are generally topsoil, claystone, sand rocks, and conglomerate. The presumable aquifer layer is the sand rocks layer. The aquifer layer of the research location has a thickness of up to 39.9 meters, with resistivity value around 51.6 $\Omega$m to 80.9 $\Omega$m. The distribution of aquifer layer of the research location has presumably become thinner from the west to the east.

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