Identification of aquifer layer using method of geo-electric resistivity in Tampabatu Village, Ampana Tete Sub-districts

Badaruddin¹, M D Th, Musa¹, Abdullah¹

¹ Department of Physics, Faculty of Math and Science, Tadulako University
E-mail: badarfisika@gmail.com

Abstract. The study was conducted using geo-electric method to identify the groundwater aquifer layer and depth which is below the surface based on the resistivity value. The purpose of this research is to know the aquifer which is identified by 3 point of measurement expanse. The research method used is geo-electric resistivity method and measurement technique used is Vertical Electrical Sounding (VES) with Schlumberger configuration. Data processing using Progress Version 3.0 software is performed to obtain the distribution of the earth surface subsurface type resistance. Based on the results obtained aquifer coating on the resistivity value ranged from 30 \( \Omega \text{m} \)-58 \( \Omega \text{m} \) with the value of formation factor 2-3 which is a free aquifer layer and aquifer medium. The aquifer layer is detected at a depth of ± 12.08 m up to ± 100 m below ground level (bgl).

1. Introduction
Ampana Tete sub-district geographically located at border by Ampana subdistrict and Ulubongka in the west, Tomini Bay in the north, Banggai district in the south and east border. Ampana Tete Sub-district covered about ± 796.02 km² of land area which administratively consists of 17 villages [1]. One of the villages in Ampana Tete is Tampabatu district 5. Tampabatu is a water shortage area, the distance of the source of fresh water from settlement is about ± 2 km driven by motorcycle. The growing population in Tampabatu village has an impact on increasing the need for clean water. The need for clean water is increasing both for the daily needs of human life, livestock and agriculture [2].

In an effort to obtain the condition of subsurface rocks, the investigation activity through the surface of the soil or underground needs to be done, so it can be known the availability of water carrier layer (aquifer), thickness and depth of [3-5]. Although ground water cannot be directly observed through the Earth's surface, ground-level investigations are a preliminary investigation of importance, at least providing a snapshot of the location of the groundwater presence. One method that can be used geo-electric method [6-8].

Investigation using geo-electric aims to determine the presence of rock layers. The rock layer also have functions as an aquifer, where the results of this geo-electric estimation will provide an overview of the state of the subsurface rock layers, especially the dispersion of the aquifer layer so that it is expected to assist groundwater supply planning in the area [9]. This geo-electric research is only done in the area of district 5 of Tampabatu Village as shown in figure 1.
2. Materials and methods

2.1. Research design
This research uses geo-electric resistivity Vertical Electrical Sounding (VES) with Schlumberger configuration.

2.2. Tools and Materials
Equipment to be used in this research: One Set Resistivity meter tool, Global Positioning System (GPS) to determine the coordinates of the position of the measuring points, Conductivity meter to measure electrical conductivity (EC) of water samples, Geological compass to determine the direction of stretch and trajectory of geo-electric, Roll meter, determining the spacing distance between electrodes, hammers, serves to plug a potential electrode stamp and current electrode into the ground. Method: Method with Resistivity meter multichannel SuperString R8 IP applies a C1C2 / 2 current electrode range beginning with a distance of 1.5 m up to a maximum distance of 150 m. While the potential electrode P1P2 / 2 are each 0.5 m for the C1C2 / 2 stretch of 1.5 - 15 m, 5 m (15 - 75 m) and 25 m (75 - 150 m). The direction of the stretch is adjusted based on the direction of the bedding as well as the location conditions.

2.3. Measurement and processing procedures
Data obtained from field measurements are current data (I) and potential difference (ΔV) and distance between electrodes. By entering the value of the geometry factor

\[ K = \frac{\pi (L^2 - l^2)}{2l} \]  

and equation

\[ \rho = a \rho_w \phi^{-m} \]  

It will resulted the pseudo resistance values of the measured results. In the interpretation, data on formation factor (F) calculated by equation

\[ F = \frac{\rho}{\rho_w} = \frac{a}{\phi^{-m}}, \]  

where the water type resistance value (\( \rho_w \)) is obtained from Equation \( \rho_w = 10000 / \text{EC} \).
2.4. Data analysis
The analysis of measured data is processed by using Progress Ver 3.0 software, subsequently deduced resistivity value by interpreting subsurface conditions combined with other supporting data such as: geological data, hydrogeology, and electrical conductivity (EC) data.

3. Results and Discussion
The measured results using Vertical Electric Sounding (VES) with Schlumberger configuration of 3 points, i.e. TS1 (VES1), TS2 (VES2), TS3 (VES3). TS1 Point Position is located in front of the local residents, precisely at the coordinates of the measuring point 00°58'40.7" LS and 121°48'11.3" BT. High location measuring 51 meters above sea level. The length of the stretch AB as far as 250 meters. TS2 point measurements in front of local residents, precisely in front of Baitus Syafa'ah mosque on the coordinate of measuring point 00°58'35.4" LS and 121°48'02.3" BT. High location measuring 35 meters above sea level using a GPS device as shown in figure 2. The length of the stretch AB as far as 200 meters. TS3 point measurements are also located next to local residents' homes, precisely at the coordinates of the measuring point 00°58'34.2" LS and 121°47'58.0" BT. High location measuring 35 meters above sea level.

Data obtained from field measurements are current data (I) and potential difference (ΔV) and distance between electrodes. The results of data measurements processed using the Progress Ver Software 3.0 and show how the resistivity value (ρ) and the depth of each layer varies. The results of processing point TS1, TS2 and TS3 can be seen in fig. 2.

![Figure 2. The cross-sectional results on measuring point TS1, TS2 and TS3](image-url)
Figure 2 shows the depth and thickness of the surface carried on the surface. Based on the geological matching of the research and the resistivity table, the layers of the measuring point (sounding) can be interpreted as table 1.

| Table 1. Interpretation of lithology from the cross-section of the progress |
|-----------------------------------------------|
| **Sounding Point** | **Layer** | **Depth (m)** | **Thickness (m)** | **Resistivity (Ωm)** | **Lithology** |
|---------------------|-----------|---------------|------------------|----------------------|--------------|
| TS1                 | 1         | 0 - 0.5       | 0.5              | 971                  | Gravel       |
|                     | 2         | 0.5 - 2       | 2                | 27.96                | Clay Sand, Silt |
|                     | 3         | 2 - 3         | 1                | 4.61                 | Clay         |
|                     | 4         | 3 - 6         | 3                | 26.63                | Clay Sand, Silt |
|                     | 5         | 6 - 17        | 10               | 102.21               | Gravel       |
|                     | 5         | 17 - 43       | 26               | 39.80                | Silt, Sand   |
|                     | 6         | 43 - 62       | 19               | 14.95                | Clay         |
|                     | 7         | 62 - 77       | 19               | 10.34                | Clay         |
|                     | 8         | 77 - 92       | 14               | 11.27                | Clay         |
|                     | 9         | 92 - ~        | -                | 3.15                 | Clay         |
| TS2                 | 1         | 0 - 1.17      | 1                | 24.77                | Clay, clay sand, silt |
|                     | 2         | 1.17 - 1.27   | 0.3              | 0.86                 | Clay         |
|                     | 3         | 1.27 - 5.07   | 4                | 9.82                 | Clay         |
|                     | 4         | 5.07 - 13.73  | 9                | 10.86                | Clay         |
|                     | 5         | 13.73 - 47.60 | 34               | 30.11                | Silt, sand   |
|                     | 6         | 47.60 - 78.01 | 30               | 43.17                | Medium sand  |
|                     | 7         | 78.01 - ~     | -                | 31.85                | Silt, sand   |
| TS3                 | 1         | 0 - 0.88      | 0.3              | 18.95                | Clay         |
|                     | 2         | 0.88 - 2.84   | 1.1              | 82.97                | Rough, pebble |
|                     | 3         | 2.84 - 5.15   | 1.2              | 3.94                 | Clay         |
|                     | 4         | 5.15 - 7.37   | 1.1              | 6.20                 | Clay         |
|                     | 5         | 7.37 - 12.08  | 4.2              | 9.59                 | Clay         |
|                     | 6         | 12.08 - 23.17 | 10.5             | 29.40                | Clay sand, silt |
|                     | 7         | 23.17 - 55.35 | 32               | 33.21                | Silt, sand   |
|                     | 8         | 55.35 - 80.05 | 25               | 24.52                | Clay, clay sand, silt |
|                     | 9         | 80.05 - ~     | -                | 27.13                | Clay, clay sand, silt |

Based on the result of data analysis to 3 point of measurement and compared with geological data, hydrogeology and formation factor value, hence obtained correlation between price of type barrier and lithology of research area. In conducting interpretation, data on formation factor (F) and water resistivity ($\rho_w$) are required. Value of water resistivity for electrical conductivity obtained in the field $\rho_w = 19.23 \, \Omega m$.

In general, based on the resistivity values obtained that are vertically found in the presence of different layers. The subsurface layers are commonly found in rock units, i.e unexplained sedimentary rocks as well as contacts with alluvial rocks and coastal sediments. The differences in obtained value of resistivity reflects that there is the difference in lithology. However, this does not indicate that each value of the type barrier represents one type of lithology. The value of type resistance from lithology is the price of the range. Besides based on the resistivity price, to predict the type of lithology is also supported by geological data, hydrogeology and formation factors. Taking into account such matters, the value of the constrained type resistance is interpreted as follows:
a. The soil cover layer with varying type resistance values, depending on the surface conditions of the location of the expected point.

b. Layers with type resistance less than 30 $\Omega$ m with formation factor $1 - 1.5$ (layers of clay and silt)

c. Layers with resistance types of 30 to 40 $\Omega$ m, with formation factor 2, are thought to consist of silt, sand (find sand) layers. Permeability of this layer is and is suspected to be a free aquifer layer (poor to medium aquifer).

d. The upper layer of 40-58 $\Omega$ m with the formation factor 3 in the medium sand area is still in the middle aquifer, in the 58-100 $\Omega$ m type barrier with the formation factor above 4 being coarse sand layer and gravel layer (gravel) which is a productive aquifer layer.

Sounding result (TS1): Depth 7 to 43 m below ground level, at resistivity value 39.40 $\Omega$ m is in formation factor 2, the type of free aquifer with a waterproof layer only at the bottom of the clay layer while at the top is rock is not water-resistant i.e silt layer, gravel and clay. This conditions causes local air pressure to affect and equals groundwaer pressure in the aquifer. Groundwater in this aquifer will be easily influenced by water on the surface. So if the surface water has been polluted, ground water will come in and easily polluted. The presence of undifferentiated aquifers is generally not so deep an average of at most 40 m from the surface of the ground whereas deeper still often encountered watertight rocks that occur since the formation of rocks or due to exposure (hardening). Therefore, if seen from the existence of this aquifer is not so deep that often called shallow aquifer [10].

Sounding result (TS2): At 13.73 meters to 47.60 meters bgl layer with a resistivity value of 30.11 $\mu$m is a silt and sand layer with permeability of this layer is suspected to be a free aquifer layer with a layer thickness of 34 meters. Depth 47.60 meters bgl to 78.01 m bgl with resistivity value 43.13 $\Omega$ m is a medium layer of sand is a layer located in middle aquifer.

Sounding result (TS3): Depth 12.08 to 55.35 m below ground surface, at resistivity value 29.40 $\Omega$ m to 33.21 $\Omega$ m is in the formation factor 2, the type of free aquifer with a waterproof layer only at the bottom of the clay layer whereas in the top is a waterproof rock that is a layer of sandstone, gravel and clay.

4. Conclusion

Based on the distribution of resistivity, has been discovered that two layers acting as aquifer, which is a free aquifer on TS1 and TS3, and a medium aquifer on TS2. The measurement point of TS1 of aquifer layer depth range from 17-43 meter below ground level (bgl) , measuring point of TS2 of aquifer layer depth range from ± 13.73 meters to thicken at depth of 100 meters bgl, measuring point TS3 aquifer layer depth about ± 12.08 meters bgl to the depth of 55.35 meters bgl.

References

[1] BPS 2016 Tojo Una-Una Regency in Figures (Publisher BPS- Statistics of Tojo Una-Una Regency)
[2] Santoso W L and Adj N T 2014 Characteristics of Aquifer and Potential Water Ground Grabel Bantul (Yogyakarta: Gadjah Mada University Press)
[3] Mogaji K A and Omobude O B 2017 Journal of Astronomy and Geophysics 6 434–451
[4] Leite D N et al 2018 Journal of Applied Geophysics 151 205–220
[5] Mogaji K A 2016 Journal of Taibah University for Science 10 584–600
[6] Aizebeokhai A P et al 2017 Data in Brief 15 828–832
[7] Anomohanran O 2015 Journal of African Earth Sciences 102 247–253
[8] Sajeena S, Abdul H V M and Kurien E K 2014 International Journal of Engineering Inventions 3 17–21
[9] Kazakis N, Vargemezis G and Voudouris K S Science of The Total Environment 550 742–750
[10] 10.Hadian M S, Mardiana U, Abdurahman O and Iman M I 2006 Indonesian Journal On Geoscience 1 P 115-128