

Mapping of the Distribution of Aquifer in Kawatuna Sub-district, Mantikulore District, Palu

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Abstract: Background: The condition of the land in Kawatuna Sub-district is dry, with vegetation overgrown only with shrubs. Dry land condition makes people difficult to get clean water sources for their daily needs. Purpose: This research aims to find out the existence of an aquifer and the depth of the aquifer in Kawatuna Sub-district. Method: The method used in this research is *Vertical Elektrikal Soundin (VES)* with *Schlumberger* Configuration. The measurement is conducted on 10 measuring points. Data is processed using *IP2WIN*. Result: The result shown by the program is in the form of distribution of resistivity(ρ), thickness (h), and depth (d) of each subsurface layer. Aquifer layer is shown by the resistivity value of 32.15 Ω m-48.03 Ω m and formation factor value of 2-5. This layer consists of sands, pebbles, and sandstones. The upper limit of this later is in the depth of 50.05-72.75m, while the lower limit is undetectable. Conclusion: Aquifer layer is distributed to the east and to the west. It can be seen from the depth of aquifer in the west which tends to be shallower than that in the east. Commonly, this layer is located below the impermeable clay layer.

Keywords: Aquifer, Geo-Electric Resistivity, Schlumberge Configuration, Vertical Electrical Sounding (VES)

1. Introduction

Palu is an area with abundant potential of groundwater resources. Based on the sheet hydrogeological map of Palu, the potential of groundwater in this area is spread in the Palu Groundwater Basin (CAT). Groundwater Basin (CAT) is an area limited by hydrogeological boundaries, in which all hydrogeological events such as the process of filling, flowing, and releasing groundwater take place-3]. Palu Groundwater Basin (CAT) makes this area has abundant water resources [4]. However, the existence of water resources is not distributed evenly in all area in Palu. One of the areas which are till lack of water resources is Kawatuna Sub-district. Kawatuna sub-district is located to the east of

Palu City, which is included in the area in Mantikulore District. According to the Statistics Center of Palu (Palu, 2016), the area of KelurahanKawatuna is 20.67km²The population is 3,575 people with a density of 173 people per km² Residential areas are spread in the north and the south, while the east and the west parts are covered with shrubs. Topography in this area consists of plains and hills. In general, the soil surface condition is dry with vegetation overgrown with shrubs. Dry land condition makes people difficult to get clean water sources for their daily needs.

Meeting the needs of clean water in this area relies only on the water management done by the Regional Water Company (PDAM) of Palu City. The water resources of the Regional Water Company (PDAM) comes from Pondo (Poboya),

Kawatuna, and Vatutela Rivers. According to the surrounding people, the water debit supplied by PDAM is still in a small amount. This is not comparable with the water needed by local people. This situation makes people search for other alternatives to meet the need of clean water. One of the ways is to look for groundwater resources. Groundwater resources have a very important role as an alternative source of raw water to meet the various needs of water [5-9]. Based on the information from the local people, there have already been several communities who made wells to obtain groundwater. However, the effort is unsuccessful due to the condition of dry land. To find out the existence of groundwater resources in this area, it is necessary to do a research. One method that can be used to identify the subsurface layer is geo-electric resistivity method.

Geo-electric resistivity is one of the geophysical methods commonly used for exploration to study the subsurface condition by examining the characteristics of electricity in rocks beneath the earth's surface [10-19]. The work principle of geoelectric method is to flow the electric current into the earth through 2 current electrodes, and then the potential difference is measured through 2 potential electrodes, so that the resistivity value can be known.

2. Method

Data collection and processing methods: Measurement of geo-electric resistivity uses Vertical Electrical Sounding method *Sounding* [20-27]. This method can determine the variation of resistivity value of horizontal layer of rock vertically. The configuration used is *Schlumberger* configuration. Data on potential difference (V), current (I), pseudo-type resistance (ρ_a) and geometric factor values of the measurement results are inversed by the *IP2WIN* program and *Progress*. The results obtained from the program are the resistivity values (ρ), depth (d), and thickness (h) of the layer at each guessing point.

To ease the process of interpretation, the electrical conductivity parameters (DHL) of well water at the research location is measured using *x-plore GLX*. The formation factor value (F) is calculated based on water resistivity value (ρ_w) and resistivity value (ρ). The result of interpretation is shown in the form of 2D cross section using *CorelDraw* program. Data collection in the field is carried out with the following steps:

- Determine the position of the measurement point.
- Determine the direction of the stretch and the electrode coordinates.
- Install electrodes with 10 m space
- Arrange the georesistivimeter and make measurements.
- Inject current into the ground via a current electrode.
- Data obtained from measurements in the field are current data (I) and potential difference (V), as well as the electrode distance.
- To avoid measurement data errors, the measurement is repeated 3 times.

Data processing and interpretation are carried out with the following steps:

- Input field data into MS Excel Software.

- Calculate the geometry factor (K) from the measurement results using Equation (1).

$$\rho_w = \frac{1000}{DHL} \quad (1)$$

- Calculate pseudo type change value (pa) from the measurement results using Equation (2).

$$\rho_t = \rho_b S_w^{-m} = a \rho_w \phi^{-m} S_w^{-m} \quad (2)$$

where ρ is a resistivity, ρ_w is a type of bottleneck filler, a is a constant that characterizes a type, rock character (texture, shape, etc.), m is a constant that characterizes a cementation character, ϕ is a porosity of a rock, ρ_t is an obstacle to a type of rock unsaturated by water, ρ_t is rock type resistance when saturated with water, S_w is the fraction of pores containing water (saturation) and n is the factor of water saturation

- Transferring the calculated data from the MS Excel Software into Notepad Software.
- The results of the type and elevation calculations obtained are then converted using the *EarthImager2D* Software to obtain a 2D cross-section model of subsurface resistivity distribution.
- The results obtained from the inversion program consist of variations in pseudo-type boundary values, depth and thickness of the layers of each stretch which are then analyzed and interpreted.
- Determine the distribution of the aquifer layer based on the cross-sectional model obtained by interpreting the processing data to obtain the level of depth and the value of a real type of hierarchy from the study area, which is then interpreted under subsurface conditions.

To get the results of a more accurate interpretation, it is necessary to support data related to the research needs that are supported, geological maps, maps of the earth, and water samples obtained from springs or well water (DHL).

3. Result and Discussion

DHL measurement obtains the average value of water resistivity of pore filler (ρ_w), which is 15.05 Ωm . This ρ_w value and resistivity value (ρ) of each layer are converted to formation factor value. Based on the resistivity value and formation factor, 3 layers are obtained, namely at layer 1, the resistivity value is <30.1 Ωm indicated by brown color; at layer 2, the resistivity value is 30.1-75.25 Ωm and the formation factor value is 2-5 with yellow color; and at layer 3, the resistivity value is > 75.25 and the formation factor value (F) is > 5 indicated in purple.

To interpret aquifer layer in the research location, each point of measurement is correlated in some resistivity cross section.

The resistivity cross section A-B (Figure 1) results in a correlation of 5 measuring points. This cross section extends from the north (point A4) to the south (point A8) with a minimum height of 123 mmsl (point A3) and a maximum of 172 mmsl (point A4). Based on the visualization of the cross section, there are 4 layers on point A4, point A10, and point

A3. Meanwhile, there are 6 layers at point A2 and point A8. In this cross section, there is aquifer layer visualized in yellow color. It is assumed that this layer consists of sands, pebbles, and permeable sandstones. The upper limit of the layer is at a depth of 56.56-68.8m while the lower limit is not detected. The shape of the layer follows the surface contour and tends to go deeper into the south. It is indicated by the

southernmost measuring point (point A8) of which aquifer layer is at 68.8m. Around the cross section, there is a well that people create (Well 1), which is 200 m from the west of Point A3. The depth of this well is ± 60 m with clear and no-smell water. The water source of this well is allegedly in this layer. The layer is located below the impermeable clay later.

Resistivity Cross Section A-B

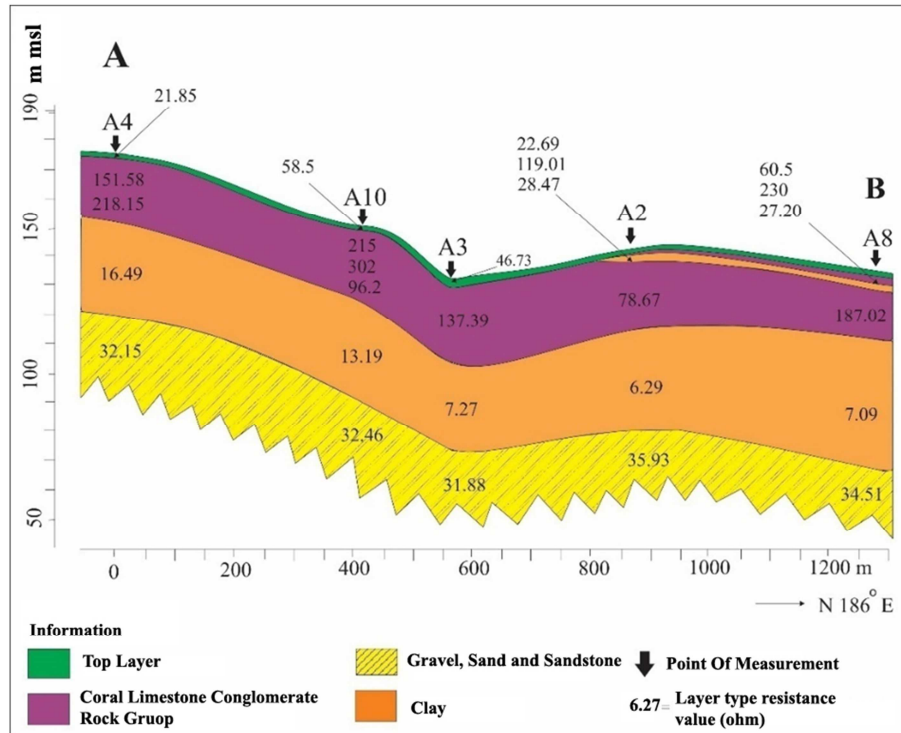


Figure 1. Resistivity Cross Section A-B.

Resistivity Cross Section C-D

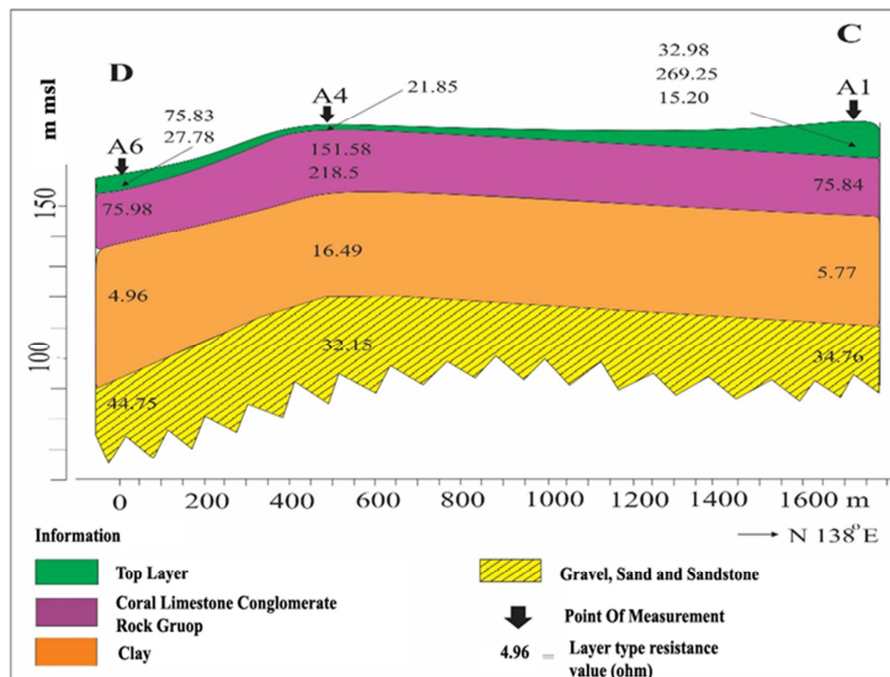


Figure 2. Resistivity Cross Section C-D.

Based on Figure 2, the resistivity cross section C-D is a result of correlation of 3 measuring points. The length of the cross section is ± 1.750 m with topography at the altitude of 156 msl (point A6) and rises to the south to an altitude of 172 msl (point A4). Based on the cross section, 4 subsurface layers are obtained. The layer allegedly to be an aquifer layer (yellow) is spread evenly at each measuring point consisting

of sand, pebbles, and permeable sandstone. The upper limit of this layer is at a depth of 56.56-67.9 m while the lower limit is not detected. This layer is below the impermeable clay layer. Around the cross section, there is Kawatuna River which is 200 m from the north of point A6, and this river flows from the east to the west.

Resistivity Cross Section C-E

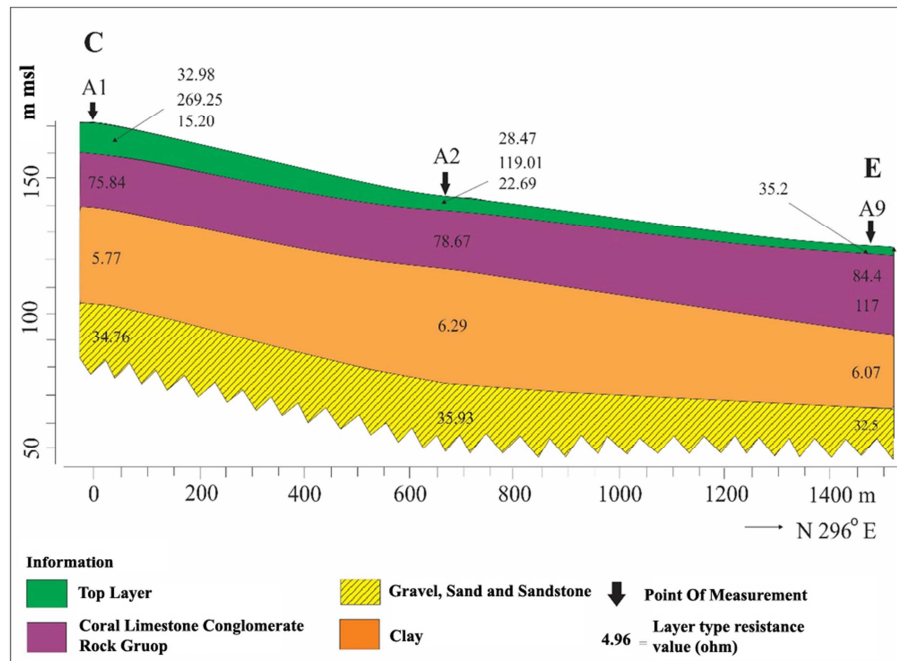


Figure 3. Resistivity Cross Section C-E.

Resistivity Cross Section C-E (Figure 3) is on the south of the research location. This cross section extends from the east (Point A1) to the west (Point A9) with topography at an altitude of 123 m above sea level (Point A9) rising to the east to an altitude of 172 m above sea level (Point A1). Based on the visualization of the cross section, there are 4 subsurface layers. Aquifer layer is visualized in yellow color, and

allegedly consists of sands, pebbles, and permeable sandstones. The upper limit of this layer is at a depth of 55.4-63.19 m (Figure 4) while the lower limit is not detected. This layer is below the impermeable clay layer. Around the cross section location, there is no well created by people.

Resistivity Cross Section D-E

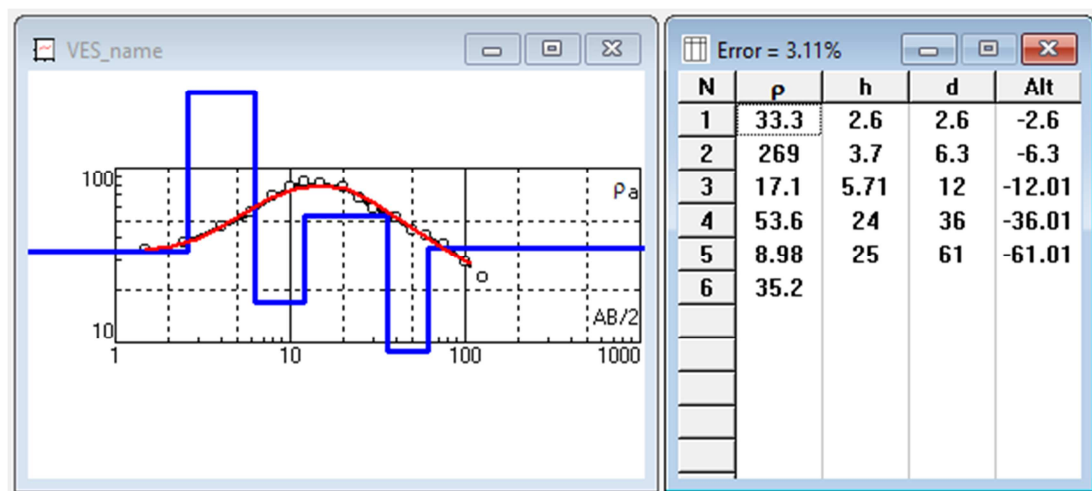


Figure 4. VES data processing point A1.

Resistivity Cross Section D-E

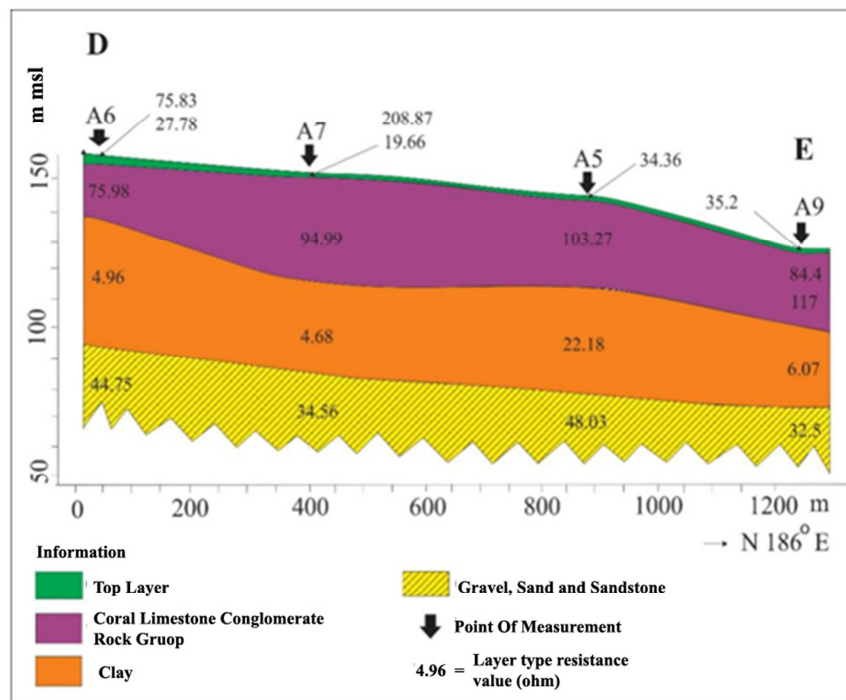


Figure 5. Resistivity Cross Section D-E.

Cross section on Figure 5 consists of Point A6, Point A7, Point A5 and Point A9. This cross section extends from the north (Point A6) to the south (Point A9) with a minimum altitude of 123 m above sea level (Point A9) and a maximum of 156 m above sea level (Point A6). Based on the visualization of the cross section, 5 layers are arranged at Point A6. At Point A7, Point A5, and Point A9, 4 layers are obtained. Based on the cross section, there is aquifer layer visualized on yellow color that allegedly consists of sands, pebbles, and permeable sandstones. The upper limit of this layer is at a depth of 55.4-72.76m while the lower limit is not detected. The shape of this layer follows the surface contours and tends to be shallower to the west. It is indicated by the westernmost point of the cross section (Point A9) of which aquifer layer is at a depth of 50.06m. Around the cross section location, there is no well created by people. Around the cross-sectional location, there is a well belonging to the River Basin Hall (BWS) of Sulawesi II (Well 2) which is 300m from Point A5. The depth of this well is ± 105 m with clear and no-smell water. The water source allegedly comes from this layer. The layer is located under the impermeable clay layer.

Based on the result of interpretation of all cross section, the detected aquifer layers have resistivity value of 32.15-48.03 Ω m and allegedly consist of sands, pebbles, and permeable sandstones. The pattern of aquifer distribution tends to be shallower to the west than that in the east. It can be seen in the westernmost point of measurement (Point A9) of which is the depth of the aquifer is at a depth of 55.4m. Meanwhile, the aquifer at the measuring point to

the east (Point A1) is at a depth of 61m. The depth of the aquifer found is in accordance with the depth of the well around the research location, where there is a well that people create (W 1) with a depth of 60m and a well belonging to Sulawesi BWS III (Well 2) with a depth of 105m, and it is assumed that the well water is in this layer. Generally, this layer is located at below the impermeable clay layer.

4. Conclusion and Recommendations

Based on the result and purpose of the research, it can be concluded that the position of aquifer layer in Kawatuna Sub-district is detected at a depth of 55.4-72.75m. This layer is interpreted by the resistivity values of 31.9-48 Ω m with formation factor value of 2-5. It is assumed that the layer consists of sands, pebbles, and permeable sandstones. This layer is distributed evenly to the east and to the west. It can be seen that the aquifer depth in the west tends to be shallower than that in the east. Generally, this layer is located below the impermeable clay layer.

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Statement on Conflicts of Interest

The authors declare that they have no competing interests.

Author Contribution

Muhammad Rusydi (conception and design of the study, preparation of draft manuscript, doing revisions or providing critique); Mohammad Dahlan Tahir Musa (data analysis and interpretation); Badaruddin (data analysis and interpretation); Yandry Albert Momor (sectional scientific management); Sandra Sandra (sectional scientific management); Mauluddin Kurniawan (sectional scientific management); Sitti Rugaya (sectional scientific management); Rustan Efendi (data analysis and interpretation); Rahmawati (data analysis and interpretation); Syaiful Hendra (data analysis and interpretation); Hajra Rasmita Ngemba (data analysis and interpretation).

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