Investigation of Groundwater Potential Based On Vertical Electrical Sounding Methode On Gosoma District In North Halmahera

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Abstract. Population growth has encourage an increasing of clean water needs as a basic human necessity, both in terms of quality and quantity. River water and rain water are sources of raw materials for these elementary needs, however global climate change has indirectly affected the hydrological characteristics of the last few decades. Thus, the use of ground water is a solution in meeting these needs. The research aims to identify the potential presence of ground water that can be used as a source of fresh water in the village of Gosoma, Tobelo, North Halmahera Regency. This potential fresh water investigation was carried out using a Mc Ohm Mark-2 OYO resistivity meter, while the Schlumberger configuration was the measurement method used. The length of the track geoelectric extends as far as 1,060 m, while for transverse profiles as far as 560 with a total number of measurement points of 6 points. The results of geoelectric measurements show that there are 2 layers that have the potential as deep aquifers. First groundwater layers predicted at a depth that varies between 21.10 m - 83.00 m and secondary groundwater layer may exist deeper than 95.90 m above the surface. This result were indicated by resistivity values measured at the observed points, where the values varies from 18.10 ohms to 91.30 ohms. Those resistivity value illustrates that lithology of the soil layer were indicated as a layer of sand and sandy tuff, where both of the rock lithologies layer have a potential as a layer of ground water.

Keywords: Vertical Electrical Sounding measurement, aquifers, groundwater potential.

1. Introduction
Water is a basic need for living things in this world, however its existence is very limited. Fresh water is only 2.74\% of the total water available on Earth in various forms, such as : 2.14\% as galci er and ice, 0.61\% as ground water and only 0.023\% as surface water in river, lake, etc. (Nace, 1967). population
growth, urban development, and industry expansion already generated an increasing of fresh water need in various forms of its activities.

Utilisation of groundwater as an alternative raw water sources to fullfill the needs of fresh water became a solution to answer the scarcity of water resources, particularly on the arid areas. Groundwater is water that exists mainly in subsurface pore spaces but also in defined channels, such as those found in karst formations, which are created by dissolution of soluble rocks such as limestone (Brands, Rajagopal, Eleswarapu, & Li, 2017). The existence of groundwater, commonly, could be predicted based on the lithology of rock that arranged an area. Water will flow to the groundwater through the aquifers, where the good aquifers, for instance: sandstone, conglomerate, fractured limestone, unconsolidated sand, gravel and fractured volcanic rocks (Freeze & Cherry, 1979).

Geoelectric resistivity method is one of the geophysical methods that successfully applied for groundwater exploration, specifically to determine the layer of water transmitters called aquifers (Van Dam & Meulenkamp, 1967) (Nejad, Mumipour, Kaboli, & Najib, 2011) (Anomohanran, 2013) (Muchingami, Hlatywayo, & Chuma, 2012). The approach hidrogeology on this method, essentially, purposes to forecast the subsurface layers, such as: aquifers delineation, lithology boundaries and geological structures (Jones & H. E. Skibitzke, 1956) (Salako & Adepelumi, 2018). This method this method has been widely applied for reasons more effective, efficient and economical than other methods.

This research was conducted to assess the potential of groundwater resources on the district of Gosoma. The utilisation of vertical electrical sounding (VES) in order to mapping the potential areas to be developed as a source of fresh water in North Maluku.

2. Research Methodology

2.1. Research Area
The research area located in the village Gosoma, Tobelo, North Halmahera as presented in figure 1a. The length of long section path was extended as far as 1,060 m (G2, G3, G4 and G4) with an interval less than 400 m, meanwhile for the transversal profile length is 560 m, due the total number of measurement points are 6 points. Based on regional geological maps published by the Bandung Geological Research and Development Center as showed in figure 1b, the physiography of the research area is included on the Western Halmahera Mandala which is composed of sandstones, clays, marlies and limestone (Madi, Syafri, & Rosana, 2018).
2.2. Measurement Tools and Methods

Principally, the resistivity method uses an artificial current to produce an electric potential field in the ground (Seidek & Lange, 2007). Further, the method work is presented in Figure 2, where direct current or low-frequency alternating current flowed into the earth through two electrodes current (P1 and P2), then the potential difference is measured through two electrodes (C1 and C2), the magnitude of the potential difference that occurs is measured on the surface with two electrodes.

![Figure 2. Principle of georesistivity method. (Seidek & Lange, 2007)](image)

In this research, a set of geoelectrical equipment used, it consists of: Resistivitymeter OYO Mc Ohm Mark-2, accu as a artificial current, current and potential cable, current and potential electrodes as presented in Figure 3. While, the Schlumberger configuration were applied for the measurement technique because this method is easy to operate, less time consuming, and in short spread of current electrodes, spacing greater depth can be achieved (Vasantrao, Bhaskarrao, Mukund, Baburao, & Narayan, 2017), moreover this configuration will produce smooth data due to variations in local resistivity on the potential electrode (Griffiths & King, 1981).
Practically, this method was implemented by widening the current electrode to the certain distance and at any given current (AB/2) in the current price (I) and potential difference (V) obtained, so that apparent resistivity value can be measured as illustrated in figure 4.

![Schlumberger configuration schema](image)

**Figure 4.** Schlumberger configuration schema

A, B and M, N is current electrodes and potential electrodes, respectively.

Basically, based on the parameters measured, the apparent resistivity could be calculated by using equation (1) and (2). Meanwhile, on this research the IPI2win was the application program used to interpreter the geoelectric resistivity data collected from the Vertical Electrical Sounding (VES) investigation.

\[
\rho_{\text{app}} = K_{SC} \frac{\Delta V}{I} \quad \text{[1]}
\]

\[
K_{SC} = \pi \frac{(a^2 - b^2)}{2I} \quad \text{[2]}
\]

\( \rho_{\text{app}} \) is apparent resistivity; \( K_{SC} \) is geometry factor; \( V \) is potential different; \( I \) is electrics current; \( a \) is distance between center point to current electrode; \( b \) is distance center point to potential electrode.

### 3. Results and Discussion

Analysis of data obtained from the resistivity measuring instrument were carried out by using IPI2win applications, where the results of this computation are resistivity values based on depth and the thickness of each layer. Furthermore, these value will be classified based on resistivities values of rock material types in order to assessing the stratification of subsurface lithology. The results of this investigation showed in Table 1, generally, the geology characteristics of the research area were structured by several rocks lithology, such as tuff, clay, sandtuff, sandstone, and breccia. Theoretically, the lithology of the soil layers at this research area that might be an aquifer layer were presented by the existence of tuff, sandy tuff, and sandstone. Thus, the potential mapping of fresh water areas can be conducted based on this characteristics lithology.

| Observed Point | Layer | Interpretation Results | Lithology       |
|----------------|-------|------------------------|-----------------|
|                | Depth (m) | Resistivity (Ω) |                  |
| G.1            | 1      | 0,00 - 0,90           | 101,00 Cover soil |
| 2              | 0,90 - 7,56 | 29,10       | Tuff            |
| 3              | 7,56 - 18,60 | 86,50       | Sandy Tuff      |
| 4              | 18,60 - 35,10 | 14,50       | Clay            |

Table 1. Resistivity values at the points observed
The aquifer depth mapping in vertical direction is shown in Figure 5. The observation points G1, G2, G3 and G5 on the southern side presented the similarity of lithological stratification with different thicknesses. The exitance clay soil becomes an impermeable layer separating tuff, sandy tuff and sandstone which has a function as aquifer. The first aquifer layer were identified at a depth of 0.90 m - 18.10 m, with the thickness of tuff and sandytuff varies from 8.00 m – 16.00 m. At the secondary aquifers layer, the lithology dominated by sandy tuff at a depth of 25.60 m – 75.60 m with average thickness of 30 m. These aquifer layers could be classified as a shallow aquifers. Moreover, the sandstone lithology were identified deeper than 90 m, which is then confirmed as a deep aquifer.
Interpretation of the results at point of G4 and G6, located on the northern side of village, showed its significantly difference compared to the observation points at the southern side. On this side, the breccia deposits were identified at a depth more than 80 m. Meanwhile, the layers of tuff, sandy tuff and sand as an aquifer layers were founded at a depth of 0.90 m – 13.00 m and 20.00 – 83.00, respectively for first and secondary layer of aquifers.

By comparing of these results, transversal section (Fig. 5a) and longitudinal section (Fig. 5b) measurements, it explained that the lithological conditions of an area can varies greatly. The thickness of aquifer layers at the southern side of Gosoma village has a better potential to be developed as a source of groundwater compared to the reverse side of village.

![Figure 5](image)

**Figure 5.** The depth of aquifers in Gosoma Village (a) transversal (b) longitudinal

### 4. Conclusions

Based on the interpretation and analysis of this research, we may conclude that:

a. Geological characteristics of the research area were composed by of Volcanic Rock, such as: local tuffs, clay, tuffs clay; and plant residues and Sedimentary Rocks, Aluvium, such as : sand, rock, sandstone, gravel. Meanwhile, the lithological soils has a potential to be an aquifer layers are sandy tuff, tuff, sand and sandstone with a varies thickness.

b. The southern side of Gosoma village has a well potential to be developed as a groundwater resources based on thickness of aquifer layers compared to the northern part of the village.
Eventhough, it still need a study to better understanding the quality of this fresh water according to health standards.

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