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3D MODELLING FOR DETERMINATION OF GROUNDWATER DRILLING LOCATION USING GEOELECTRIC RESISTIVITY METHOD DIPOLE-DIPOLE CONFIGURATION

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ABSTRACT

We attempt to determine groundwater drilling location at Villa Tlogomas Residential, Lowokwaru Subdistrict, Malang City East Java where the new unit will be built, using the geoelectric resistivity method, dipole-dipole configuration. Measurements were taken at five lines. Line 1, 2 and 3 with a long stretch 100 meters. Line 4 and line 5 with a long stretch 60 meters. Line 4 and 5 intersect line 1 until 3 on the north and south. The distance between the electrodes as far as 5 meters for each line. Based on 2D modeling and 3D modeling, it can be found lithology in the research areas consist of soil or wet clays, tuff, saturated gravel, and breccias. The groundwater distribution in the saturated gravel which located at a depth about 6,7 meters to 11,8 meters below the subsurface. From the modeling results, the point of groundwater drilling is recommended at a depth 9-11 meters in 4 drilling points which is in the point where the line intersects each other.

Keywords: Geoelectric method, resistivity, dipole-dipole configuration, groundwater.

1. INTRODUCTION

Water is a primary need in our life and becomes an important part of living creatures. The using of waters is constantly increasing, in line with the development of urban areas. The construction of a housing indicates an increase in the number of people, and indirectly impact on increasing the number of water needs (Yudistira, 2012). In most parts of the world, water is a scarce resource. That might seem strange because there is so much water on Earth. Almost all of the water on Earth, more than 97 percent of it, is seawater in the oceans. The rest is called fresh water because it does not have a high salt content. Most of the world’s fresh water is frozen solid in large glaciers in Antarctica and Greenland. Almost all of the fresh water that is available for human use is either contained in soil and rock below the surface, called groundwater, or in rivers and

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lakes (AGI, 2016). The existence of water in urban areas is very important, considering the lives of people who have a dynamic life. In fulfillment of the clean water, people in urban areas can not rely on water from the direct water source as in surface water (rivers, lakes and other). It is possible to have been contaminated either directly or indirectly from human activity. So, the groundwater can be an alternative to meeting those needs. (Kurniawan, 2008).

Investigations of groundwater with the study of the aquifer zone is a good solution in the future to determine the distribution of groundwater, especially for new housing to be built. The needs for enhanced water is indispensable as one of the most materials in survival in these places. Efforts are needed to increase the potential of groundwater resources that exist in order to balance the needs of groundwater are likely to continue to increase. So the exploration of groundwater are technically using geoelectric resistivity can be a solution to supply of groundwater in the construction of society, especially in a new housing, without damaging the surrounding areas and one of the eco-friendly method. This research was conducted at the residents of Villa Tlogomas as efforts to find a database of groundwater for new housing. This area is emerging as an alternative road that directly connected between Malang city and Batu city. There is a lot of new housing construction, so the development of groundwater allocation in supporting the communities living around this place is very needed.

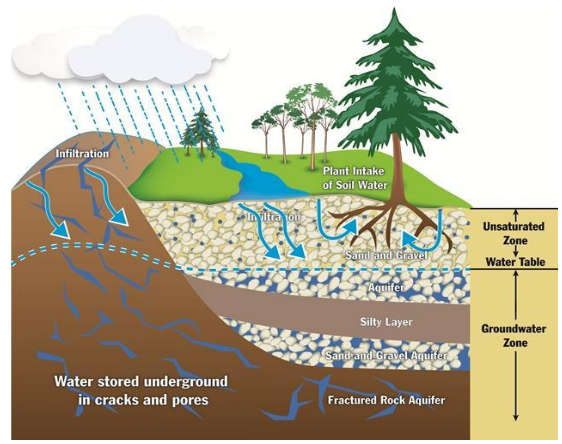

Figure 1: Groundwater (Trimper, 2014).

Groundwater conditions can be determined from the condition of the aquifer. The aquifer is a layer of rock or geological formations that have a structure that allows water to enter and move through it under the normal conditions (Todd, 1980). The groundwater illustrated can be seen in Figure 1.

Geoelectrical methods are used extensively in groundwater mapping for investigation of the vulnerability of aquifers and shallow aquifers themselves. The vulnerability of aquifers is closely related to the heterogeneity of the clay cap. The clay content of the formation defines the electrical formation resistivity with clayish less permeable formations showing low resistivities and sandy permeable formations showing high resistivities. The geoelectrical method is capable of mapping both low and high resistive formations and therefore a valuable tool for vulnerability studies. The main principle of this method is to utilize geoelectric resistivity response of the

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electrical properties from the rocks due to the injection current supplied to the subsurface, so it can be measured the value of the potential difference as a results, and the amount of resistivity can be measured based on the parameters of current and potential.

2. METHOD

Acquisition of data carried out on 22-23 March 2016, with research location at Villa Tlogomas Residential, Lowokwaru District, Malang, East Java, Indonesia. Located at 7^0 56' 14.39" S dan 112^0 35' 31.61" E (Figure 2). This location was chosen this area will be the next project for the new unit will be built. Dipole-dipole configuration is used in this research. Measurements were taken at five lines. Line 1, 2 and 3 with a long stretch 100 meters. Line 4 and line 5 with a long stretch 60 meters. Line 4 and 5 intersect line 1 until 3 on the north and south.

Figure 2: Survey Design and location overlay with Google map

3. RESULT AND DISCUSSION

3.1 2D modeling

The 2D modeling results from line 1 untill line 5 shown in Figure 3-7, form the results, description of subsurface in the research areas had a good continuity, with four lithology layers. The first layer on a range of resistivity values from 3.12 Ωm until 20 Ωm, this is identified as a soil or wet clays layer. Resistivity value of clays has a range of 1-100 Ωm, with 40% specific soil containing in clays has an average resistivity value around 8 Ωm.

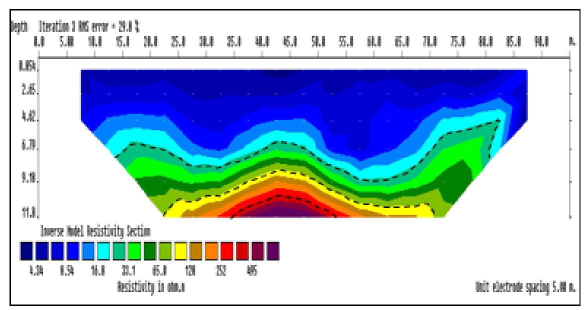

Figure 3: 2D modelling from Line 1, low to high resistivity values are indicated by colour gradation from blue to red

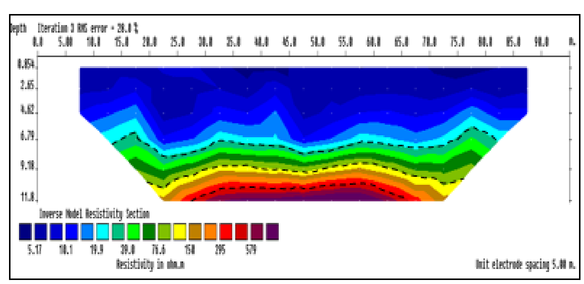

Figure 4: 2D modelling from Line 2, the color description used is the same as picture 1

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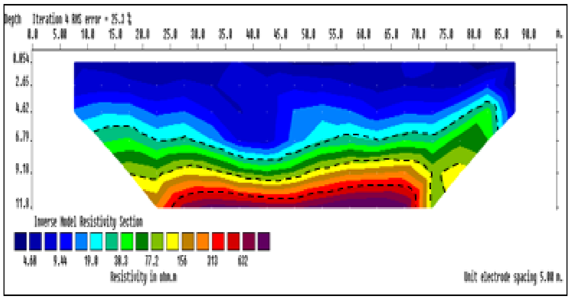

Figure 5: 2D modelling from Line 3, the color description used is the same as picture 1

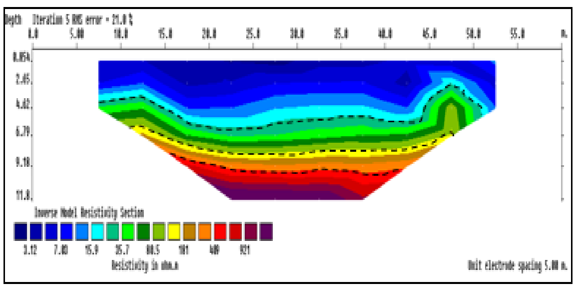

Figure 6: 2D modelling from Line 4, the color description used is the same as picture 1

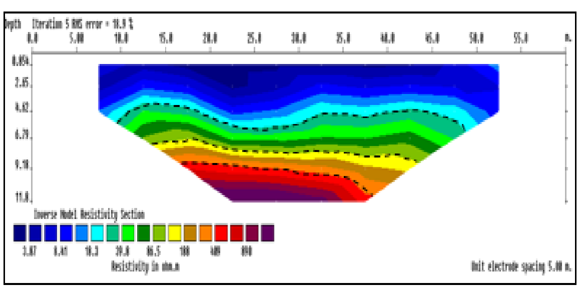

Figure 7: 2D modelling from Line 5, the color description used is the same as picture 1

The second layer with a range of resistivity values 20 Ωm to 100 Ωm identified as tuff layer. This result was correlated with rock formation deduce from the geological map of Malang regional shets. The research areas are located in the tuff Malang formations, forming of sandstone tuff, breccias tuff, tuff, lapilli tuff, and pumice tuff, which can be seen Malang areas was once a volcanic region. Tuff rock is a pyroclastic rock that came from volcanic eruptions which have fine grains. Resistivity value for the volcanic tuff rocks (tuffs volcanique) is 20-100 Ωm.

The third layer is a groundwater zone area which can be regarded as saturated areas with lithological occupied by water instead of air. This layer has a range of resistivity values 100 Ωm to 300 Ωm identified as a saturated gravel. Gravel lithology is an accumulation of gravel, pebbles, and sands that has not undergone compaction, while saturated gravel is gravel lithology that occupied by water.

The fourth layer has the biggest resistivity values range among each other that is more than 400 Ωm, identified as breccia rock layers. This layer is waterproof and compact due to poor porosity so that can be categorized as aquifuge layer. The resistivity value of breccias rock in the range 400-10000 Ωm, as well as the results of research conducted by Irjan (2012) regarding mapping the groundwater (aquifers) potential based on Wenner sounding data in the Batu city near the research areas, the resistivity value from breccias rock is between 600-900 Ωm.

3.3 3D modelling

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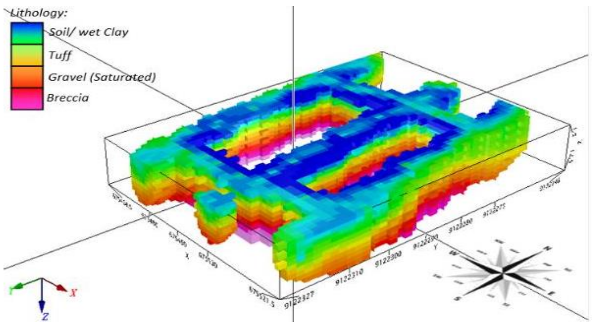

Figure 8. 3D Modeling of resistivity survey for 5 line with line 1,2,3 respectively stretch from east to west and line 4,5 respectively stretch from north to south. Colour bar indicate type of lithology that exist in the layer

Based on the 3D modelling shown in Figure 10, the result is not much different from 2D modelling. The rock lithology is composed of wet soil or clay, tuff, saturated gravel and breccia rocks. Identification of lithology based on resistivity values obtained were then correlated with geological maps and tables of rock resistivity values.

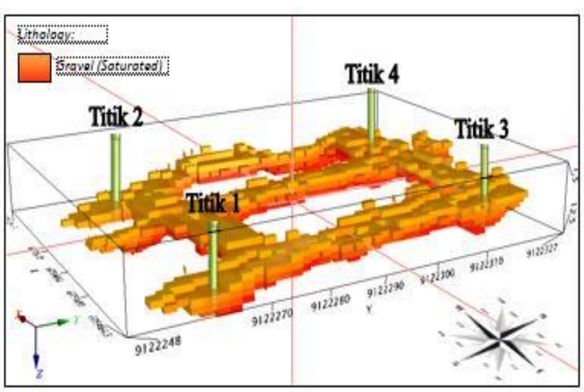

Figure 9: Plausible location for groundwater drilling based on 2D and 3D modelling.

Recommendation for drilling location is based on the results from 2D and 3D modelling, both of the position and depth determined based on the layer that potentially contained groundwater that is on the third layer, saturated gravel. It is known that the properties of the water flow from the high to the low places, so does as the water flows in the river always flows from the upstream to the downstream. Liquid flow from a higher to a lower place, or liquid to flow under the influence of gravity to achieve the lowest possible areas to contain it (Muslim, 2009). In determining the drilling point in terms of saturated gravel layer located at the lowest position so that the groundwater is obtained to the fullest.

Based on the results of the study, we propose 4 points for groundwater drilling, where the saturated gravel layer is in the deepest position and the thickest layer. Locations that meet these criteria are at the intersection between lines 1, 3, 4 and 5 which are the corners of the research area. In a geographical position, these four points are at the latitude and longitude as follows

Point 1 : 7^{0}56’15,9”S 112035’31,9”E

Point 2 : 7^{0}56’15,7”S 112035’30,5”E

Point 3 : 7^{0}56’13,3”S 112035’32,3”E

Point 4 : 7^{0}56’13,2”S 112035’31,0”E

4. CONCLUSION

Based on the research that has been done, it can be concluded that:

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1. The type of lithology on subsurface in the research areas consists of four layers, soil or wet clays, tuff, saturated gravel and breccias.
2. The spread of groundwater is at a depth of approximately 6.7 meters to 11.8 meters on subsurface level. Groundwater is spread on saturated gravel.
3. The groundwater drilling points is recommended at for the fourth point with coordinate $7^0$56’15, 9”S 112035’31, 9”E for the first point, $7^0$56’15, 7”S 112035’30, 5”E for the second point, $7^0$56’13, 3”S 112035’32, 3”E for the third point, and $7^0$56’13, 2”S 112035’31, 0”E for the fourth point. The depth of drilling for all four points ranged from 9 to 11 meters below the surface level.

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