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VERTICAL ELECTRICAL SOUNDING TO IDENTIFY THE DEPTH OF GROUNDWATER IN TANAH MAS AREA, NORTH SEMARANG, SEMARANG CITY

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ABSTRACT

Water is the most of basic needs of living things. The need of water tends to increase for daily life, industrial agricultural, and livestock. Due to of population growth, the need of residential areas has increased. This mean that water consumption increased so the amount of water has become limited. This study aimed to identifying the depth of groundwater in Tanah Mas area, North Semarang, Semarang City. This study used the VES resistivity geoelectrical method with Schlumberger configuration. In Schlumberger configuration, the voltage electrode distance is much smaller than the current electrode distance. Research data were taken by *Resistivitymeter* Naniura NRD 22 S in five locations with stretch length of 200 meters. Data were processed using *Microsoft Excel, Ip2win,dan Rockworks* softwares. The result of this study were found rock layers below the surface consists oftop soil, clay and sand layers. The groundwater were found is a shallow aquifer which isbelieved to be in the sand layer from 9.92 to 37.70 meters depth. 2D and 3D form were modeled to explained the distribution and depth of groundwater.

Keywords: VES, resistivity, groundwater.

INTRODUCTION

Humans and all living things on earth need water. Water is source life for the earth, because all living organisms are composed of cells that contain water (Kodoatie, 2008). Ground water is used as a water supply for humans (Bahri *et al.*, 2017). Urban development of Semarang city has *grown* rapidly, one of them is industrial sector. The presence of these industries certainly increased the used of groundwater, which, if out of control would lead to environmental degradation, namely a decreased in ground water reserves and would have an impact on the presence of groundwater for raw water needs of people around it.

Based on Putro's researched (2016), it was stated that in Tanah Mas Residence had been sea water intrusion. In general, sea water intrusion has been detected in the northern, eastern and southern area of Tanah Mas Residence with an intrusion depth from 19 to 26 meters above ground surface (Supriyadi *et al*., 2107). It fears a clean water crisis will occur in the future. In order to anticipate the need for raw water, irrigation and industrial, geological surveys should be conducted to identify the depth of groundwater.

The method used in this researched is geoelectrical method. The geoelectrical method is one of the method in geophysics that studies the characteristics of electricity by flowing DC (*Direct Current*) with high voltages on the ground. This geoelectrical method is also a quite widely used, and the results were quite well used (Bisri, 1991). This geoelectrical calculation based on the fact that different materials would have different types of resistance when electric current is flowed. The use of *Vertical Electrical Sounding* (*VES*) has become very popular in groundwater exploration due to its simplicity (Abdullahi *et al*., 2014). In addition for being simple and effective, these techniques also require simple interpretation in groundwater research (Adelusi *et al.,* 2014). Studies around the world also stated the importance of this method in solving groundwater problems (Hussain *et al.,* 2017).

This study aimed to identifyingthe depth of Groundwater used vertical electrical sounding method. Resistivity is one of the physical characteristic that belong to rocks, that is, the ability to pass electricity, if rocks more difficult to pass through electric current, then it becomes more resistivity (Suyanto & Utomo, 2014). Earth's resistivity related to the type of mineral, fluid content and the degree of water saturation in the rock. The commonly used method in resistivity measurement in generally by injecting an electric current into the earth using two current electrodes (A and B), and measured potential differences with two potential electrodes (M and N) as shown in Figure-1.

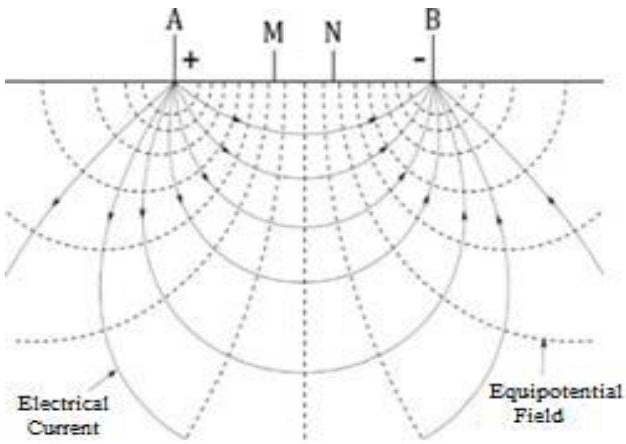

Figure-1. Equipotential surface and direction of electric current due to two current sources (I and - I) on a homogeneous earth surface (Reynold, 1997: 425).

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The potential difference between MN caused by current injection at AB is:

$$\Delta V = V_M - V_N = \frac{\rho I}{2\pi}\left\{\frac{1}{AM} - \frac{1}{BM} - \frac{1}{AN} + \frac{1}{BN}\right\}$$

$$\rho = \frac{2\pi}{\left\{\frac{1}{AM} - \frac{1}{BM} - \frac{1}{AN} + \frac{1}{BN}\right\}}\frac{\Delta V}{I}$$

With,

$$K = \frac{2\pi}{\left\{\frac{1}{AM} - \frac{1}{BM} - \frac{1}{AN} + \frac{1}{BN}\right\}}$$

$$K = \frac{2\pi}{\left(\frac{1}{AM} - \frac{1}{BM}\right) - \left(\frac{1}{AN} - \frac{1}{BN}\right)}$$

Then,

$$\rho = k\frac{\Delta v}{I}$$

K is a correction factor due to the location of the potential electrode and the current electrode.

To get the apparent resistivity value of each layer, the electrodes has arranged in such a way that current and potential electrodes could be connected to each other. In principle, thefarther distance between electrodes, the deeper depth of theguess is obtained.

METHODOLOGY

This study was done with measured rock resistivity by ResistivitymeterNaniura NRD 22 S in 5 (five) location points that spread in Tanah Mas Residence, North Semarang Regency as shown in Figure-2.

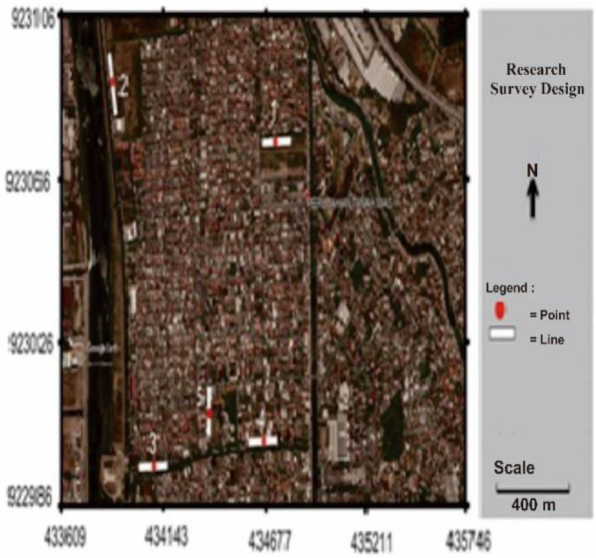

Figure-2. Location of measurement points for rock resistivity.

Dataresultof geoelectrical measurements were treated using Microsoft Excel software to calculate the apparent resistivity value, *Ip2win* software to processed, and *Rockworks* software to gained depth and groundwater distribution.

RESULTS AND DISCUSSIONS

Research data were taken by *Resistivitymeter* Naniura NRD 22 S in five locations with stretch length of 200 meters. The first location is coordinates 6^o 57'29.46 "LS and 110^o 24'31.74" BT. Data were processed using Microsoft Excel and *Ip2win* softwares. After data processed, the resistivity values and depths are shown in Table-1 below:

Table-1. Resistivity values and depths at 1st location.

Depth (meter)	Resistivity (Ohm meter)
0.00 - 1.00	20.10
1.00 - 4.09	7.39
4.09 - 18.00	0.67
18.00 - 32.10	11.50

The secondlocation is coordinates 6^o 57’24.26” LS dan 110^o 24’00.36” BT. After data processed, the resistivity values and depths are shown in Table-2 below:

Table-2. Resistivity values and depths at 2nd location.

Depth (meter)	Resistivity (Ohm meter)
0.00 - 1.31	49.70
1.31 - 9.92	0.37
9.92 - 25.22	6.26

The third location is coordinates 6^o 57’56,39” LS dan 110^o 24’09.31” BT. After data processed, the resistivity values and depths are shown in Table-3 below:

Table-3. Resistivity values and depths at 3rd location.

Depth (meter)	Resistivity (Ohm meter)
0.00 - 1.00	10.80
1.00 - 18.70	1.03
18.70 - 37.70	7.13

The fourth location is coordinates 6^o 57’52.76” LS dan 110^o 24’30.85” BT. After data processed, the resistivity values and depths are shown in Table-4 below:

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Table-4. Resistivity values and depths at 4th location.

Depth (meter)	Resistivity (Ohm meter)
0.00 - 2.17	10.80
2.17 - 6.76	0.19
6.76 - 11.97	24.00
11.97 - 29.97	0.08

The fifth location is coordinates 6° 57’51.49” LS dan 110° 24’21.34” BT. After data processed, the resistivity values and depths are shown in Table-5 below:

Table-5. Resistivity values and depths at 5th location.

Depth (meter)	Resistivity (Ohm meter)
0.00 - 2.05	6.06
2.05 - 6.81	1.21
6.81 - 14.14	0.32
14.14 - 27.24	4.70

Based on the results of field data that has processed and analyzed by comparing geological components such as morphology and geological map at Figure-3 of the researched location.

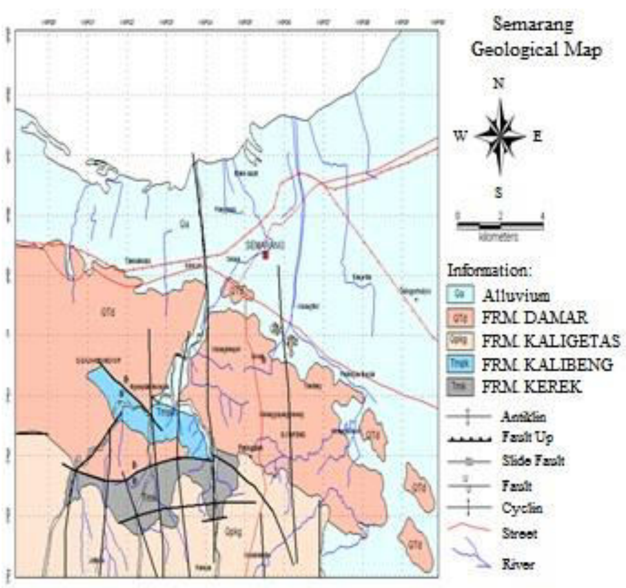

Figure-3. Semarang geological map.

It could be seen that the structure of rock types based on their resistivity values is shown in Table-6.

Table-6. Types of soil orrocks based on resistivity values at researched location.

Type of soil/ Rock	Resistivity (Ohm meter)
Top soil	6.06 - 49.70
Clay Filled Salt Water Clay	0.08 - 0.67 1.03 - 24.00
Sand Filled Groundwater	4.70 - 11.50

At the first location, it was suspected to have four types of soil. The layer is in the form of a top soil layer located in the housing to a depth of 1.00 m with a resistivity value of 20.10 Ωm. The clay layer is at a depth of 1.00 m to 4.09 m with a resistivity price of 7.39 µm. The clay layer containing salt water is at a depth of 4.09 m to 18.00 m with a resistivity value of 0.67 Ωm. Water-filled sand layer is at a depth of 18.00 m to 32.10 m with a resistivity value of 11.50 Ωm.

At the second location, it is suspected that there are three types of soil layers. The top soil layer is in the housing to a depth of 1.31 m with a resistivity value of 49.7 µm. The clay layer containing salt water is at a depth of 1.31 m to 9.92 m with a resistivity price of 0.37 Ωm. The water-filled sand layer is at a depth of 9.92 m to 25.22 m with a resistivity value of 6.26 Ωm.

At the third location it is suspected that it has three types of soil layers. The top soil layer is in the housing to a depth of 1.00 m with a resistivity value of 10.80 Ωm. The clay layer is at a depth of 1.00 m to 18.70 m with a resistivity value of 1.03 Ωm. A layer of sand filled with water that is at a depth of 18.70 m to 37.70 m with a resistivity value of 7.13 Ωm.

At the fourth location, it was suspected to have four types of soil. The top soil layer is in the housing to a depth of 2.17 m with a resistivity value of 10.80 Ωm. The clay layer contains salt water at a depth of 2.17 m to 6.76 m with a resistivity price of 0.19 19m. The clay layer is at a depth of 6.76 m to 11.97 m with a resistivity value of 24.00 Ωm. The clay layer containing salt water is at a depth of 11.97 m to 29.92 m with a resistivity value of 0.08 Ωm.

At the fifth location it is suspected to have four types of soil layers. The top soil layer was in the housing to a depth of 2.05 m with a resistivity value of 6.06 Ωm. The clay layer is at a depth of 2.17 m to 6.81 m with a resistivity price of 1.21 Ωm. The clay layer containing salt water is at a depth of 6.81 m to 14.14 m with a resistivity value of 0.32 Ωm. Water-filled sand layer is at a depth of 14.14 m to 27.24 m with a resistivity value of 4.70 Ωm.

Below are the results of researched striplog data for each measured striplog points shown in Figure-4.

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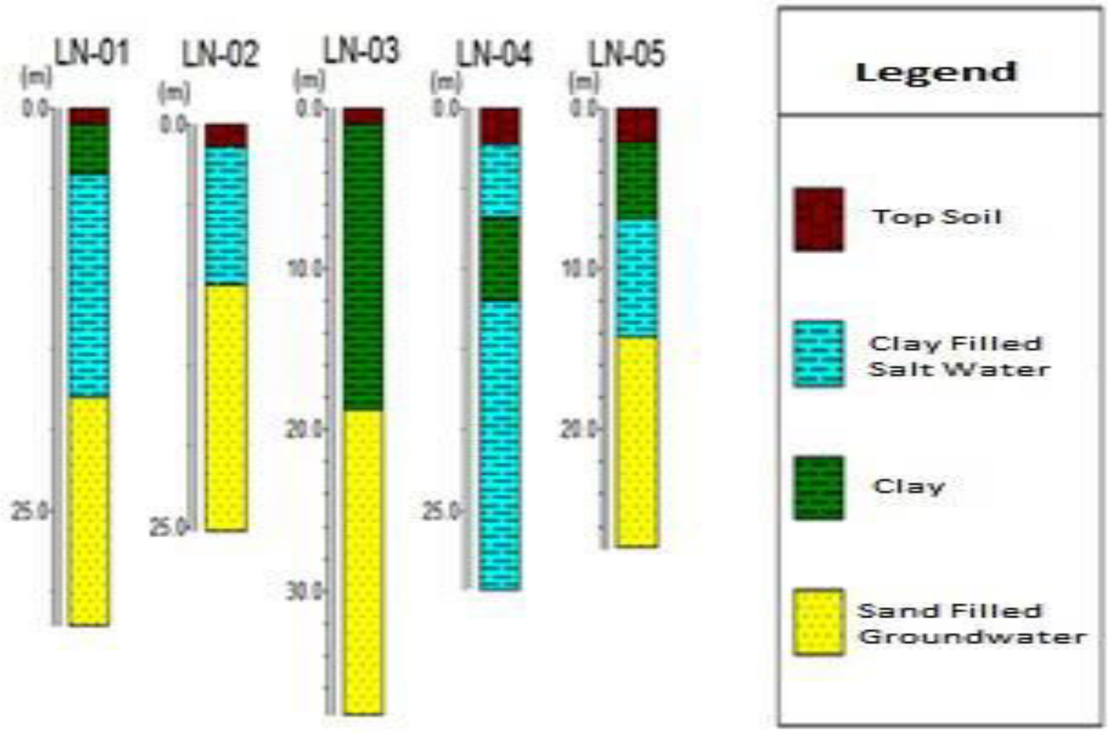

Figure-4. Striplog point.

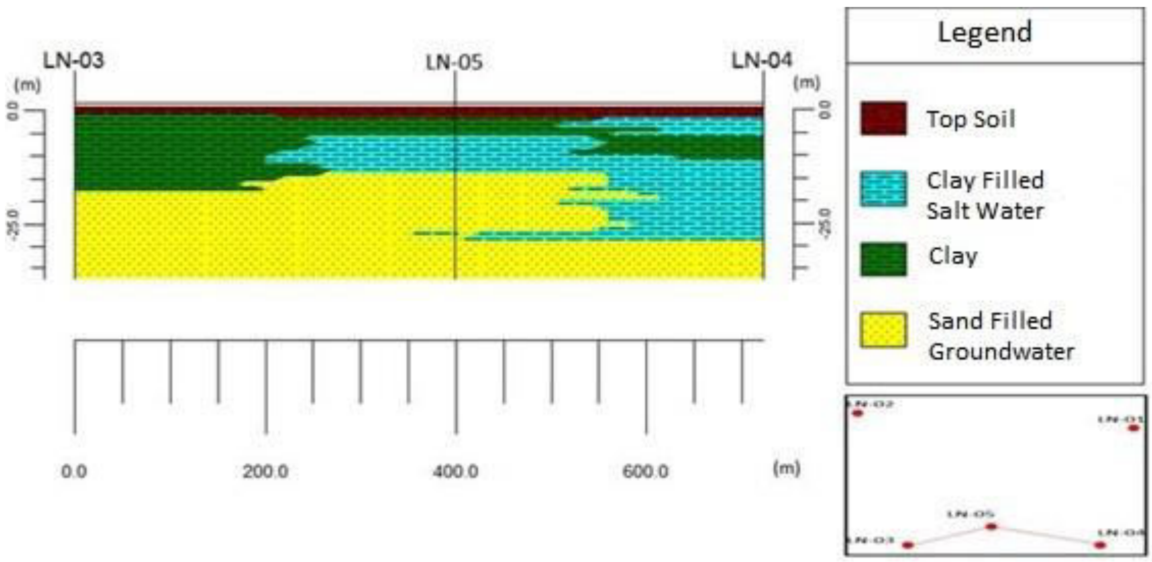

Figure-5. Cross section line 3, 5, and 4.

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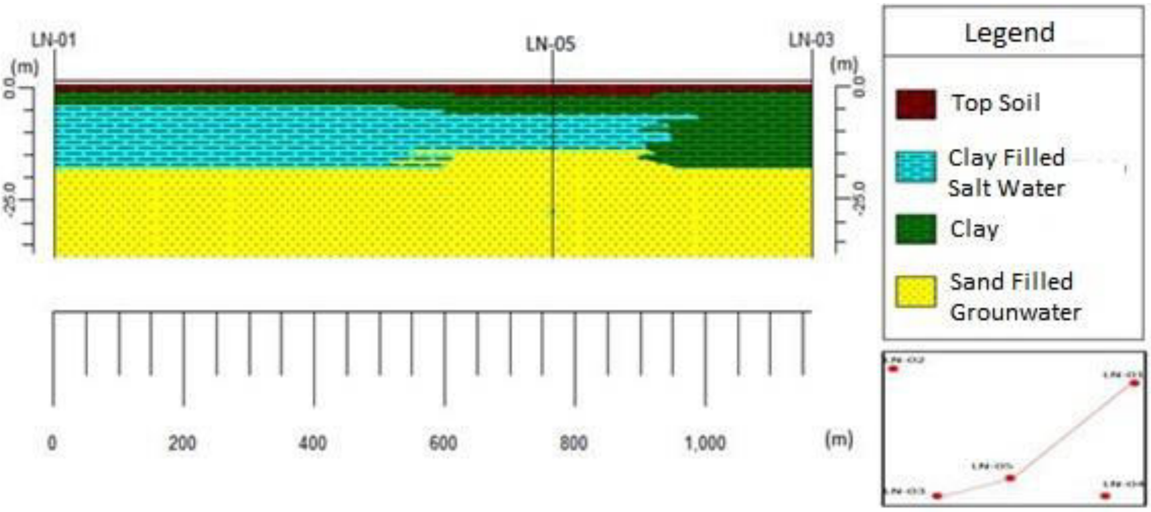

Figure-6. Cross section line 1, 5, and 3.

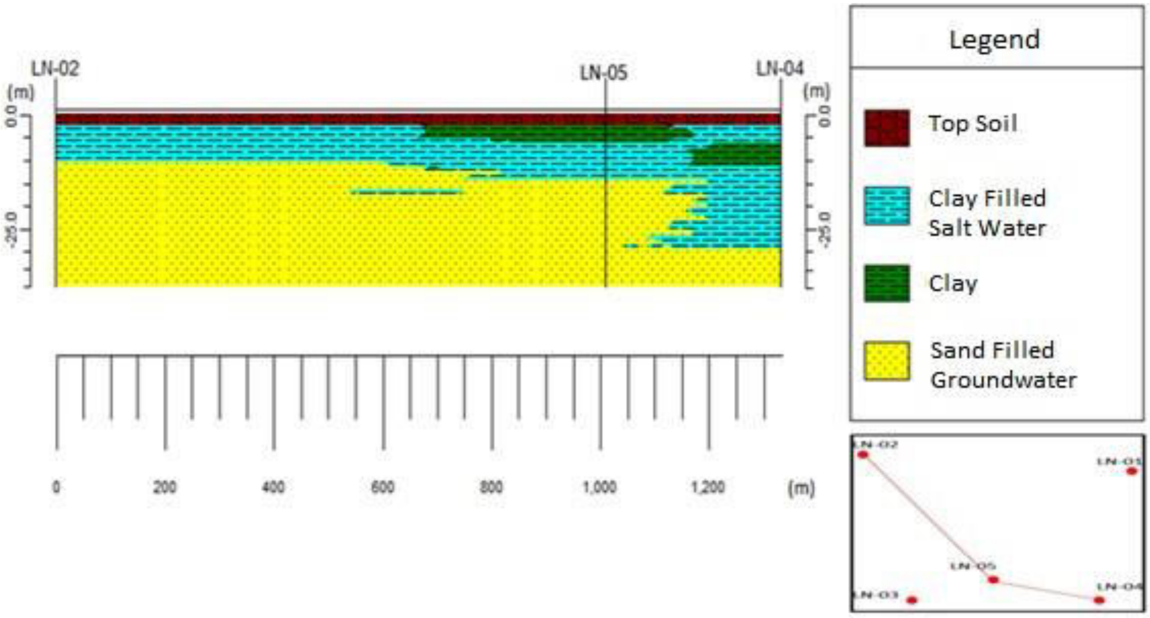

Figure-7. Cross section line 2, 5, and 4.

Figure-5 through 3 measured points included points 3, 5, and 4, an illustration seen through the rock formations which dominated by sand and variations in the clay layer inserted by sea water / salt water. Sand aquifer layer is known in three different depths and thicknesses. At points LN-03 aquifers, has found from 18.70 to 37.70 meters depth with 19.00 meters thickness. At the point LN-05 sand layer, has found from 14.14 to 27.24 meters depth with 13.10 meters thickness. At the point ofLN-04 aquifers has found from 29.97 to 35.00 meters depth with 5.03 meters thickness.

Figure-6 the measured points stretched from the northeast towards the southwest. At points LN-01 aquifers, has found from 18.00 to 32.10 meters depth with 14.10 meters thickness. At the point LN-05 sand layer, has found from 14.14 to 27.24 meters depth with 13.10 meters thickness. At points LN-03, aquifers has found from 18.37 to 37.70 meters depth with 19.00 meters thickness.This type of aquifer is a shallow aquifer.

Figure-7 the measured points stretched from the north west towards the southeast. At points LN-02, aquifers has found from 9.92 to 25.22 meters depth with 15.30 meters thickness. At the point LN-05 sand layer, has found from 14.14 to 27.24 meters depth with 13.10 meters thickness. At points LN-04 aquifers, has found from 29.92 to 35.00 meters depth with 5.08 meters thickness.This type of aquifer is a shallow aquifer.

3D modeling was carried out to gain prediction model of a wider distribution pattern in all researched location. 3D model is the result of interpolation at the entire measured points of the researched location.

Below is the result of 3D model which is intended for the display from southwest shown in Figure-8.

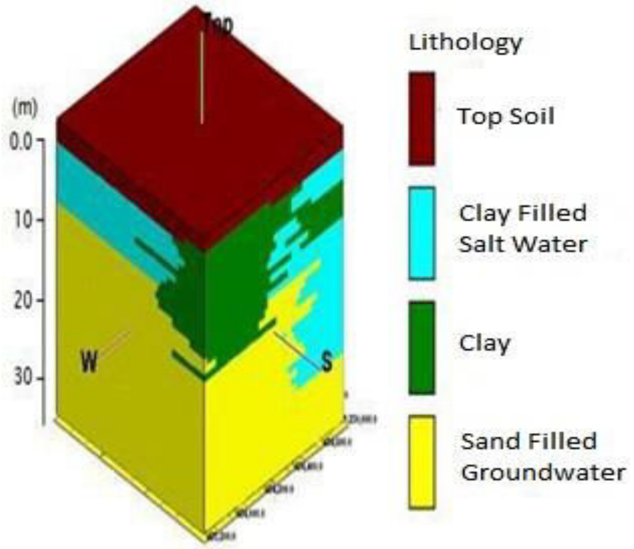

Figure-8. Regional 3D lithology model (from the southwest side).

Based on Figure-8, the lithology in researched location is mostly clay and sand units. The presence of groundwater or aquifer is estimated to be in the sand lithology units.The sand lithology has good porosity and permeabilityvalues.The holes in the sand are filled with fluid.The presence of aquifers is spreaded almost in all researched location, that means indicated that location has good groundwater prospects. Below is the distribution and depth of groundwater in sand layer for the view from the southeast side, shown in Figure-9.

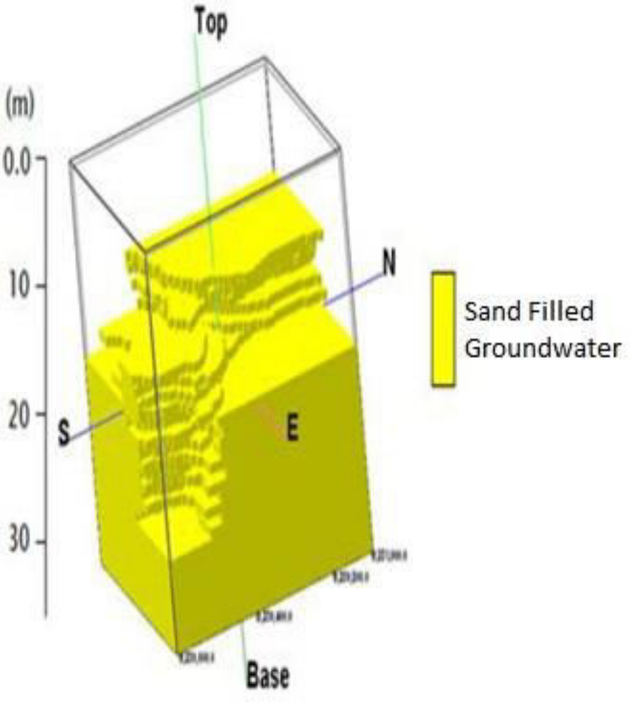

Figure-9. 3D model of water distribution soil in sand layer (from the southeast side).

From Figure-8 and Figure-9, it is known that there is one type of groundwater aquifer, which is a shallow aquifer not depressed in the Tanah Mas Residence, North Semarang Regency, Semarang City. These aquifers has distributed at different depths.

It is assumed in this area there was a equal distribution due to all of the researched location found the similar groundwater aquifers.The selection of research points is based on equal distribution and possible conditions from the location. Therefore, the data represented the whole areas of Tanah Mas Residence. The areas also include an Alluvium forms consist of top soil, clay, and sand layers. The depth of shallow groundwater aquifers is from 9.92 to 37.70 meters depth.

CONCLUSIONS

Based on the data researched and discussion about the depth of ground water used geoelectrical method in Tanah Mas Residence, North Semarang Regency, Semarang City it can be concluded: The presence of groundwater is from 9.92 to 37.70 meters depth and the sub-surface layer are composed of top soil, clay contain salt water, clay, and sand filled with groundwater layers.

REFERENCES

Abdullahi M. G., Toriman M. E. & Gasim M. B. 2014. The Application ofVertical Electrical Sounding (VES) For Groundwater Exploration in Tudun Wada Kano State, Nigeria. International Journal of Engineering Research and Reviews. 2(4): 51-55.

Adelusi A. O., Ayuk M. A. & Kayode J. S. 2014. VLF-EM and VES: an application to groundwater exploration in a Precambrian basement terrain SW Nigeria. Annals of Geophysics. 57(1): 1-11.

Bahri F. A., Rismayanti H. F. & Warnana D. D. 2017. Groundwater Analiysis Using Vertical Electrical Sounding and Water Quality Tester in Sukolilo Area, Surabaya, East Java: Significant Information for Groundwater Resources. IPTEK Journal of Proceedings Series. 2(2): 74-78.

Bisri M. 1991. Groundwater Flow. Malang: Brawijaya University Press.

Hussain Y., Ullah S.F., Akher G. & Aslam A. Q. 2017. Groundwater quality elevation by electrical resistivity method for optimized tubewell site selection in an ago-stressed Thal Doab Aquifer in Pakistan. Modeling Earth Systems and Environment. 3(1): 1-9.

Kodoatie J. K. 2012. Groundwater Layout. Yogyakarta: Andi.

Putro, A. S. P., Supriyadi & Khumaedi. 2016. Application of 3D Resistivity Method for Distribution of Seawater Intrusion in the Tanah Mas Residential North Semarang. NATURAL B. 3(4): 298-302.

ISSN 1819-6608
ARPN Journal of Engineering and Applied Sciences

Reynold J.M. 1997. An Introduction to Applied and Environtmental Geophysics. England: Jhon Wiley & Sons, Ltd.

Supriyadi Khumaedi & Putro A. S. P. 2017. Geophysical and Hydrochemical Approach for Seawater Intrusion in North Semarang, Central java, Indonesia. International Journal of GEOMATE: geotechnique, construction material and environment. 12(31): 133-139.

Suyanto I. & Utomo A. S. 2014. Analisis Data Resistivitas Dipole-dipole UntukIdentifikasi Dan Perhitungan Sumber Daya Asbuton Di Daerah Kabungka, Pasarwajo, Pulau Buton, Sulawesi Tenggara. Jurnal Fisika Indonesia. 17(50): 1-7.