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Study of Geohydrology Potential of Urban Area in Sumbersari District of Jember Regency, Indonesia

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Study of Geohydrology Potential of Urban Area in Sumbersari District of Jember Regency, Indonesia

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ABSTRACT

The increase of population, housing facilities and infrastructure in Sumbersari District of Jember Regency is significant in 2012. This causes groundwater to raise sharply exploits of 200 liters/ second to 800 liters/second. The long-term goal of this research was to determine the potential magnitude of groundwater in order to obtain the maximum threshold of groundwater exploitation. The specific target of this research is to obtain the distribution or flow of groundwater in the urban zone. Prediction methods groundwater Geo electric potential is subsequently performed using analysis tools for the interpretation of the Geo hydrological condition Ip2WIN computing based programs. Stages activity is the collection of map of urban Geo hydrological study, daily rainfall data collection station at least 3 rain, field investigations by means of geoelectric Schlumberger configuration in 4 area stretching east-west and north-south, the analysis of data in the laboratory with computational software IP2WIN, calculation of the availability of groundwater, water balance calculation. The Result showed that the maximum limit on the amount of groundwater exploitation that groundwater sustainability awake and anticipating water shortages or drought is approximately 2494.125 liter/sec, assuming groundwater making 5 liters/sec in the groundwater wells that may be performed in the District Sumbersari District Jember is a maximum of 500 groundwater well.

.***Key Words:*** *Groundwater, Geohydrology, Geo electric.*
_____

1. INTRODUCTION

Availability of clean water that can be utilized by neighborhood is one of the natural resources which has to be renewed. The utilization is done by human population all over the world, especially by the population in Sumbersari District, Jember Regency. Clean water can be collected from the utilization of surface water available such as rivers and lakes. In addition to surface water, ground water is also can be used as source of clean water. Availability of water resources can not be unrelated from the hydrology cycle. Hydrology cycle can be described as every deformation and movement of water from the atmosphere, land surface or ground water as a dependent complex system (Kodoatie, 1996).

All the system in the cycle is controlled by sun incoming radiation or sun outgoing radiation. Detailed process of hydrology cycle is as follows: before reaching the surface of soil, some of the rain water is blocked by the vegetation and the other falls to the land surface through the leaves gaps or flows down through the tree barks. Small part of it will be evaporated immediately to the atmosphere. Some of the rain water that reaches the soil surface will undergo infiltration and the other will flow down as surface run off to the lower elevation. The infiltrated water will flow horizontally or vertically, forming ground water. Ground water is water which occupies the cavities in geological layers. Soil layers under ground water surface is called saturated zone, meanwhile unsaturated zone is usually above the saturated zone to the soil surface, where cavities are filled with water and air. Because water is incluing soil moisture inside the root zone, thus this means so important to the farming, botany and geotechnical engineering. There is no clear boundary between the saturated and unsaturated zone because both has interdependent boundary, which water from both zone can move towards each other (Soemarto, 1987). Ground water also can be described as water under soil surface. One of the soil water sources is infiltrated rain water, which flows down through the cavity between soil grains. This water can effect soil properties related to settlement, foundation stability, slope stability et cetera, especially for the fine grained soil (Utomo, 2005).

The availability of underground water (in aquifers) has a strategic role. In terms of utilization, ground water can be carried out immediately according to current needs by pumping techniques through boreholes, as well as surface water utilization. In the storage side, ground water can actually have a value of reserve quantity in a much larger amount than surface water, in accordance with the volume of the existing aquifer, and is not lost by evaporation or not easily contaminated. In addition to the reserve quantity value, underground water quality can be maintained properly due to the physical and chemical filtration and cleaning process by soil and rock media. If surface water always correlates directly with rainfall and evaporation and also surface runoff into the sea through rivers, it is not the case for the ground water. Underground water is actually a long-term clean water reserve that supports the preservation of clean water reserves in an area.

Exploitation of the potential of groundwater sources in the Sumbersari District District of Jember Regency has been carried out through groundwater drilling at several points both by individuals, private and government agencies. However, the water discharge generated at some points has been felt to be insufficient to meet water needs. To meet the need for clean water, it is necessary to know the potential of groundwater and the potential of underground water content from sources of groundwater that can be drilled. Thus, it is necessary to search for more potential and ground water sources. This can be discovered through investigation of the local geological conditions and the determination of the physical condition of the subsurface. On the other hand, exploitation of ground water must be balanced with efforts to conserve ground water reserves. This conservation effort is carried out to maintain the sustainability of groundwater sources that can be exploited. With the presence of well-maintained forests on the surface, the sustainability of ground water reserves in aquifers can also be maintained. This conservation must also be supported by the availability of aquifer potential data such as the position of aquifers under the earth's surface, aquifer thickness, aquifer permeability. Especially, to find out the availability of groundwater potential data that can be used directly and to support efforts to conserve the groundwater resources, investigations into the existence and dimensions of aquifers in the Jember Sumbersari Region are carried out. Based on the lithology, the aquifer is divided into 4 (Davis, 1966): free aquifer, stressed aquifer, leaking aquifer and hanging aquifer. Types of aquifer can be illustrated as in the figure below:
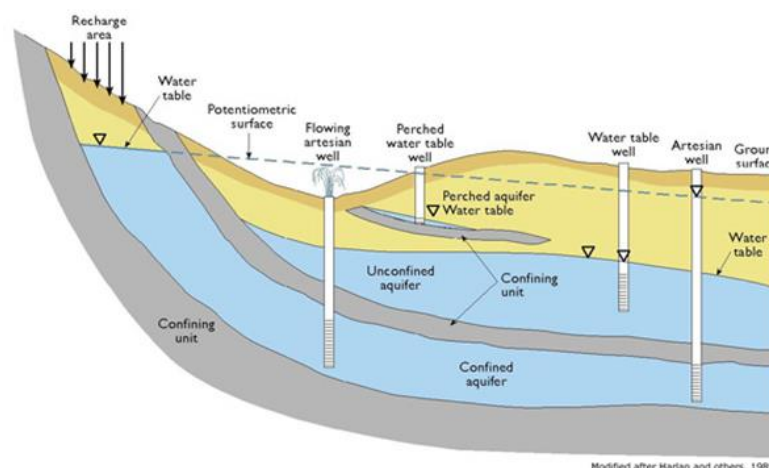

Figure 1. Types of aquifer

Thus, we need to know the existence and potential of aquifers, as a storage medium for water under the ground surface. But until now, the potential availability of clean water that can be stored in aquifers under the earth's surface in Jember Regency is not well known, because the distribution and position and dimensions of the aquifer and the connection between aquifers are not well known. Mapping of aquifers in this investigation area needs to be done as an effort to provide basic data on the determination and utilization, and also the development of underground water potential. The mapping is carried out through this investigation by collecting secondary data about the geological and geohydrological conditions of rock layers and supported by local geological observations in the field and equipped with electrical measurements of the ground. The ground's electrical measurements are carried out to determine subsurface physical conditions and determination of the distribution pattern and thickness of aquifers. This electrical method has proven its reliability in determining groundwater carrier layer (aquifer) below the earth's surface. Geoelectric surveys can be used to indirectly determine the presence, position and dimensions of geological material beneath the surface, for example: depth of surface material, depth of groundwater level, location of faults, thickness and evaluation of gravel sediments or clay layers (Fetter, 1988 : 485). The geoelectric method is believed to be the best method in the subsurface hydrogeological investigation. Here is the principle of the geoelectric method: each geological material has different types of electrical resistance. Resistivity of geological material is influenced by the ability of the rock to store water, ground water content, porosity and water quality and the type of material itself. By using geoelectric methods and studying geological and

geohydrological conditions, mapping of underground water aquifers in Jember Regency can be done to meet the need for clean water.

2. RESEARCH METHODOLOGY

In this research, things we have to do in order to determine the location of a groundwater aquifer are location survey, finding out the general description of the investigation area, geological conditions, the conditions of the investigation area's geological hydro and exploration of *Vertical Electrical Sounding* (VES) geoelectric resistance. To get an overview of the subsurface structure, geophysical exploration is carried out by *Vertical Electrical Sounding* (VES) geoelectric resistance method with Schlumberger configuration. The technical implementation of this research is as follows:

2.1 Preparation Phase

Before conducting the exploration process, the preparation stage must be carried out, the stages are the location of measurement survey and the determination of the path for Geoelectric measurements. The next preparation is planning the field measurements. This is related to the acquisition design which is associated with the desired depth target and data accuracy. Because each location has different characteristics, the acquisition must be designed appropriately to get maximum results.

2.3 Exploration Phase

In this investigation, geoelectric measurement with *Vertical Electrical Sounding (VES)* method in Schlumberger configuration is used. This method is used to determine the change in type resistance value for each layer in a measurement point. Whereas the measurement is done by installing 4 electrodes (2 current electrodes and 2 potential electrodes) which are placed parallel in a straight line like Figure 8. with certain space. Geoelectric data acquisition is carried out by injecting an electric current into the subsurface to get a response from the subsurface in the form of electrical voltage. In retrieving the data with this Schlumberger configuration VES method, the equipment used is Campus Tigre Resitivity-meter brand, 4 cable rolls with a length of about 600 meters each, current electrodes and potential electrodes of 2 pieces each (Figure 2.) and some supporting equipments as follows: tape measure, geological compass, slice hammer, *Global Positioning System* (GPS), and some handy talkies.
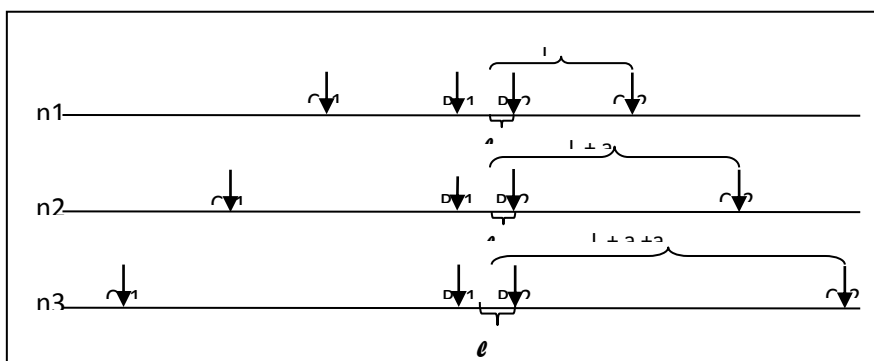

Figure 2. Transfer of Schlumberger configuration electrodes

Figure 3. *Resistvity-meter Equipment*

2.4 Data Processing Phase

The data obtained is done by geometric correction at the field according to the distance / spacing of the track. Then data processing is done using Ipi2WIN Software - Resistyvity Sounding Interpretation from Moscow State University. The results of data processing obtained are in the form of resistivity values for each layer at a certain depth. The data obtained from the acquisition process is used as an input to geoelectric processing software. Nevertheless, it needs to be done first in the geometry

correction process for each field data. The processing result is in the form of a resistivity distribution. Color images that describe the type of distribution of resistance provide information about the content contained in the subsurface structure. The sample of data processing result is provided in Figure 4.
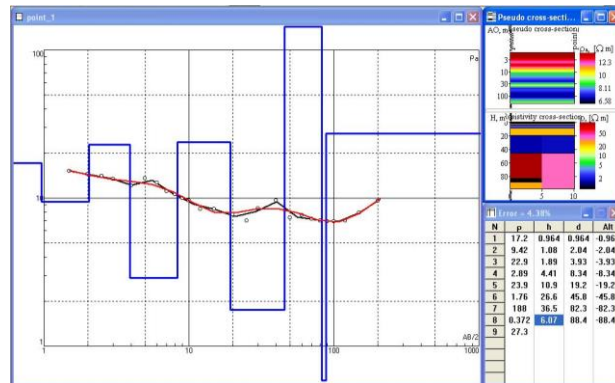

Figure 4. Examples of the results of processing VES using Ip2Win

From the results of data processing using IP2WIN software, the distribution and 3-dimensional groundwater aquifers can be described using Rock Work 2006 software from Rock Ware Incorporated and also by using this software, we can get the volume of aquifer layers, so that we can estimate how much water content we have. Examples of lithological and groundwater aquifers can be seen in Figure 5. and Figure 6.
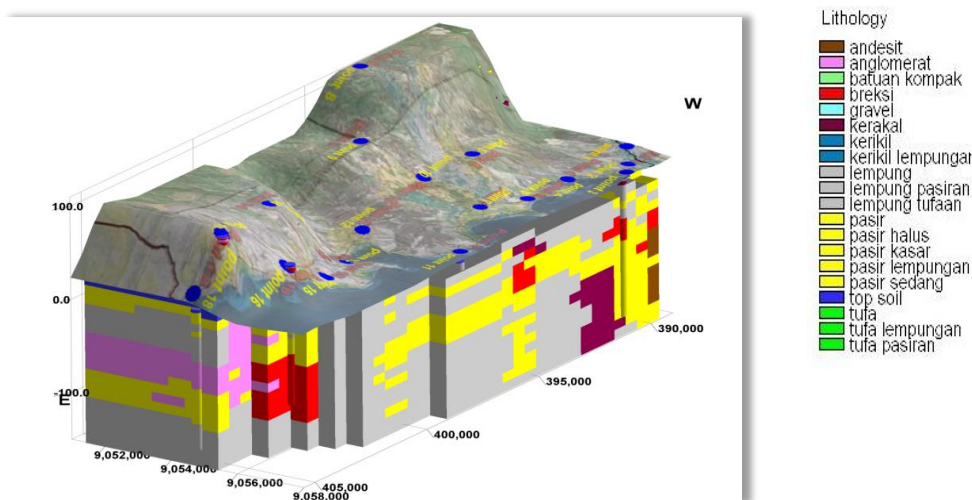

Figure 5. lithological distribution of rock "the cylinder that slopes down is sounding data or drilling data
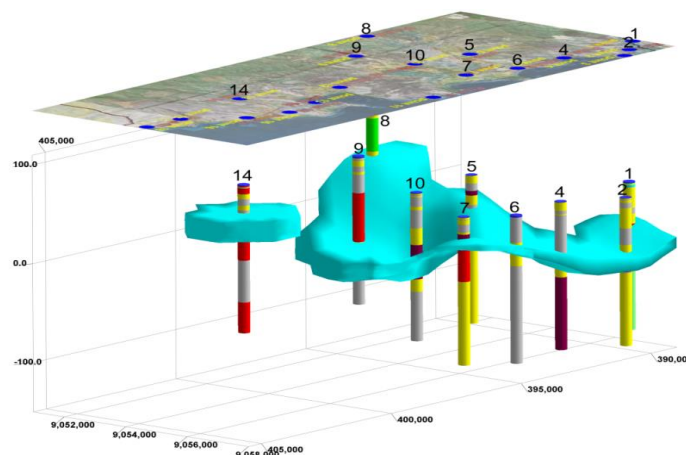

Figure 6. Distribution of ground water aquifer

3. RESULTS AND DISCUSSION

3.1 Data Collecting

Data can be collected in the free area and far from densely populated area, but still in the urban area and administratively located in Sumbersari District, Jember Regency. Geoelectric tools are used to estimate groundwater by processing data using IP2Win software. Estimation using geoelectric devices is done at only a point with data collection distance intervals at 25 m, 50 m, 100 m, 200 m and 500 m.

3.2 Research Location and Measurement Results

In the figure below, there are 4 red dots that point some locations of geoelectric experiment. The locations are as follows: Akbid Bina Husada Jember, Gor Polikteknik Negeri Jember, RRI Jember and Jember military police headquarter. Data which is collected around Akbid Bina Husada area in Sumbersari District, Jember Regency in the form of type resistance measurement as provideed in the table below is from the geoelectric experiment. One of the examples is the first dot as follows.
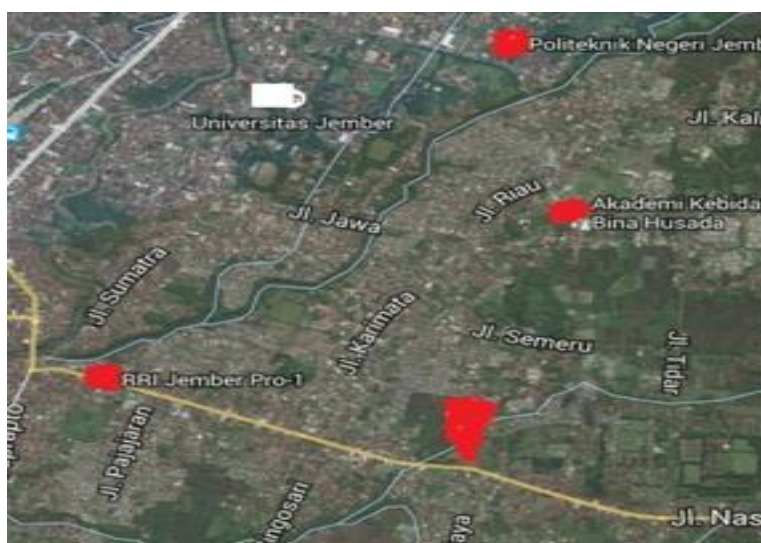

Figure 7. Geoelectric Exploration Location

Table 1. Type Resistance Measurement Result from Point 1 (Schlumberger)

a/2 / L/2	0,5	5,0	10	25	v	I	RHO (v/i)*k
1.5	6,28				0,866	78,000	0,070
2.0	11,8				0,436	79,000	0,065
2.5	18,8				195,600	70,000	52,533
3.0	27,5				3,800	75,000	1,393
4.0	49,5				63,000	73,000	42,719
5.0	77,8				19,300	61,000	24,615
6.0	122,3				5,200	64,000	9,937
8.0	200,3				4,500	62,000	14,538
10.0	313,4				4,100	73,000	17,602
12.0	451,6				4,100	76,000	24,363

15.0	706.1	62,8		4,200	89,000	2,964
20.0	1255	177,8		2,000	61,000	5,830
25.0	1962	188,5		10,300	56,000	34,671
30.0	2826	274.9	125,7	22,400	75,000	37,542
40.0	5025	494.8	236,6	40,600	315,000	30,495
50.0	7853	777.5	377	31,450	410,000	28,919
60.0	11309	1123	549,8	23,500	378,000	34,181
75.0	17671	1759	867.9	314,1	26,550	381,000	21,888
100	31415	3133	1555	589	9,150	262,000	20,570
125		4900	2438	942,5	2,700	168,000	15,147
150		7060	3518	1374	2,300	141,333	22,360
200		12558	6267	2474	1,650	366,000	11,153
250		19627	9800	3887	11,950	506,000	91,798
300		28266	14121	5615	6,367	504,000	70,930

3.3 Data Processing

According to the value or rock resistance in the measurement area, the value of the apparent type of resistivity at the measurement point at a certain depth can be found (as described in the literature review chapter). From the value of the apparent type of resistivity that has been obtained and processed using the IP2WIN Software, we can get the type of resistance value at each layer at a certain depth.The results of processing G1 measurement point data using IP2WIN Software can be seen in Figure 3. The figure shows the value of each soil layer in a certain depth. The graph shows 3 colors which are black that indicates the measurement data in the field, red indicates the layer at each depth, and the blue one as shown in the form of numbers on the corner of picture. Those numbers represent ρ (type resistance in each layer), h (layer thickness), and d (depth for each point). Resisitivity values or types resistance from each layer obtained will later be interpreted into certain rocks. Figure 8 shows results from the data processing of point 1, which is located around Akbid Bina Husada Jember, Sumbersari District, Jember Regency. Data processing is done using software IP2Win.
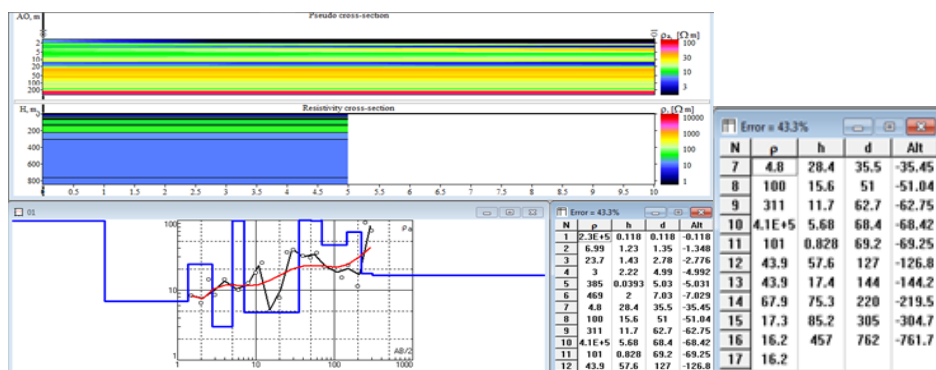

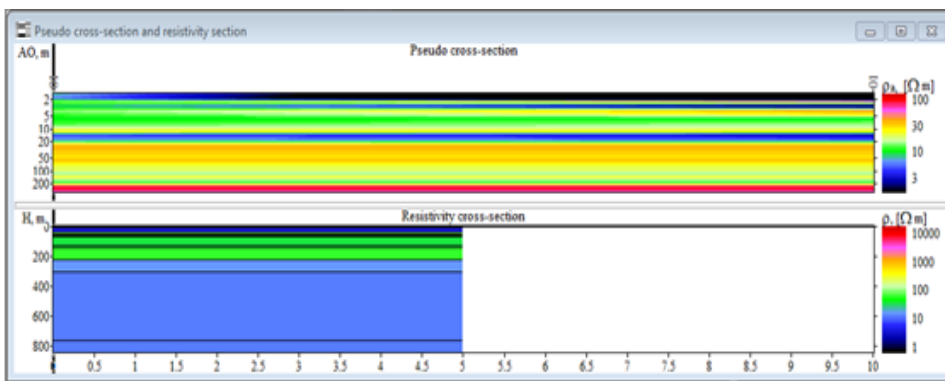**Figure 8. Data processing results Using IP2Win Software at Point 1**

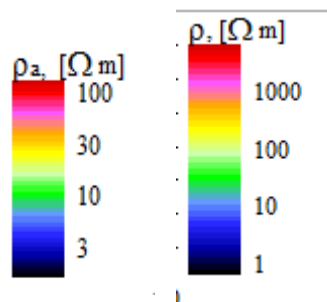**Figure 9. Geoelectrical Resistivity at Point 1**

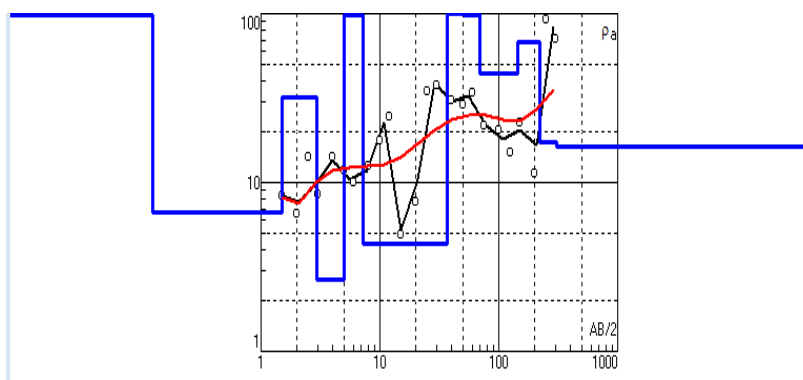**Figure 10. Colors That Show Resistivity Value at Point 1**

Figure 11. Geoelectric Matching Curve Method at Point 1

Figure 12. Resistivity Output of Each Layer at Point 1

N	ρ	h	d	Alt		N	ρ	h	d	Alt
1	2.3E+5	0.118	0.118	-0.118		7	4.8	28.4	35.5	-35.45
2	6.99	1.23	1.35	-1.348		8	100	15.6	51	-51.04
3	23.7	1.43	2.78	-2.776		9	311	11.7	62.7	-62.75
4	3	2.22	4.99	-4.992		10	4.1E+5	5.68	68.4	-68.42
5	385	0.0393	5.03	-5.031		11	101	0.828	69.2	-69.25
6	469	2	7.03	-7.029		12	43.9	57.6	127	-126.8
7	4.8	28.4	35.5	-35.45		13	43.9	17.4	144	-144.2
8	100	15.6	51	-51.04		14	67.9	75.3	220	-219.5
9	311	11.7	62.7	-62.75		15	17.3	85.2	305	-304.7
10	4.1E+5	5.68	68.4	-68.42		16	16.2	457	762	-761.7
11	101	0.828	69.2	-69.25		17	16.2			
12	43.9	57.6	127	-126.8						
13	43.9	17.4	144	-144.2						

3.4 Estimation Result Interpretation

Each rock has its own resistivity value characteristics, so that one rock with another will have different resistivity values. With the different resistivity values of each rock this can be used as a reference to determine certain types of rocks with certain resistivity values as well. Data processing using IP2WIN Software produces rock resistivity value (soil layer) at a certain depth, with the presence of resistivity values we can determine what rocks exist at one measurement point. By defining the rock at that point, then it will be possible to determine the location of the underground aquifer at one point. Underground water aquifers will occur if there is a soil layer which has a high permeability above or between the waterproof layers. Example of water-resistant soil layer is clay rock and a layer which water can pass through (has high permeability) is a sand rock. The results of the interpression of each measurement point G1, G2, G3dan G4 can be seen in the Table 2. Data interpression result is shown based on error or the smallest error rate as in point G2 with error rate 59.1%. Based on table 2. (correlation between resistivity value and types of rock), following is the result:

Figure 13 : Resistivity Output Table of Each Layer at Point 1

Table 4. The output of the IP2win Software program and the type of soil and rock in each layer

Layer	Error (%)	ρ (Ohm.m)	Layer Description	Thickness
Layer 1	43.3 %	2.8E+5	Top Soil	0 – 0.119
Layer2	43.3 %	5.21	Wet and Soft Silty Clay	0.119 – 0.719
Layer3	43.3 %	13.8	Silty Soil, Sandy	0.719 – 4.23
Layer 4	43.3 %	1.42	Wet and Soft Clay	4.23 – 5.11
Layer 5	43.3 %	520	Dry Soil Bedrock	5.11 – 533
Layer 6	43.3 %	171	Bloomed Bedrock filled with moist Soil	5.33 – 11.1
Layer 7	43.3 %	2.48	Clay Soil, Wet and Soft	11.1 – 26
Layer 8	43.3 %	100	Clay Soil, Wet and Soft	26 – 35.7
Layer 9	43.3 %	14580	Bedrock	35.7 – 66.9
Layer 10	43.3 %	4512	Bedrock	66.9 – 78.8
Layer 11	43.3 %	101	Ground Water	78.8 – 114
Layer 12	43.3 %	43.9	Clay Soil	114 – 127
Layer 13	43.3 %	43.9	Clay Soil	127 – 146

Layer 14	43.3 %	54.4	Clay Soil	146 – 220
Layer 15	43.3 %	17.3	Sand Soil	220 – 305
Layer 16	43.3 %	16,2	Sand Soil	305 -

3.5 Ground Water Profile

From the estimation point results, there are false interpretations between point 1, 2, 3, 4. Those mistakes happen at point 4, therefore the estimation result in this profile may be low in accuracy. Ground water profile can be obtained if we have done the geoelectricresearch. Figure 19 shows soil layer profile.
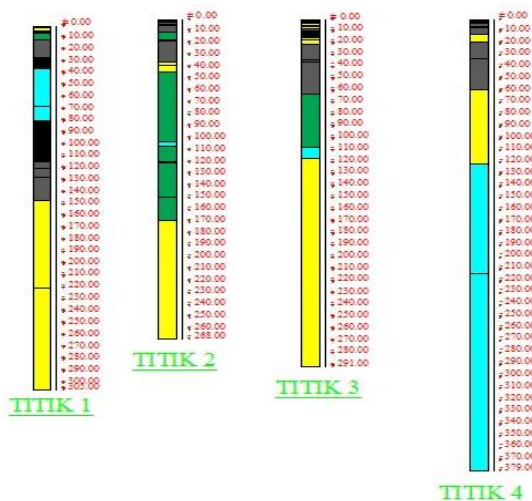

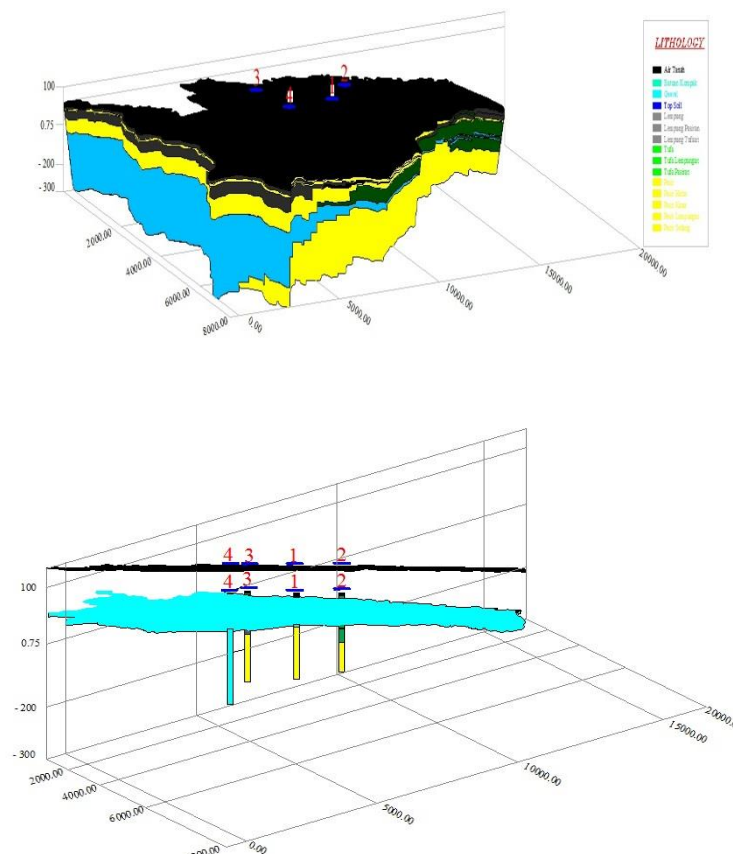
Figure 19. Soil Aquifer for Each Point

Figure 20. 2D image of lithological distribution of rock "the cylinder that slopes down is sounding data or drilling data".

Figure 21. 2D image of ground water aquifer distribution
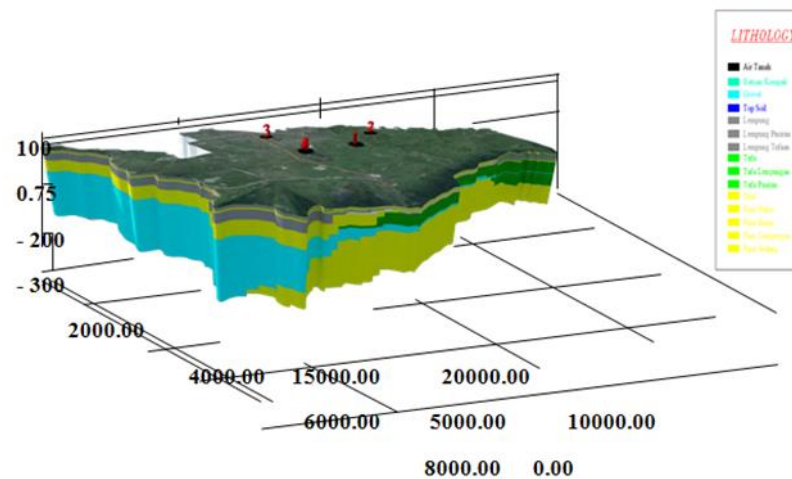
Figure 22. 3D image of lithological distribution of rock "the cylinder that slopes down is sounding data or drilling data"
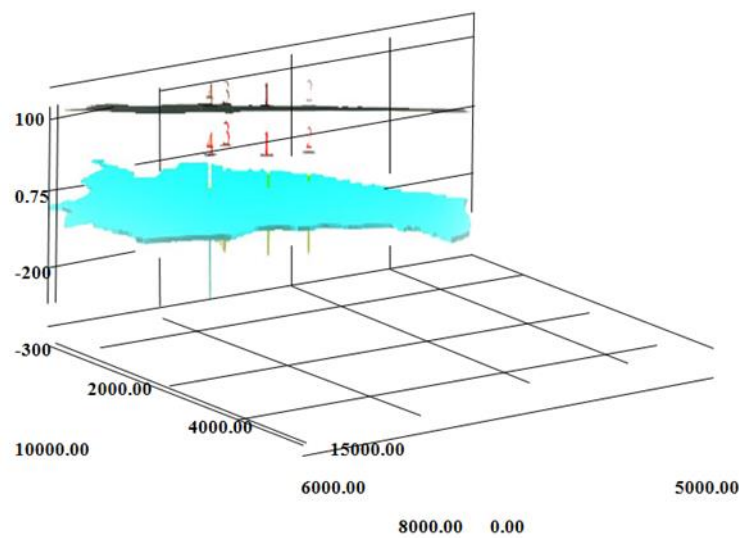

Figure 23. 3d image of ground water aquifer distribution

4. CONCLUSION

Based on the research result, data processing and discussion, conclusions can be obtained as follows: 1) The IP2WIN program can be used for resistivity estimation in urban area of sub-district of Sumbersari, Jember Regency. 2) From the results of geoelectric research, we can find out various types of soil layers in urban area of sub-district sumbersari jember regency. 3) The results of 2D and 3D geohydrology interpretation in urban area have been obtained from Sumbersari sub-district, Jember regency. 4) the result of the lowest depth resistivity is 268 m, the highest is 379 m with a maximum depth of 500 m. Some suggestions that need to be considered for geoelectric researchers including the following: 1) It is necessary to estimate rock resistivity with other software, for example with the res2Dinv program and arciView, 2) To get a better accuracy, geoelectric points need to be increased to 25 points. 3) It is necessary to add geoelectric points to a minimum of 25 points in the boundaries of Sumbersari sub-district, Jember regency.

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