Identification of aquifer potential by using resistivity method: A case study in Kedawung and Sambirejo district, Sragen, Central Java, Indonesia

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Abstract: It has been done geophysics survey by using resistivity method with Schlumberger configuration in Sambirejo and Kedawung subdistrict, Sragen regency, Indonesia. This research aims to identification of aquifer potential in those area. Totally there are 22 site surveys where 11 sites located in Sambirejo and 11 sites located in Kedawung subdistrict. Data collection was performed by using Resistivitymeter OYO McOHM-EL with length of current electrode from 1,5 meter up to 350 meter. Data processing was done by using IP2win software, while cross section was processed using Rockwork software.

The result shows that in Sambirejo subdistrict, the aquifer layer consist of clayey sand and sand, While in Kedawung subdistrict, The aquifer layers consist of clayey sand, sand, gravel sand, gravel and breccias. Identification of groundwater potential zones as good and very good category was show that the sounding point was have a huge of groundwater source for in Sambirejo subdistrict is TS2, TS5, TS7, TS8, and TS9 , while in Kedawung subdistrict is TS13, TS14, T15, TS16,TS17,TS18, TS19, TS20, TS21 dan TS22, respectively.

1. Introduction

Water is a vital requirement for living things, it is very importance for plants, animals and particularly human. Population growth and development in various fields will increase the needs for water. Groundwater is essential for drinking water, household, industrial, irrigation, mining, urban and more. At world level, groundwater was used 50% for drinking water, 20% for irrigation water, 40% for the needs of industry [3]. Water scarcity is problem for human and other living things.

Ground water is water that contained in a layer of soil or rock beneath the subsurface. It is water that moves in the soil contained in the space between grains of soil that seeped into the ground and joined to form soil layers called aquifers. An aquifer is a body of saturated rock through which water can easily move [12]. Aquifers must be permeable, porous and saturated. There are some common rock which is as a good aquifer, for instance sandstone, conglomerate, fractured limestone, unconsolidated sand, gravel and fractured volcanic rocks [1].

Sragen is a regency in Central Java province. The capital is located in Sragen, about 30 km eastern of Surakarta with coordinate 7° 15’ – 7° 30’ S and 110° 45’ – 111°10’ E. The total area of Sragen regency is
about 941.55 km² and is divided into 20 sub-districts. Within the past decade, every dry season, several villages in Kedawung and Sambirejo district, was always experiencing a shortage of water. The drought that hit in this area not only on agricultural land, but also springs or resident wells. Therefore, the search for ground water resources have become an important issue to villages was experiencing drought. This research was conducted to identified aquifer potential in Kedawung and Sambirejo district.

2. Method

Electrical Resistivity method is one geophysics method which is used in the investigation of groundwater. Some recent studies about detection ground water using Vertical Electrical Sounding (VES) method [4,5,6,7,8,9]. The VES is a geoelectrical method for measuring vertical change of electrical resistivity. The VES gives detail information on the vertical succession of different conducting zones or formations and their individual thickness and true resistivity below a given point on the earth surface [2]. The principle of VES method is injected electric current into the earth through two electrode currents. The potential difference that occurs is measured through two electrodes potential. The results of measurement of current and potential difference for each particular electrode spacing, can be determined variations of resistivity value below the measuring point (the point of sounding). The following equation is used to calculate the resistivity value [2]:

$$\rho_{\text{emu}} = K_{SC} \frac{\Delta V}{I}$$

(1)

$$K_{SC} = \frac{\pi (a^2 - b^2)}{2b}$$

(2)

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

Figure 1. Schlumberger array

C1, C2 and P1, P2 is current electrodes and potential electrodes, respectively.

3. Geology

Figure 2 shows regional geology map of Sragen regency where consist of six rock formations i.e. Kalibeng formation, Kabuh formation, Notopuro formation, Young Volcanic Deposits of Lawu and Alluvium deposits. The study area is located in Young Volcanic Deposits of Lawu, where composed by volcanic sandstone, volcanic silt-claystone, breccias and lava [11]. The survey location is located at Kedawung
Subdistrict and Sambirejo Subdistrict, Sragen regency, Central Java, Indonesian. it is lies at $7^\circ 27' - 7^\circ 32'$ S and $111^\circ 00' - 111^\circ 06'$ E.

Data acquisition was done by using Resistivity meter OYO McOHM-el model 2119C with length of maximum current electrode spacing (AB) is 700 meter. Amount of data as much as 22 points that is 11 sounding points in Sambirejo district and 11 sounding points in Kedawung district. The data obtained from the field surveys were processed to obtain the apparent resistivity.

**Figure 2.** Regional geology map [11]

**Figure 3.** Studi area. VES locations (black dotted), solid line with letter is cross section line. Inserted map is Java island.
4. Result and Discussions

Processing data is done by using partial curve matching techniques with IPi2win software which the outputs are resistivity values, thickness and depth of layer. Further step is interpretation of result by considering the geology of the study area and list of resistivity of rock, where the research areas located in the young volcanic deposits of Lawu mountain. These area are composed by sand stone, clay rocks and breccias. Lithology of the aquifer layer is detected in the form of clayey sand, sand, gravel sand, gravel, and breccias, while lithology of aquiclude layer is detected in the form of clay, sandy clay, and lava.

Table 1 shows the depth and thickness of aquifers in Sambirejo district. Aquifer layer in the Sambirejo district were found as much as 1 to 4 layers with variation in thickness. The aquifer layer consist of clayey sand and sand, clayey sand layer have thickness between 9.67 metre to 55.5 metre, while sand layers have thickness between 17.5 metre to 49.2 metre. Table 2, shows the depth and thickness of aquifers in Kedawung Subdistrict. Aquifer layer in the Kedawung Subdistrict were found as much as 1 to 4 layers with differentiation of thickness. The aquifer layers consist of clayey sand, sand, gravel sand, gravel and breccias. The thickness of clayey sand ranging from 22.3 to 50.4 meter, and sand layer have thickness range of 13.4 to 67.58 meter, gravel sand layer have thickness between of 28.1 to 44.76 meter, gravel layer have thickness of 6.9 to 49.3 metre, and breccias layer have thickness of 85.9 metre.

| VES | Location            | Depth (m) | Thickness (m) | Lithology    | Groundwater potential |
|-----|---------------------|-----------|---------------|--------------|-----------------------|
| TS1 | Geblak Musuk        | 32.2 - 55.3 | 23.1          | Sand         | Moderate              |
|     |                     | 55.3 – 107  | 39.6          | Clayey Sand  |                       |
|     |                     | 124-147    | 24.1          | Clayey Sand  |                       |
| TS2 | Sidoharjo Musuk     | 55.5 – 73.1 | 17.5          | Sand         | Very Good             |
|     |                     | 73.1 – 114  | 40.7          | Clayey Sand  |                       |
|     |                     | 114 -154   | 40.2          | Sand         |                       |
| TS3 | Gempol              | 30.5 – 58.4 | 27.7          | Sand         | Moderate              |
|     |                     | 58.4 – 71.9 | 13.5          | Clayey Sand  |                       |
|     |                     | 71.9 – 81.6 | 9.67          | Clayey Sand  |                       |
| TS4 | Gempol              | 16.8 – 41  | 24.2          | Sand         | Moderate              |
|     |                     | 104 – 128  | 24.3          | Clayey Sand  |                       |
| TS5 | Gempol              | 34.5 – 74.1 | 39.6          | Sand         | Good                  |
|     |                     | 74.1 – 114  | 39.9          | Clayey Sand  |                       |
| TS6 | Blimbing            | 23.1 – 78.4 | 55.5          | Clayey Sand  | Moderate              |
| TS7 | Daganggan Blimbing  | 32.77 – 58.16 | 25.39    | Sand         | Very Good             |
|     |                     | 113,37 – 168.3 | 54.96     | Sand         |                       |
| TS8 | Sidorejo Blimbing   | 33.74 – 81.54 | 47.8      | Sand         | Good                  |
| TS9 | Sidorejo Blimbing   | 23.95 – 58.75 | 34.80    | Sand         | Very Good             |
|     |                     | 101.63 – 148.29 | 46.66    | Sand         |                       |
| TS10| Jatiarum Kliro      | 71.54 – 110.25 | 38.71    | Sand         | Moderate              |
| TS11| Dawung Kliro        | 36.09 – 43.66 | 7.47     | Sand         | Poor                  |
|     |                     | 43.66 – 58.41 | 14.77    | Sand         |                       |
Table 2. Position, thickness, depth and groundwater potential in Kedawung district

| VES   | Location               | Depth (m)          | Thickness (m) | Lithology       | Groundwater Potential |
|-------|------------------------|--------------------|---------------|-----------------|-----------------------|
| TS12  | Punthuk Mojodadi       | 43 – 56,4          | 13,4          | Sand            | Moderate              |
|       |                        | 145 – 170          | 25            | Sand            |                       |
| TS13  | Mojodoyong Mojodadi    | 34,15 – 86,52      | 52,37         | Sand            | Very Good             |
|       |                        | 86,52 – 112,3      | 25,78         | Sand            |                       |
|       |                        | 170,9 – 209,3      | 38,4          | Sand            |                       |
| TS14  | Gempol Mojodadi        | 23,8 – 66,7        | 42,9          | Gravel sand     | Good                  |
| TS15  | Gondang Mojodadi       | 43,7 – 101         | 57,3          | Sand            | Good                  |
| TS16  | Wungurejo Mojodadi     | 50,74 – 118,3      | 67,58         | Sand            | Very Good             |
| TS17  | Wungurejo Mojodadi     | 34,3 – 63,4        | 29,1          | Gravel          | Good                  |
|       |                        | 63,4 – 70,3        | 6,9           | Gravel          |                       |
|       |                        | 70,3 – 92,7        | 22,3          | Clayey sand     |                       |
|       |                        | 92,7 – 143         | 50,4          | Clayey sand     |                       |
| TS18  | Ngabeana Kedawung      | 46,93 – 98,9       | 51,97         | Sand            | Good                  |
| TS19  | Sukorame Kedawung      | 20,8 – 52          | 31,2          | Gravel sand     | Very good             |
|       |                        | 82,6 – 168         | 85,9          | Breccia         |                       |
| TS20  | Mojokerto Mojokerto    | 68,9 – 126         | 56,6          | Sand            | Good                  |
| TS21  | Candirejo Wonokerso    | 62 – 95,8          | 33,7          | Sand            | Very good             |
|       |                        | 95,8 – 145         | 49,3          | Gravel          |                       |
| TS22  | Nglaban wonokerso      | 73,61 – 118,4      | 44,76         | Gravel sand     | Very Good             |
|       |                        | 118,4 – 152,9      | 34,5          | Gravel sand     |                       |
|       |                        | 152,9 – 181,1      | 28,21         | Gravel sand     |                       |

We made a cross section from several VES points, i.e. A-B section, C-D section, C-F section and E-A section. The result of each section is interpreted from result of VES. Based on these cross section, it can provide delineation of the position, thickness of the aquifer layer and layer which is not an aquifer (aquiclude).

Figure 4. Cross section
5. Conclusions

The result show that in Sambirejo district, the aquifer layer consist of clayey sand and sand, clayey sand layer have thickness between 9.67 metre to 55.5 metre; while sand layers have thickness between 17.5 metre to 49.2 metre. In Kedawung district, the aquifer layers consist of clayey sand, sand, gravel sand, gravel and breccias. The thickness of clayey sand is ranging from 22.3 to 50.4 metre, sand layer have thickness range of 13.4 to 67.58 metre, gravel sand layer have thickness between of 28.1 to 44.76 metre, gravel layer have thickness of 6.9 to 49.3 metre, and breccias layer have thickness of 85.9 metre. The entire study area can be classified as very good, good, moderate and poor for groundwater potential zones. Identification of groundwater potential zone as good and very good category was shown in Sambirejo district are TS2, TS5, TS7, TS8, and TS9 , while in Kedawung district are TS13, TS14, T15, TS16, TS17, TS18, TS19, TS20, TS21 and TS22.

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