

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 $7^{\circ} 15' - 7^{\circ} 30' \text{ S}$ and $110^{\circ} 45' - 111^{\circ} 10' \text{ E}$. 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 been 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] :

$$\rho_{semu} = K_{SC} \frac{\Delta V}{I} \quad (1)$$

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

ρ_{semu} is apperent resistivity; K_{SC} is geometry factor; ΔV is potential different; I is electrics current; a is distance between center point to current electrode; b is distance center point to potential electrode.

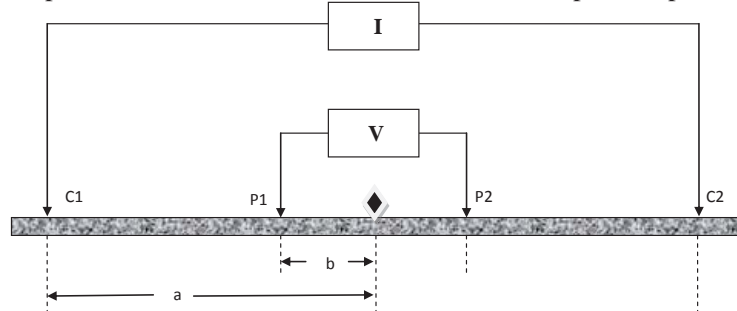


Figure 1. Schlumberger array

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.

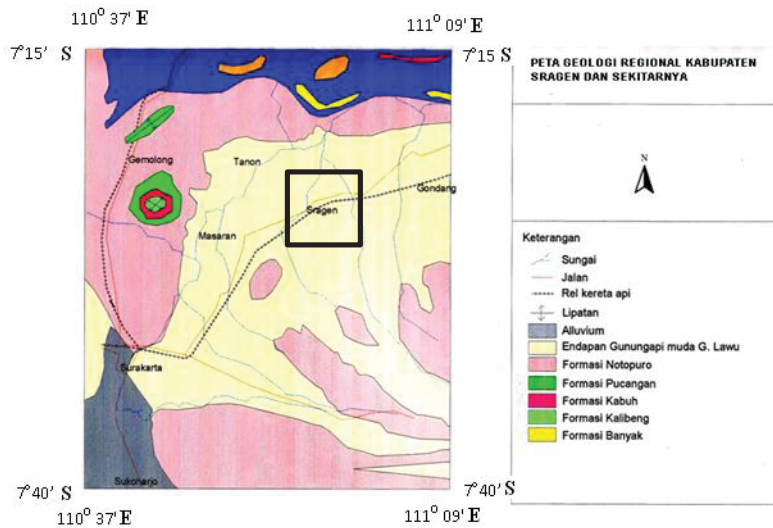


Figure 2. Regional geology map [11]

Data aquisition was done by using Resistvitymeter 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.

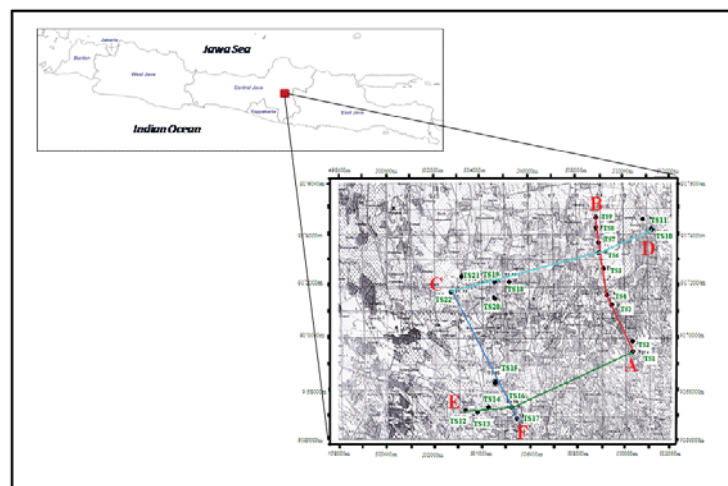


Figure 3 . Studi area. VES locations (black dotted), solid line with letter is cross section line.

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.

Table 1. Position, thickness, depth and groundwater potential zone in Sambirejo district

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	Dagangan 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	Ngabean 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).

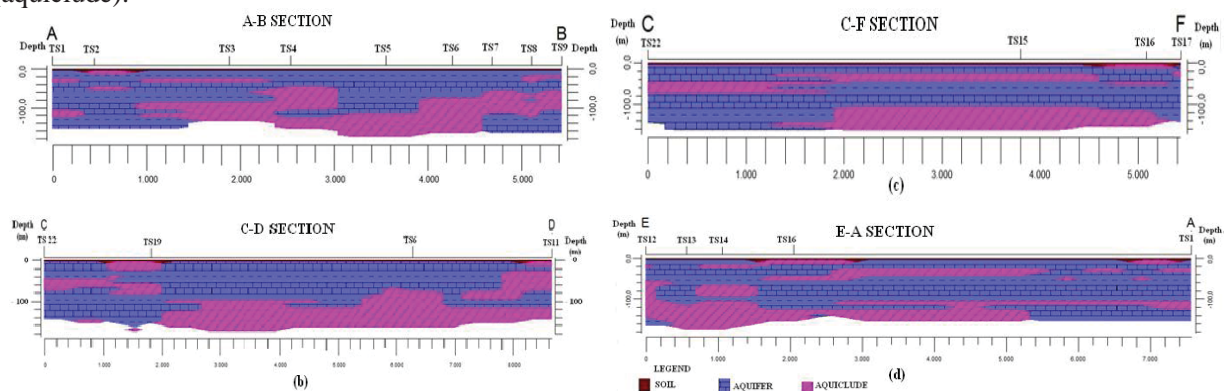


Figure 4. Cross section

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 ground water 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.

6. Acknowledgement

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7. References

- [1] Freeze RA, Cherry JA, Groundwater, Hempstead H, Prentice Hall International, 1979.
- [2] Telford WM, Geldart LP, Sheriff RE, Keys DA, *Applied Geophysics*. Cambridge University Press, London. 1976.
- [3] UNESCO, Groundwater resources of the World and their use . In: Zekster IS, Everett LG (eds), IHP-VI Series on Groundwater, 6. 2004.
- [4] Srinivasan K, Poongothai S, Chidambaram S, 2013 *European Scientific Journal* **9**(17) ISSN: 1857 – 7881 (Print)e-ISSN 1857- 7431
- [5] Anomohanran O, 2011 *International Journal of the Physical Sciences* **6**(33) pp. 7651-7656
- [6] Keleko TDA, Tadjou JM, Kamguia J, Tabod TC, Feumoe ANS, Kenfack JV, 2013 *Journal of Water Resource and Protection* **5** (6)
- [7] Obianwu VI, Atan OE, Okiwelu AA 2015 *Applied Physics Research* **7**(2) Canadian Center of Science and Education
- [8] Ahilan J and Kumar GRS, 2011 *Archives of Applied Science Research* **3**(2) 414-421
- [9] Nejad HT, Mumipour M, Kaboli R and Najib OA, 2011 *Journal of Applied Sciences*, **11**3765-3774
- [10] Sajeena, S, Hakkim AVM and Kurien EK, 2014 *International Journal of Engineering Inventions*, **3**(6): 17-21
- [11] Suharyadi 2005, *Laporan Penyelidikan Geolistrik Untuk Eksplorasi Air Bawah Tanah Di Daerah Kedawung dan Gondang Kab. Sragen Propinsi Jawa Tengah*, Laboratorium Geologi Tata Lingkungan Jur. T.Geologi Fak. Teknik Universitas Gadjah Mada, Yogyakarta
- [12] Todd DK, *Groundwater hydrology (third Edition)*: John Wiley and Sons, New York, 535 p. 1980.