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RESEARCH ARTICLE

Groundwater exploration using Vertical Electrical Sounding (VES) Method at Toro Jaya, Langgam, Riau

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Abstract

Vertical Electrical Sounding (VES) method is one of many methods in geophysics that was conducted in this research at Toro Jaya, Langgam, Riau. The aim of this research is to investigate and locate the depth of groundwater layer (aquifer). Data acquisition of VES was carried out using GEOCIST with Schlumberger configuration of electrode. There are four VES point in this research with various length of cable ranging from 135 m up to 200 m. From four VES point shown two different of resistivity value range. Very low resistivity value with range 0,34 – 0,9 Ωm interpreted as aquifer layer. The aquifer layer of research area divided into two types which are unconfined aquifer and confined aquifer. Meanwhile, another resistivity value ranging from 1,69 – 7 Ωm was interpreted as clay layers.

Keywords: Groundwater, Vertical Electrical Sounding (VES), Schlumberger, Aquifer

1. Introduction

In agriculture, water resources to fulfill the need of plant is important in large amount. Groundwater is the best alternative water resources to supply the water needed for agriculture, industrial and domestic purpose (Chandra et al., 2010; Putra and Yuskar, 2017). Groundwater is defined as water that fill the porosity of soil or rock that reserve the water in subsurface. Generally, groundwater classified into two types which are confined aquifer and unconfined aquifer. Both of them only differentiated based on appearance of impermeable layer above the aquifer.

Geophysics survey especially geo-electrical survey is widely used in order to locate the groundwater resources (Asry et al., 2012; Azhar et al., 2016; Hamzah et al., 2008, 2007; Jumary et al., 2002). One of geo-electrical methods is Vertical Electrical Sounding also known as VES. VES is a method to generate one dimensional of resistivity distribution in vertical section. This method very popular used to determine the subsurface resistivity anomaly that very helpful to investigate water saturated layer. A survey of subsurface resistivity value using one dimensional method was conducted at agriculture area in Toro Jaya village, Ukui district, Riau Province. The aim of study is to locate and identify the water saturated layer (aquifer) that can be water resources for agriculture purpose and domestic purpose (Kausarian et al., 2018). The study area is bounded by latitudes S 00015'09" to 00015'25" and longitudes E101053'58" - 101054'14" (Fig. 1).

2. Setting of The Study Area

The study area characterized by gentle hill with elevation from 45 m to 70 m. Geological setting of study area is included in Central Sumatra Basin (CSB) that consist of Minas Formation, Old Alluvium and Young Alluvium. Young Alluvium deposited during Holocene-aged with materials gravels, sands and clay. The old Alluvium generated from aged Pleistocene to Holocene consists of gravels, sands, clays, vegetation rafts and peat swamps. Whilst, the oldest formation of study area is Minas Formation that consists of gravels, distribution of pebbles, sands and clays (Clarke et al., 1982).

The study area is very close to Kampar Kanan's rivers that considered as fluvial meandering system. Meandering river lead to high erosional process at outer bank of channel and high depositional process at inner bank of channel (Yuskar et al., 2018; Yuskar and Choanji, 2017, 2016a, 2016b). Based on hydrogeological map of Indonesia Pekanbaru's Sheet, the study area consist of two types of aquifer , Productive aquifer with wide spreading and intermediate productive aquifer with wide spreading. The maps of hydrogeological can be seen at Fig 2.

3. Methodology

Vertical Electrical Sounding (VES) is a method that involve in electrical resistivity survey. Basically electrical resistivity survey is measuring potential between two electrodes while transmitting a direct current between another two electrodes. The penetration of current is parallel with the distance between electrodes. The various of spacing between electrode will lead to information of resistivity stratification (Hamzah et al., 2007).

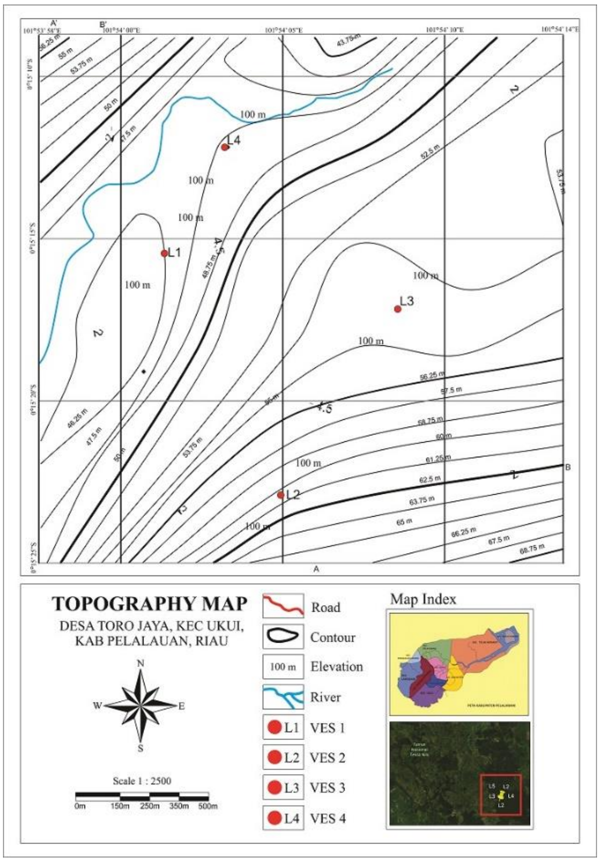

Figure 1. Map of study area

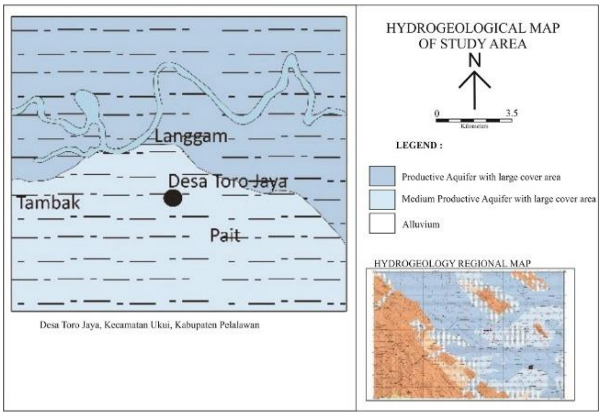

Figure 2. Hydrogeological map of study area

VES survey was carried out using GEOCIS that consists of Geocis machine, electrodes, cable, connector, cable clip, battery and laptop (Fig. 3). Four electrodes arranged in a straight line with various electrode spacing. The maximum length of wire to connect four electrodes is 200 m while the minimum is 2 m. Four electrodes arrange using Schlumberger array where two outer electrodes as current electrode and two inner electrodes as potential electrode (Koefoed). The current electrode spacing (AB) ranging from 2 m to 200 m (AB/2 = 1 m to 100 m). The distance used for potential electrodes (MN) ranged from 0,5 m sampai 10 m. the data acquisition at field was carried out by changing electrode spacing between each measurement (Hamzah et al., 2007).


Figure 3. Equipment of Vertical Electrical Sounding (VES)

The data collected from the field are current (I) and Voltage (V). Resistance (R) value can be calculate with equation between current (I) and voltage (V):

$$R = V/I$$

To calculate the apparent resistivity (ρa), geometry factor (k) is needed. Geometry factor (k) for schlumberger can be calculate with formula:

$$k = \frac{\pi(S^2 - a^2/4)}{a}$$

From resistance (R) value and geometry factor (k), apparent resistivity (ρa) calculate with formula:

$$\rho a = R.k$$

Schlumberger Orellana and Mooney (1966) master curve using to differentiate of make the partition of resistivity value. The result of apparent resistivity plotted into graph log and then look the curve that match or close with shape of apparent resistivity plotted. Based on the master curve that matched partition of resistivity value and thickness can be determined.

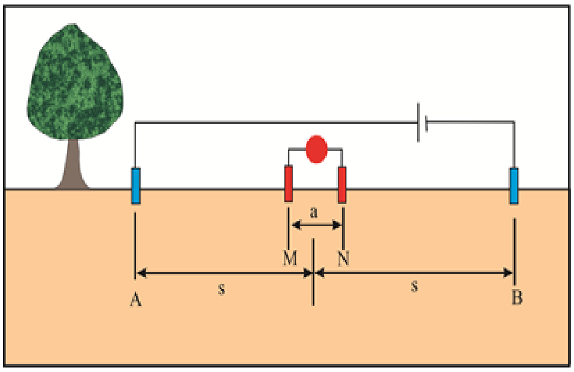

Figure 4. Electrode configuration of Schlumberger

4. Result and Interpretation

There are four VES points named VES1, VES2, VES3 and VES4 has processed to produce one dimensional model of subsurface resistivity. The model is representing the true condition of subsurface with various resistivity value. The changing of resistivity value indicate the different material of subsurface.

4.1 VES1

VES1 located at coordinate 00015'15,4" S and 101054'01,3" E with maximum spread length is 130 m. The result of data processing of VES1 shown at Fig.X with depth penetration up to 10 m. VES1 divided into three layers based on the different of resistivity value.

Figure 5. Field data acquisition using GEOCIS equipment

The first layer has resistivity value 2,6 Ωm with depth up to 3 m from the surface that interpreted as clay layer. The second layer is very low resistivity value (0,52 Ωm) that associate with aquifer layer. This aquifer layer classified as confined aquifer because overlay by impermeable layer which is clay layer. The depth of aquifer layer starting from 3 m to 9 m from surface. Whereas, the third layer also interpreted as clay layer with resistivity value 1,69 m at depth more than 9 m.

4.2 VES2

The point of VES2 located at 00015'22,90" S and 101054'04,95" E. Length of spreading between outer electrode (current electrode) is 130 m with depth maximum up to 7 m. VES2 interpreted into three layers based on various of resistivity value. The first layer interpreted as aquifer layer with very low resistivity value (0,9 Ωm). This aquifer layer categorized as unconfined aquifer because there is no layer above aquifer that prevent water to penetrate. The depth of unconfined aquifer layer is up to 3 m from surface. The second layer has resistivity value 4,5 Ωm that interpreted as clay layer with depth from 3 m to 6 m beneath surface. The clay layer overlay the third layer that interpreted as confined aquifer layer (0,9 Ωm) that can be found at depth more than 6 m.

4.3 VES3

Maximum spreading of electrode for VES3 is 200 m that located at latitude 00015'17,17" S and longitude 101054'08,55" E. The maximum depth penetration from VES3 data processing is up to 7 m. there are three layers was interpreted at VES3 which are unconfined aquifer layer, clay layer and confined aquifer. Unconfined aquifer layer defined by low resistivity value (0,34 Ωm) with depth up to 2,3 m from the surface. Below unconfined aquifer layer interpreted as clay layer with thickness approximate 4,6 m bounded from depth 2,3 at upperpart and 6,9 at bottom part. Resistivity value for this layer is 1,7 Ωm. The lower layer detected from VES3 is very low resistivity value (0,51 Ωm). This layer interpreted as confined aquifer because the layer covered by clay layer above. The thickness of confined aquifer layer cannot be determined because the layer below not detected.

4.4 VES4

VES4 located at coordinate 00015'17,17" S and 101054'08,55" E with line spreading up to 80 m. the maximum depth of VES4 is more than 5 m with resistivity value ranging from 0,9 – 7 Ωm. The result divided into two layers which are clay layer and aquifer layer. The clay layer represented by low resistivity value with range 1,4 – 7 Ωm. The thickness of this layer 3,4 m starting from surface up to 3,4 m of depth. Clay layer act as cap layer for below layer because clay is impermeable that prevent water to infiltrate to subsurface. Beneath the clay layer is the layer with low resistivity value (0,91 Ωm). these layer representing water saturated layer with unknown the thickness of layer because the layer below is not detected. This water saturated layer classified into confined aquifer because the layer above is clay layer.

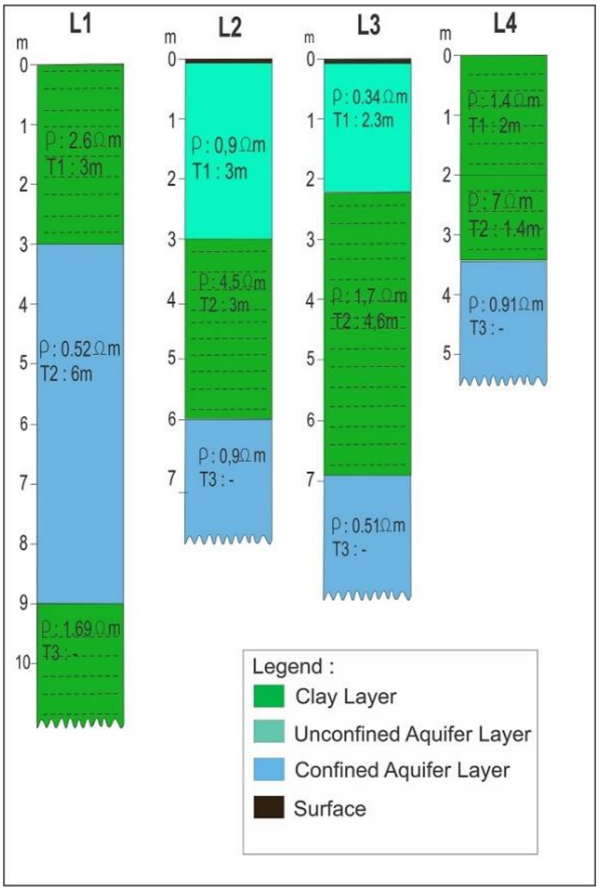

Figure 6. Model Log resistivity value of VES1, VES2, VES3 and VES4

5. Discussion

Water saturated or aquifer layer is the target of this study. The resistivity value of aquifer layer is associated with low resistivity value. From the result of VES1, VES2, VES3 and VES4 shown the resistivity value of study area ranging from 0,34 up to 7 Ωm. The resistivity value below 1 Ωm represented water saturated layer while clay layer interpreted with above 1 Ωm of resistivity value (Table 1). Furthermore, water saturated layer of study area divided into two types they are confined aquifer and unconfined aquifer. Unconfined aquifer layer detected at VES2 and VES3 with depth reach 3 m while confined aquifer layer found at all VES point with various depth starting at 3 m to 7 m.

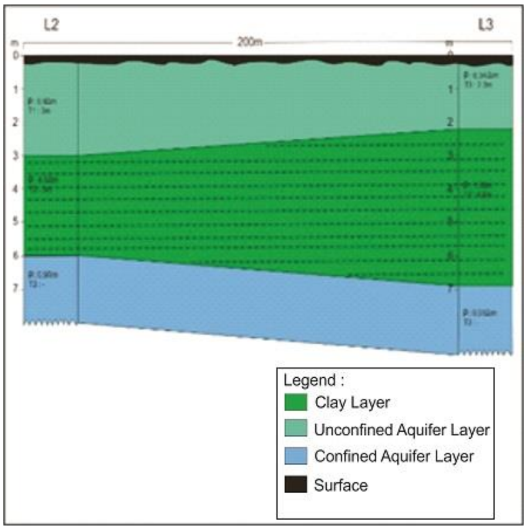

Figure 7. Correlation between VES2 and VES3

Correlation between VES2 and VES3 showing the distribution of unconfined aquifer at 2,3 m to 3 m of depth. Both of VES located at high elevation around 56 m to 60 m. the unconfined aquifer proved by there are some wells around study area. The groundwater level of the well is very near with surface just around 5 cm. meanwhile, confined aquifer of study area has various of depth. Based on those depth a map of distribution confined aquifer was generated (Fig. 7). The confined aquifer of study area is getting shallower to western part of study area with the deepest aquifer found at 7 m.

Table 1. Resistivity value interpretation of study area

No.	Resistivity value	Interpretation
1	0.34 – 1 Ωm	Aquifer layer
2	1 – 7 Ωm	Clay layer

6. Conclusion

Exploration of groundwater as alternative water resources using Vertical Electrical Sounding (VES) at Rumbio Jaya, Ukui, Riau has been conducted. The resistivity of study area ranging from 0,34 – 7 Ωm. the groundwater represented by very low resistivity value ranging from 0,34 - 1 Ωm. Aquifer layer at study area divided into two types which are confined aquifer and unconfined aquifer. Confined aquifer is the target of this study can be found at depth 3 – 7 m. the deepest aquifer is 7 m that found at eastern part of study area (VES3) and gradually getting shallow toward western part of study area.

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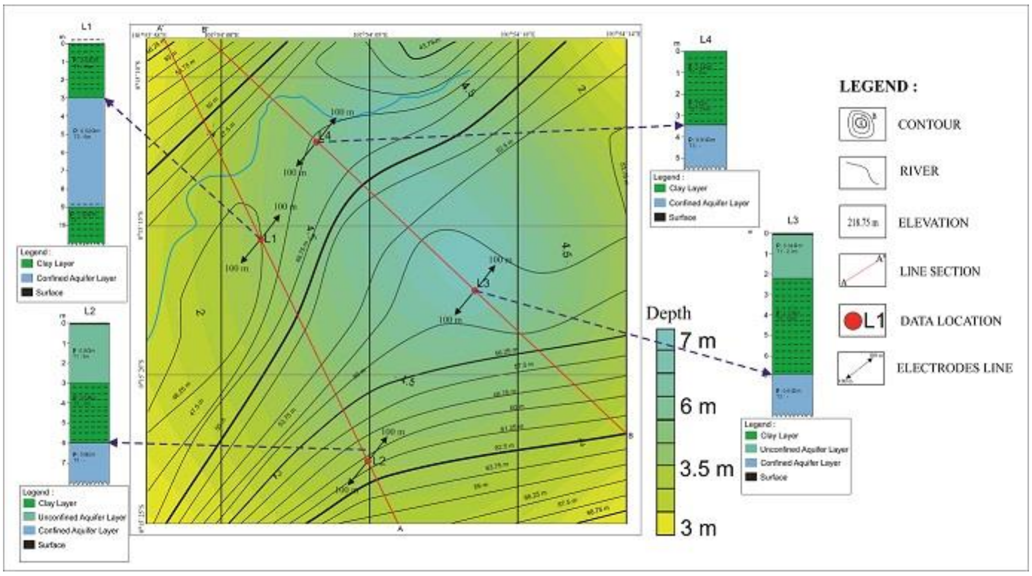

Figure 8. Map of groundwater distribution of study area

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