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Application of Self-Potential Method to Observe Groundwater Flow in Tanjungpura University Area, Pontianak

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ABSTRACT

The study aims to observe groundwater flow in the Tanjungpura University area, Pontianak, West Kalimantan. Data collection applied three lines have a length of 65 m, a distance between the lines is 5 m, and a space between the porous pots is 5 m. Each line has 12 points to measure the self-potential value. The results showed that the variation of the self-potential value before the correction was -9.98 mV to 17.24 mV, while after correction, it was -10.52 mV to 16.92 mV. The self-potential distribution shows that the relatively high potential value is in the south, while the low is in the north. The distribution of self-potential values in the study location is caused by groundwater movement, which flows north. In addition, groundwater also flows to the south, especially at 20-30 m from the base station. Thus, the low self-potential value in the north can be used as a reference to identify groundwater accumulation to explore raw water in the study location.

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I. Introduction

The groundwater has a significant role because its use is needed in everyday life. It can be found at different depths, and it depends on local geological conditions [1]. Even though its availability is abundant in the aquifer layer, information about groundwater presence is needed so that it can be used optimally. One of the information required by society for groundwater utilization is groundwater flow so that its existence can be identified.

Groundwater is water that comes from layers of soil or rocks. It has an essential role in living things, including maintaining the balance of nature, maintaining the availability of raw water for domestic and industrial purposes. The aquifer layer contains alternative raw water that can be used for the community's daily needs. As the population increases, the amount of water demand also increases.

The need for clean water in Pontianak, especially at the Tanjungpura University area, is provided by *Perusahaan Daerah Air Minum* (PDAM). However, the availability of water managed by PDAM has a few obstacles in the dry season. The water quality sometimes decreases, for example, a change in taste to be more brackish and even salty. Therefore, it is necessary to provide information about alternative raw water sources to solve these problems.

Geophysical methods have been conducted to investigate the condition and presence of groundwater. For example, groundwater conditions in coastal areas are generally carried out to determine the effect of intrusion on its presence [2]. Both unconfined and confined aquifers exist that store and stream groundwater [3][4]. So that information can be used as a reference for exploiting groundwater in domestic and industrial. One of the methods in geophysics that can be used to analyze subsurface conditions is self-potential [5].

The self-potential method is a passive method that utilizes self-potential that occurs under the earth's surface. This method has been used to identify groundwater movement [6][7], seawater intrusion [8][9], leachate distribution [10], soil movement [11][12], monitoring contaminant [13], underground river flow [14], and water leakage through dams [15]. Self-potential on the surface is caused by the presence of electrochemical and mechanical activities [16]. This method's use is relatively more uncomplicated [17] because the costs required are relatively cheap. This method's working principle measures the static stress on the earth's surface by using two porous pots (porous electrodes) [18] connected to a multimeter. The purpose of using a porous pot is to eliminate the effect of electrode polarization during measurements [17]. This method is considered very responsive for identifying conductive objects, for example, metal minerals [19]. Based on the description above, it is necessary to determine the distribution of potential values and groundwater flow around the area of Tanjungpura University, Pontianak using the SP method.

II. Theory

Self-potential (spontaneous potential) occurs below the earth's surface caused by electrochemical or mechanical activity. One of the factors that control these two activities is subsurface water. The potential is also related to the weathering of sulfide mineral bodies, mineral density of various rocks at geological contact, material organisms' bioelectric activity, corrosion, temperature, and pressure gradient in subsurface fluids. The types of self-potential anomalies and their sources, as shown in Table 1.

Table 1. The types of self-potential anomalies and their sources [16]

Source	Type of anomaly
▪ Sulphide ore bodies ▪ Graphite ore bodies ▪ Magnetic and other electronically conducting minerals ▪ Coal ▪ Manganese	Negative [hundreds of mV]
▪ Quartz vein ▪ Pegmatites	Positive [tens of mV]
▪ Fluid streaming, geochemical reaction, etc	Positive/negative [≤ 100 mV]
▪ Bioelectric (plants, tree)	Negative [≤ 300 mV]
▪ Groundwater movement	Positive/negative [up to hundreds of mV]
▪ Topography	Negative [up to 2 V]

Four mechanisms can produce self-potential, namely as follows :

a. Electrokinetic potential (streaming potential)

Electrokinetic potential occurs when something moves, namely fluid (electrolyte solution) in the pores of rock. The moving fluid will produce a difference in hydrostatic pressure so that it will produce an electric potential difference which is expressed in the following equation (1) [16].

$$\delta V = \frac{\varepsilon\mu C_E \delta P}{4\pi\eta} \quad (1)$$

Where δV is the electric potential difference, ε is the dielectric constant, μ is the electrolyte resistivity, C_E is the electrofiltration coupling coefficient, δP is the difference in hydrostatic pressure, and η is the dynamic viscosity of the electrolyte.

Streaming potential can cause high anomaly values to the topography so that higher areas generally have more negative potential values. For an example of the self-potential anomaly produced by pumping from a well as shown in Figure 1.

b. Diffusion potential (liquid junction)

Diffusion potential will arise when two metal electrodes are inserted into two solutions of different concentrations. In rocks, variations in electrolyte concentrations produce a diffusion potential when there is a difference in the movement of anions and cations.

c. Nerst potential

Nerst potential can be found in the clay layer with a negative charge when two identical electrodes are inserted into a homogeneous electrolyte with different concentrations. In the solution, there is no difference in potential. However, at other electrodes, there is a potential difference.

d. Mineralization potential

Mineralization potential occurs when two metals as different electrodes are inserted into a homogeneous solution. There is a potential difference between these electrodes, which is known as electrolytic contact potential. It occurs with both the streaming and the diffusion potential.

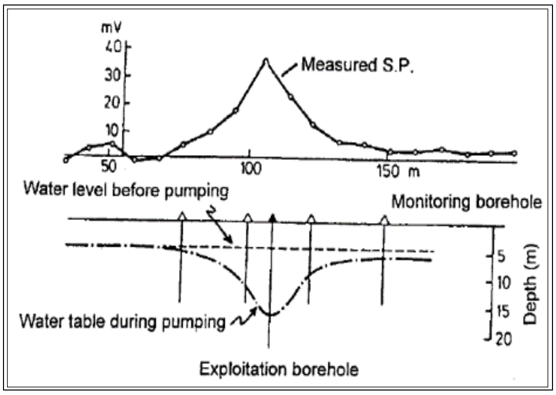

Figure 1. Example of the self-potential anomaly produced by pumping from a well [16]

III. Method

The study was conducted in the area of Tanjungpura University, Pontianak City, which is at coordinates $0^0$03'08.60"S - $0^0$03'14.10"S and $109^0$20'56.50''E - $109^0$21'05.40"E. The potential value measurement applied three lines (L_1, L_2, L_3) with a length of 65 m each. The design and measurement locations are shown in Figure 2.

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Figure 2. Survey design at the study location

This measurement applies a fixed base configuration using two electrodes (porous pots). The fixed base configuration has the advantage that looping is not required in measurement and the data processing is simpler. The measuring point's potential is measured by one porous pot at the reference point (base station), and another porous pot moves along the measurement path at a fixed distance. The reference point in the mineralized zone measurement is an area not included in the mineralized zone being measured. The cable required in this configuration is relatively long because one electrode is fixed at the reference point and one of the other electrodes is measured at the farthest. An illustration of the potential measurement with a fixed base configuration and the spot axis's schematic is shown in Figure 3.

Data acquisition in the field is conducted using two methods: time and position functions. The data based on the time function is used to make corrections to the data based on the position function. This reference point is outside the survey target area and used to collect the database. This rover measurement is conducted along the measurement line with the planned distance. Each line's potential value distribution is then plotted over an area to observe the groundwater flow in the study location.

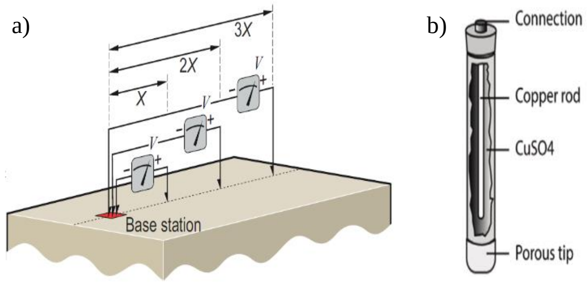

Figure 3. a) Illustration of potential measurement by fixed base configuration [20]; b) schematic of porous spot [18]

IV. Results and Discussion

As a function of time, the data acquisition process is conducted outside the target survey area. It is used as a place for collecting the self-potential database. The results of the self-potential variation based on the time function are shown in Figure 4. Measurements were conducted during the data acquisition process in the field at 11.54 am - 01.30 pm. This data is obtained every two minutes, assuming that it can correct the potential value obtained based on the position function. The variation of the potential value during measurement is 3.72 - 6.94 mV.

The data acquisition process as a function of the position is conducted in 3 lines. The line length is 65 m, the distance between the lines is 5 m, and the space between the porous pots is 5 m. Each line is conducted at 12 points to measure the potential value. Figure 5 shows the results of the potential measurements on the three lines. The potential value on line 1 is -10.52 mV to 18.24 mV, on line 2 is -3.92 mV to 12.10 mV, and on line 3 is -7.74 mV to 2.92 mV.

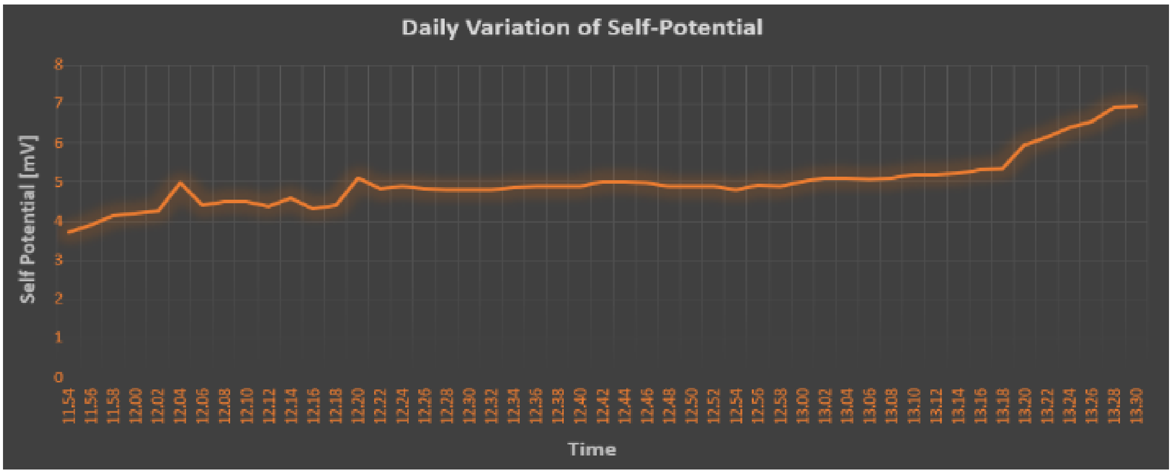

Figure 4. Self-potential base on daily variation

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Figure 6 shows the distribution of self-potential values at the study location. This distribution is obtained by combining the self-potential values on the three lines. Based on the isopotential contour map, the variation before correction is -9.98 mV to 17.24 mV, while after correction is -10.52 mV to 16.92 mV. The interpretation process is based on the distribution of self-potential values that have been corrected for daily variations. In general, the self-potential distribution pattern shows that the relatively high potential value is in the south (shown in white to red), while the relatively low potential value is in the north (purple to blue). The distribution of self-potential values in the study location is thought to be caused by groundwater flow movement [16]. The self-potential distribution with a value of ≤ 100 mV is a value caused by fluid movement [5][21].

Figure 7 shows the groundwater flow below the surface. A black arrow symbol indicates groundwater flow prediction. The arrow's length indicates the flow velocity based on qualitative interpretation [6]. The groundwater flows from high potential to low potential [14]. The low potential value indicates groundwater distribution to the area [22]. In general, groundwater is thought to flow to the north. In addition, groundwater also flows to the south of the study location, especially at 20-30 m from the base station. Thus, the low self-potential value in the north (purple to blue) can be used as a reference to identify groundwater accumulation to explore raw water in the study location.

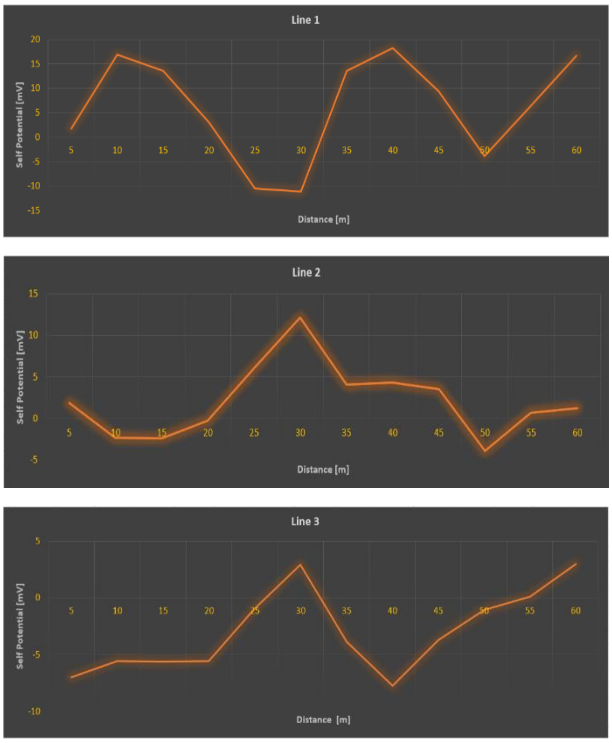

Figure 5. The measurement result of self-potential; Line 1 (top), Line 2 (middle), and Line 3 (bottom)

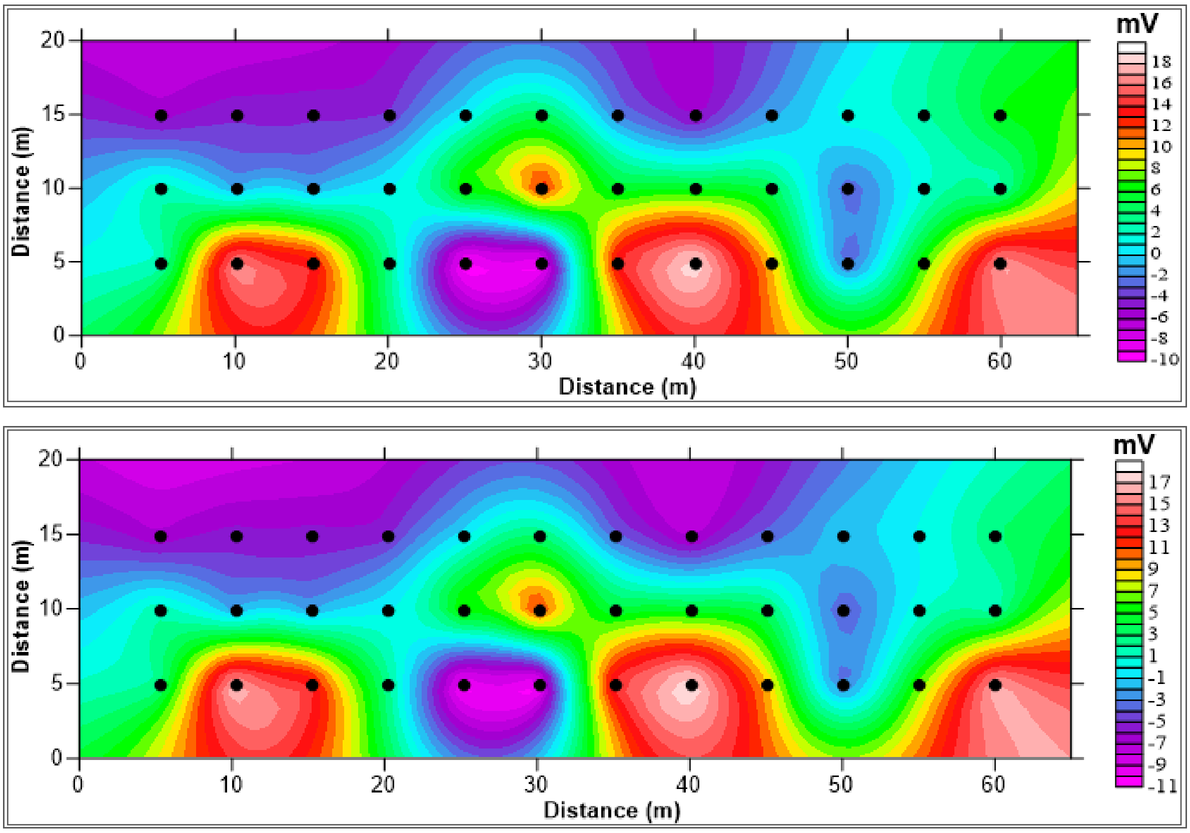

Figure 6. Self-potential distribution; before daily variation corection (top) ; and after daily variation corection (bottom)

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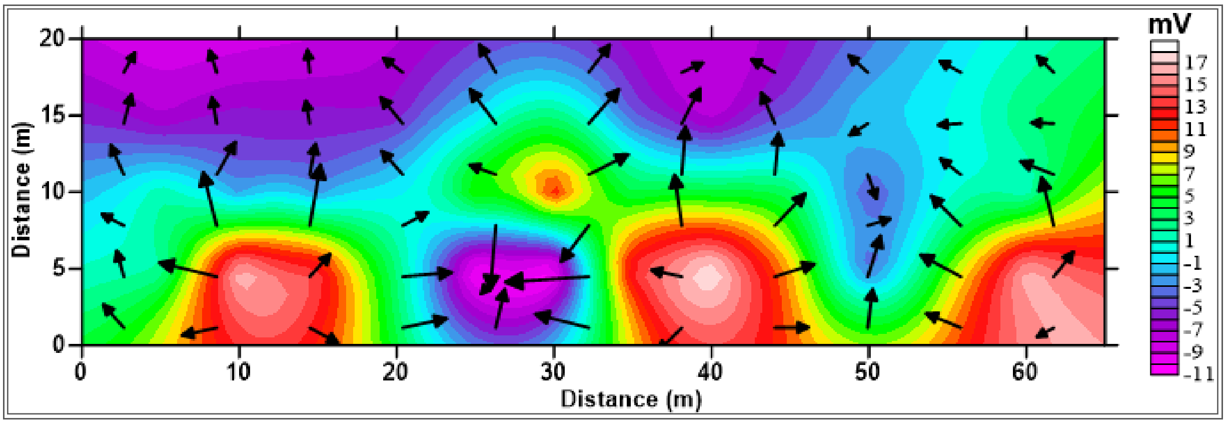

Figure 7. Prediction of subsurface groundwater flow

V. Conclusion

Based on the results of this study, it can be concluded that the variation in the self-potential value before correction is -9.98 mV to 17.24 mV, while after correction, it is -10.52 mV to 16.92 mV. The self-potential distribution shows that the relatively high potential value is in the south, while the low is in the north. The distribution of self-potential values in the study location is caused by groundwater movement, which flows north. In addition, groundwater also flows to the south, especially at 20-30 m from the base station. Thus, the low self-potential value in the north can be used as a reference to identify groundwater accumulation to explore raw water in the study location.

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