IDENTIFYING CHANGES OF GROUNDWATER POTENTIAL WITH THE INTERPRETATION OF SELF-POTENTIAL ANOMALY

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ABSTRACT

The Self-Potential (SP) method was used to identify changes in the potential groundwater in the area of Gampong Lengkong, Langsa City. The data acquisition technique was carried out with a fixed base technique with a measurement count of four acquisition lines. Research is conducted for two months that July and August are the same to monitor the changes in the SP value associated with the change of SP anomaly. SP value of the acquisition result is used as a reference for estimating the potential of groundwater. Interpretation is made qualitatively and quantitatively. Qualitative interpretation through analysis maps of the isopotential contours compared between the first month and the second month of measurements in the field. The interpretation is quantitatively by assuming the source of the subsurface anomaly fix geometry models of cylinders or spheres is done by the inversion modeling using the Levenberg-Marquardt method. The results showed that there was a reduction in SP value in the second month, indicating the potential shortage of groundwater in the region. The decrease in groundwater potential is also shown in the inversion results, where the result of the calculation of SP anomaly source parameters in the first month is estimated to be at 7.77 meters to 11.05 meters below the ground in the monthly measurements second.

Keywords: SP Anomaly; Groundwater; Fixed Geometry; Langsa

Introduction

Water is a natural resource that is needed by living creatures. Water has an important benefit in life that directly impacts the social and economic welfare of the community. The existence of water resources needs to be managed well in quality or quantity, and this is done so that water resources can be utilized sustainably for human needs. The most widely utilized water by humans is groundwater.

Gampong lengkong is one of the areas in the Langsa Baro subdistrict located in Langsa City, Aceh. This village is thought to have abundant groundwater reserves. However, due to rampant exploitation of groundwater in this village,[1] it is feared to reduce groundwater reserves.

Groundwater that is overutilized can cause the impact of the groundwater crisis marked by decreased groundwater level and the occurrence of subsidence.[2,3,4]

Reduced groundwater can be lead to drought and geological disasters from beneath the surface. By looking at the condition, it is done research to observe the potential groundwater in the village.

One of the geophysical methods used to detect groundwater is the self-potential (SP) method. This method is simple, but it can work well for the exploration of external surfaces.

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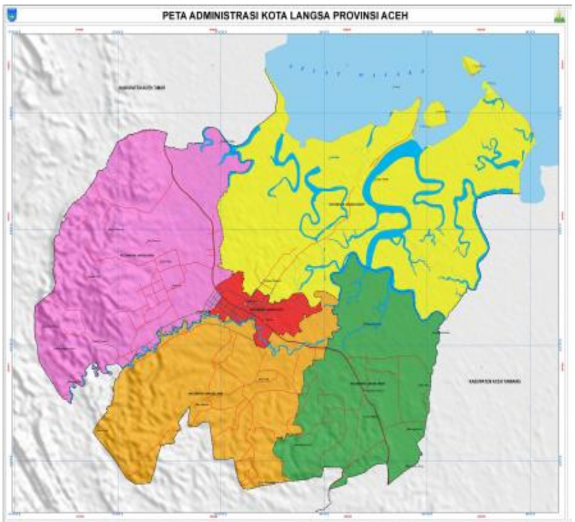

Figure 1. Langsa City Map

SP method is very appropriate for mapping the distribution of anomalies related to the direction and relative magnitude of fluid flow. Several research applications on SP have been conducted for groundwater identification.[5,6,7] Other than that, this method is also applied to some subsurface identification activities such as the identification of geothermal potential,[8] leachate distribution mapping,[9] fault identification,[10] and applied to mapping corrosion environment.[11]

In this research, the SP method is used to suspect groundwater potential in groundwater exploitation areas. The purpose of this research is to investigate and predict changes in groundwater potential at the research site. The technique is used to identify the potential for subsurface water by using four different lines. Interpretation of the potential value of the acquisition result is used as a reference for estimating the potential of subsurface water.

Methods

Research Location

The research was undertaken in Gampong Lengkong, Langsa Baro regency, Langsa City, Aceh province. The measuring path consists of 4 passes, as shown in Figure 1. The measuring line extends from the southeast to the northwest, where each line is parallel. The measurement line is taken on a parallel trajectory because the research site is around a residential area, so only this trajectory is possible for measurement.

Figure 2. Location of the study[12]

Research Procedure

A preliminary survey is done so that the location of real research in the field can be known. This survey looking for information about the state of the terrain that will be made research place. Based on the results of the preliminary survey specified the appropriate line for acquisition data. The acquisition of field data was carried out on four lines, each line having a distance of 88 meters with a space between the electrode 4 meters on the entire line. The data retrieval technique used is a fixed base, where one of the porous pot electrodes remains at the base point, and the other electrode moves along the track at the same interval. The measured natural potential is the potential between the two electrodes.

Researchers collecting data twice, first in early July and second in early August 2019. Acquisition data twice retrieval as compare data to observe the change of SP anomalies obtained from the first and second months of research.

This comparison is carried out to changes in groundwater conditions over an interval of one month. At the time of the study, the weather in the month was relatively hot with moderate rainfall.

Before the data acquisition process is performed, porous pot electrodes are first calibrated to ensure the tool used is in good condition. The measurement data in the field is then corrected. SP data correction is used to determine the daily correction value. Daily corrections are made because the measurable SP data in the field has not shown potential value in the area, so it is necessary to make daily corrections. After correction of SP data, the correction data is processed using Surfer 13 to determine the direction of water distribution in the research area. Then the data is reprocessed using Matlab R2013a to estimate measurable SP anomaly parameters. Interpretation of SP data was made in two ways that are qualitative and quantitative.

The qualitative interpretation was through the analysis of the isopotential contour map based on the potential value of the corrected field data measurement. The interpretation is quantitative done by modeling inversion of the fixed geometry model by assuming the subsurface model is spherical or cylindrical—quantitative interpretation to determine the parameters of the anomaly resulted by the isopotential contour. The calculated parameters include the electric moment dipole (K), depth to the center of the body (h), polarization angle (θ), and shape factor (q).

Along the measurement line (x), a resulting potential value from a spherical surface object and cylinder model is formulated given by[13]:

$$V(x_i, h, \theta) = K \frac{x_i \cos\theta + h \sin\theta}{\left(x_i^2 + h^2\right)^q} \qquad (1)$$

Where, V = SP anomaly (mV), K = electric moment dipole (mV), h = depth of the center (h), θ = polarization angle (°), q = shape factor, and x = distance. With $i = 1, 2, 3, ...N$

This inversion modeling aims to identify the underlying parameter of the SP anomaly. In this study, SP anomaly sources were indicated due to the presence of groundwater aquifer in the subsurface. Estimation of the parameter of the cause of the SP anomaly is done using the Levenberg-Marquardt method. This method has been tested on synthetic data[14] and observed data.[15]

Result and Discussion

First Measurement

The resulting measurement of Self-Potential is natural electric potential in mV units. The SP value of measurements in the first month has negative and positive potential. The measured self-potential is ranged from -8 mV to 44 mV. Qualitative interpretation of the results of self-potential data processing using Surfer 13. and its result can be seen in Figure 3.

Line of data collection in residential areas and the presence of home businesses that utilize groundwater showed a decrease in the value of SP during this study.

Based on the SP anomaly map in the first month of research, as shown in Figure 3, it can be stated that the research location has low SP anomaly values in the northeast and southwest. The low SP anomaly value of the section ranges from 8 to-8 mV. SP anomaly is relatively high, 20-44 mV, dominant in the eastern and northwest part of the research location. Presence of high and low potential values adjacent to the indication of the expected anomaly source derived from a groundwater aquifer. A-B Cross-section profile as a source of anomalies depicted in profile curves. Also, SP data from A-B is calculated by inverse modeling using MATLAB R2013a to estimate the SP anomaly parameter value.

The results of the inversion modeling for A-B cross-section using the Levenberg-Marquardt method are shown in Figure 4.

Figure 4 shows the SP value curve recovered by the calculated result curve of the A-B cross-section. It shows that the calculation results close by to the bottom surface model.

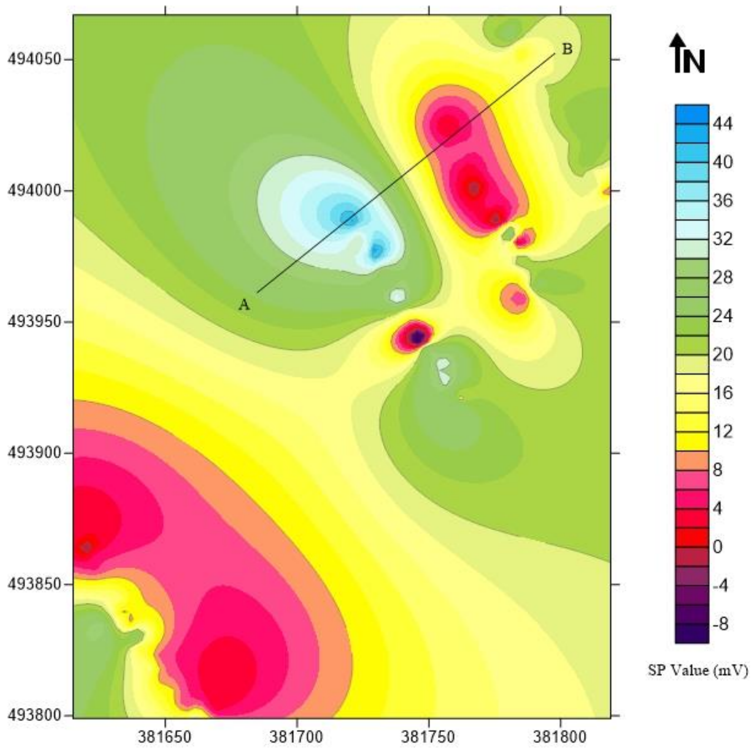

Figure 3. Isopotential contour map at 1st month

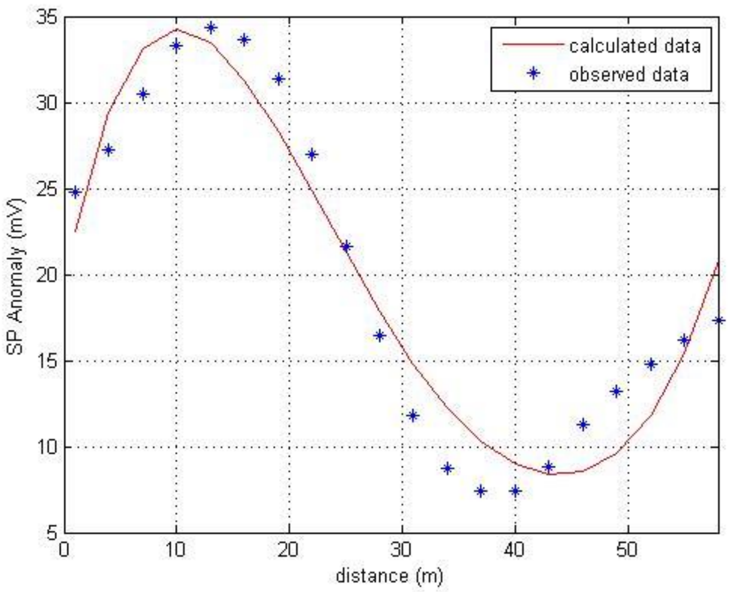

Figure 4. The result of inversion A-B cross-section

Second measurement

In the second month of field data acquisition, the measured self-potential value ranges from 0 – 56 mV. Qualitative interpretation of the self-potential data processing results using Surfer 13 displays a cross-section of the isopotential contour map shown in Figure 5.

From Figure 5. the contour view in the second month of measurement, it appears that the high potential value in the previous month became relatively lower in this month, which is worth 6 – 18 mV. It is assumed that there is a reduction of SP value resulting from reduced anomaly sources in the research area, which is a reduction in groundwater potential or the growing presence of groundwater aquifer in the research location.

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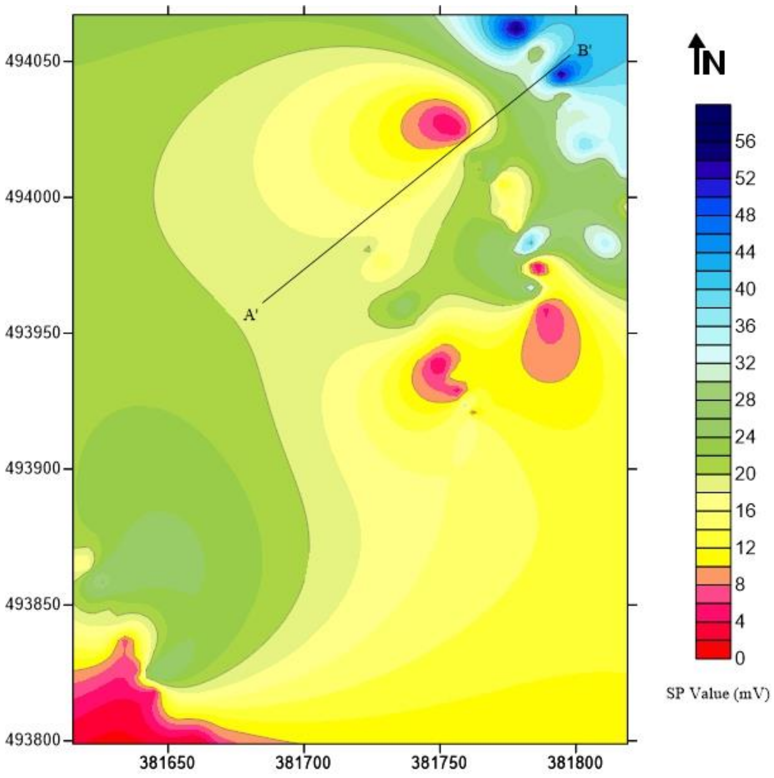

Figure 5. Isopotential contour map at 2nd month

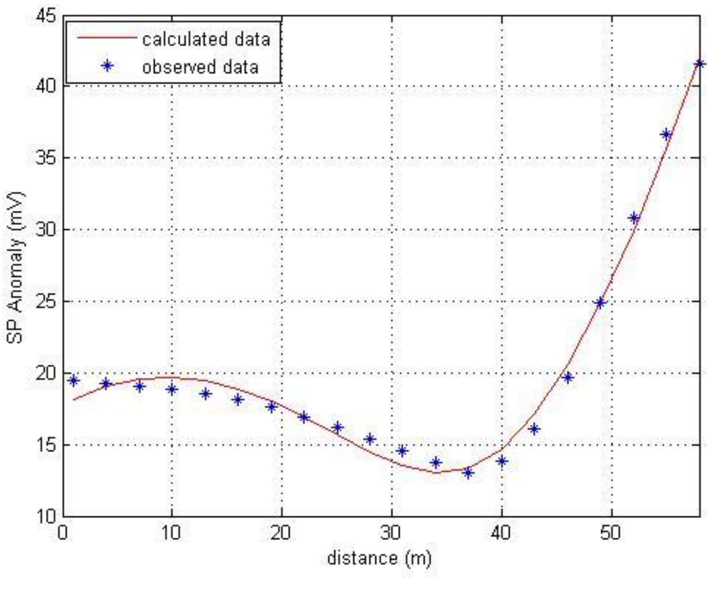

Figure 6. The result of inversion A'-B' cross-section

The digitization process is carried out at the same position in the contours map. SP anomaly values in cross-sections are created in the form of cross-section profiles. The Data from the profile is subsequently performed inversion modeling to estimate the value of the anomaly source parameters in subsurface the cross-section A'-B'.

The profile curve and inversion result modeling of A'-B' cross-section results are shown in Figure 6. Results of Inversion modeling obtained an estimation of parameter values affecting SP anomalies measured in the field. Comparing the results of the inversion of these two cross-section profiles is shown in Table 1.

Table 1. Result of SP inversion using the Levenberg-Marquardt method

No.	Parameters	1st Month	2nd Month
1.	K (mV)	0.01	0,09
2.	θ (°)	79,87	78,93
3	h (m)	7,77	11,05
4.	q	0,98	0.53

In the inversion results shown in table 1, it appears that there is a change in the SP anomaly source parameter value from two measurements in different months. Based on inversion using equation (1), the calculation data shows that the electric dipole moment in the second month is 0.09 mV to be relatively more significant than the first month of only 0.01 mV. Changes in the polarizing angle (θ) source anomaly not so important changed the direction as far as 0,94°.

In the first month of acquisition data, the approximate depth of the SP anomaly source predicted is groundwater aquifer at a depth of 7.77 meters. The approximate geometric shape of the source of the anomaly is a horizontal cylinder ($q = 0,98$) [13].

In the second month, the depth measurement from the SP anomaly source changes to be deeper, which is expected to be at a depth of 11.05 meters. The calculated data can be determined that the groundwater aquifer further from the surface, indicating the potential for groundwater reduction at the research site. And the prediction geometry of the SP anomaly changes to a vertical cylinder ($q = 0,53$). Suppose the geometry factor of the subsurface anomaly is associated with groundwater aquifer. In that case, it can be concluded that during two months, measurements in the condition of aquifer water also change with the change of water condition, potentially soil in the location.

Conclusion

Qualitative interpretation results indicate the alteration of SP anomalies resulting from changes in groundwater potential. Groundwater potential tends to diminish in the second month of research. This is based on quantitative interpretation results that estimate that the potential groundwater in the aquifer decreases depth so that it becomes further away from the ground compared to the previous month. The deeper the water aquifer states, the fewer water reserves in the subsurface.

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