ISSN: 2579-5821 (Print)
ISSN: 2579-5546 (Online)
URL address: http://journal.unhas.ac.id/index.php/geocelebes
DOI: 10.20956/geocelebes.v7i1.20524

Jurnal Geocelebes Vol. 7 No. 1, April 2023, 8 – 16

Application of Self-Potential Method in Mapping Leachate Flow Around Rasau Jaya Landfills, Kubu Raya Regency

Kaharudin, Yudha Arman, Muhardi*

Department of Geophysics, Universitas Tanjungpura, Pontianak, Indonesia

*Corresponding author. Email: muhardi@physics.untan.ac.id

Manuscript received: 27 March 2022; Received in revised form: 14 July 2022; Accepted: 14 September 2022

Abstract

This study uses the self-potential method to map the leachate flow around the Rasau Jaya landfill, Sungai Raya District, Kubu Raya Regency. The study was carried out in 2 areas, the north and south of the landfill. Data acquisition using a fixed base configuration by applying ten lines. Each line has a length of 105 m with 5 m, and the distance between the porous pots is 5 m. The measurement results show that the potential value distribution at the first location is -19.62 mV to 8.44 mV, and the potential value at the second location is -55.50 mV to 23.26 mV. The interpretation shows that leachate accumulation from the landfill in the first area has a potential value of -19.62 mV to -13 mV. The second location has a potential value of -55.50 mV to -36 mV. Based on isopotential contour maps, leachate accumulation in the first location is thought to be in the north to northeast of the landfill, while in the second location, it is thought to be in the southwest to the west of the landfill.

Keywords: leachate; self potential; landfill; Rasau Jaya.

Citation: Kaharuddin., Arman, Y. and Muhardi. (2023). Application of Self Potential Method in Mapping Leachate Flow around Rasau Jaya Landfills Kubu Raya Regency. *Jurnal Geocelebes,* 7(1), 8–16, doi: 10.20956/geocelebes.v7i1.20524

Introduction

The existence of landfills will cause problems for the surrounding environment, such as the distribution of waste and leachate. Leachate comes from rainwater that seeps into the waste pile to transport dissolved materials from the waste decomposition process. Leachate spreading is the main problem caused by waste piles in landfills because it can potentially contain heavy metals that can harm the environment. If the treatment is not maximized, leachate can contaminate the groundwater used by the community. (Hartini and Yulianto, 2018). Rasau Jaya District has peatlands with an area of 51,391 ha (Krisnohadi, 2011). Leachate flow will easily seep below the peat soil's surface so that it can contaminate groundwater.

Rasau Jaya landfill is located on peatland, and its waste management applies an open dumping system. Peatlands will quickly absorb water into the soil (Muliadi et al., 2019). In rainy conditions, the leachate discharge into the treatment plant is predicted to be more significant. The infiltration process of rainwater mixed with leachate will quickly seep into the soil. Leachate seepage is highly dependent on the physical properties of the ground, especially porosity and permeability. Peat soils have high porosity and permeability, making them water-saturated soils (Sampurno et al., 2018).

One of the geoelectric surveys that can be used to observe leachate distribution is the self-potential (SP) method. The SP method is a passive geophysical because it utilizes natural electric potential. One of the causes of electric potential at the surface is water seepage underground (Thanh et al., 2020). The natural electrical potential of the earth is caused by electrokinetic, diffusion, and mineralization processes. This method is effectively used for shallow exploration activities or no more than 100 m (Telford et al., 1990). This method is also often used in environmental studies (Soupios and Karaoulis, 2015), such as detecting fluid flow (Vaidila et al., 2015), identifying groundwater flow (Muhardi et al., 2021), identifying subsurface hot fluid flow (Pratama et al., 2017), leachate distribution mapping (Handoko et al., 2016), and identifying contaminant fluid flow distribution (Bavitra, 2018).

This research aims to map the leachate flow around the Rasau Jaya landfill using the SP method. This method can detect anomalous self-potential values originating from subsurface fluid flow indicated by positive or negative values of less than 100 mV (Telford et al., 1990). Groundwater utilized by some residents around the landfill is potentially contaminated by leachate seepage. Identification of leachate flow can provide initial information for the community and village government to anticipate the impact of leachate on the environment.

Research Method

The measurement was carried out in 2 locations around the Rasau Jaya Landfill, Sultan Agung Street, Kuala Dua Village, Sungai Raya Sub-district, Kubu Raya Regency, West Kalimantan. The first location is north of the landfill (residential area), while the second is south of the landfill, as shown in Figure 1. Data collection was carried out with as many as five passes at each research location. The track length was 105 m, the distance between tracks was 5 m, and the space between porous pots was 5 m. Thus, potential data was obtained with a grid of 105 m. Thus, the data was obtained with a 5 m x 5 m grid, and the area at each location was 3,300 m^2.

The use of porous pot electrodes in SP method measurements is to avoid polarization effects (Siswoyo, 2018). In this study, the electrodes were made using a 1.5-inch paralon with a height of 20 cm. The porous medium used as a base is made of wood with a thickness of 3 cm. The connectors used were copper wires. Copper sulfate (CuSO4) solution was used to increase the sensitivity of the porous pot electrode (Prasetya et al., 2022). An illustration of the porous pot scheme can be seen in Figure 2.

Measurement of potential values in the field using a digital multimeter. The electrode installation applied a fixed base configuration. One electrode was placed at the reference point (base), and the other electrode moved along the measurement path (rover). The electrodes were installed in the ground to a depth of 30-50 cm. Data collection in the field is done by two methods, namely, based on the time function and position function. An illustration of natural potential measurement in fixed base configuration can be seen in Figure 3.

The mapping of leachate flow is based on subsurface water flow, which is relatively shallow. The distribution of potential values shown by the isopotential contour map will be a reference in identifying leachate flow because leachate flows by the flow of subsurface water, from high to low potential. Meanwhile, the presence of leachate is determined by relatively small and negative potential values because leachate is conductive. After all, it contains metal minerals.

Figure 1. Research design map.

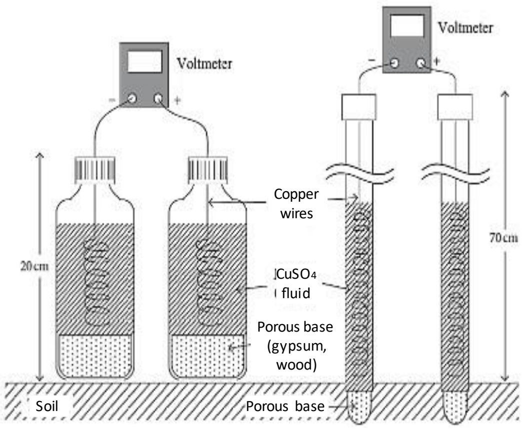


Figure 2. Porous pot scheme illustration (Goto et al., 2012).

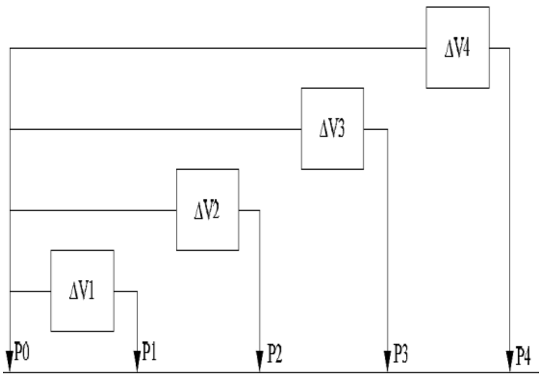


Figure 3. Illustration of fixed base configuration (Indriana et al., 2007).

Result and Discussion

The First Location

The distribution of natural potential values at the first location is shown in Figure 4. The values obtained vary from negative to positive, which have -19.62 mV to 8.44 mV. The change in potential value with distance on the five lines does not show a regular pattern. However, lines 1 and 2 generally have more negative values than the other lines, especially in the middle of the line. This is because the first location is in a residential area, so this value is strongly influenced by the activities of residents, especially in water utilization.

The isopotential contour map at the first location was obtained by combining the five lines, as shown in Figure 5. The lower potential values are in the center and the southwest, while the higher values are in the center to the northeast. The potential distribution pattern is thought to be caused by the distribution of leachate from the landfill and community household activities, as this location is in a residential area.

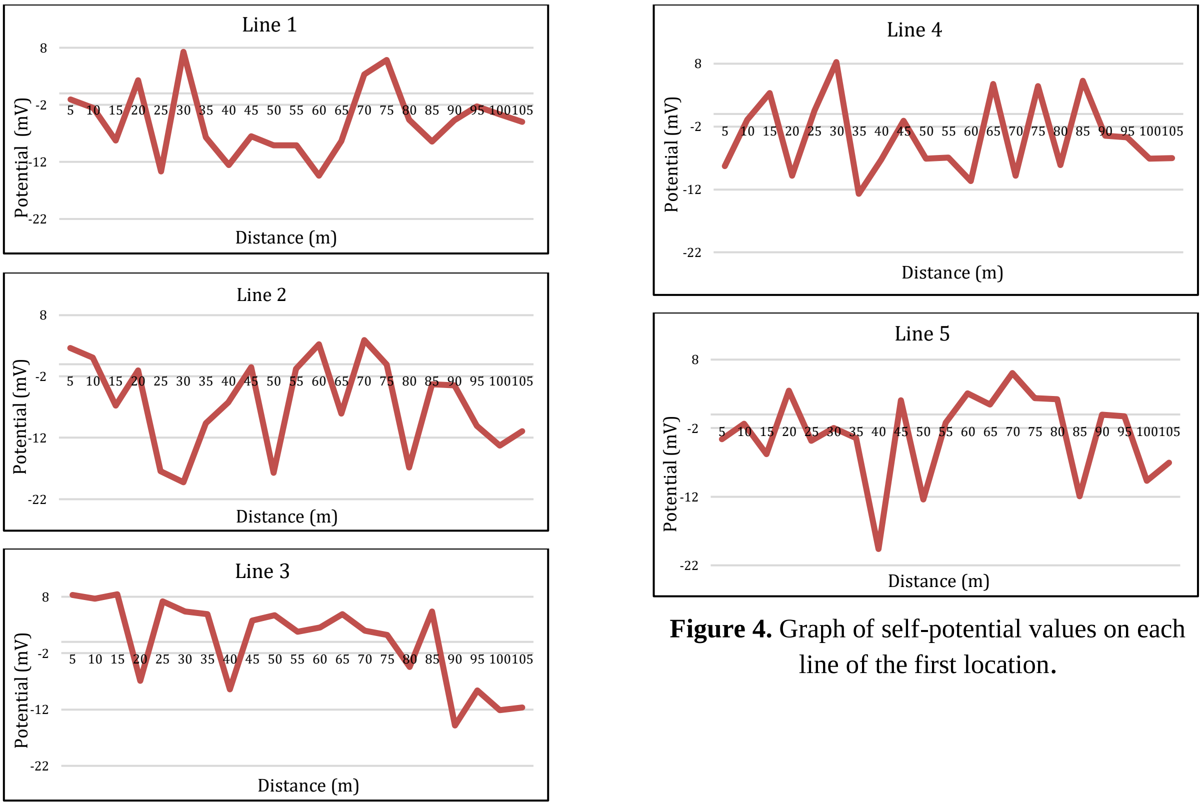


Figure 4. Graph of self-potential values on each line of the first location.

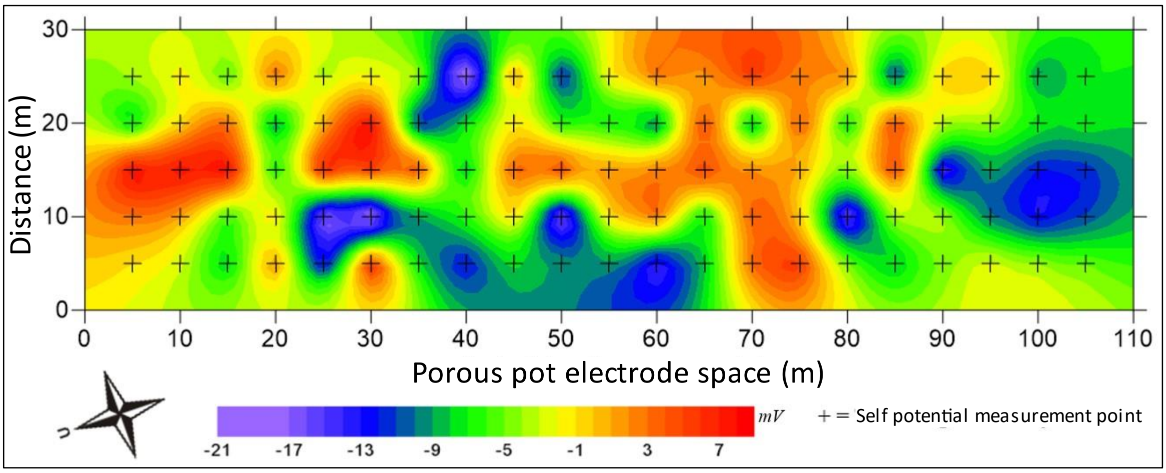


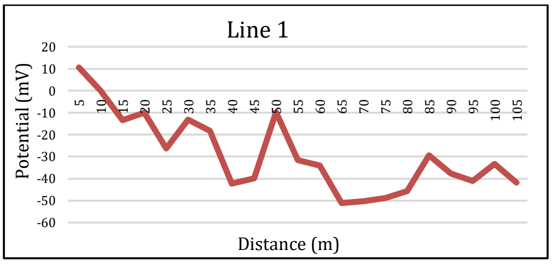
Figure 5. Isopotential contour map of the first location.

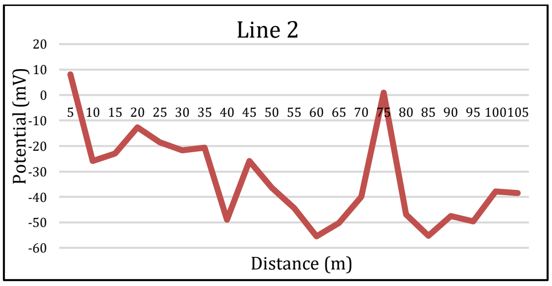
The Second Location

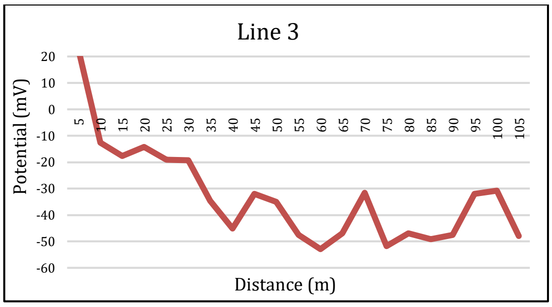
The distribution of natural potential values at the second location is shown in Figure 6. The values obtained vary from negative to positive, which have -55.5 mV to 23.26 mV. In general, there is a decrease in potential value as the distance from the reference point increases. This result shows that the closer to the landfill, the smaller the potential value obtained. The five lines' small and negative potential values are generally located at a distance of 10 - 15 m from the reference point or 90 - 95 m from the landfill. In general, the distribution of potential values in the five lines is negative, with almost the same pattern.

The isopotential contour map at the second location was obtained by combining the five lines, as shown in Figure 7. The lower potential values are located in the northeast, while the higher values are located in the southwest. The potential distribution pattern is caused by leachate distribution from the landfill.

The natural potential anomalies displayed at the first and second locations are thought to be due to the accumulation of fluid flow below the ground surface. The flow is thought to originate from conductive material mixed with near-surface groundwater and leachate from waste. The fluid flow mechanism is also due to the influence of gravity, as it is in the direction of the topographic slope of the study site. At higher topography, the potential value tends to be greater than at lower topography. The nature of the fluid flows from a high place to a lower place.







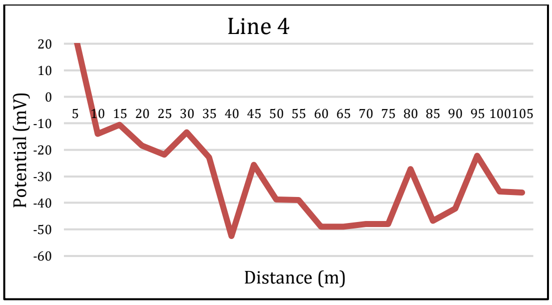


Figure 6. Graph of potential values at each line of the second location.

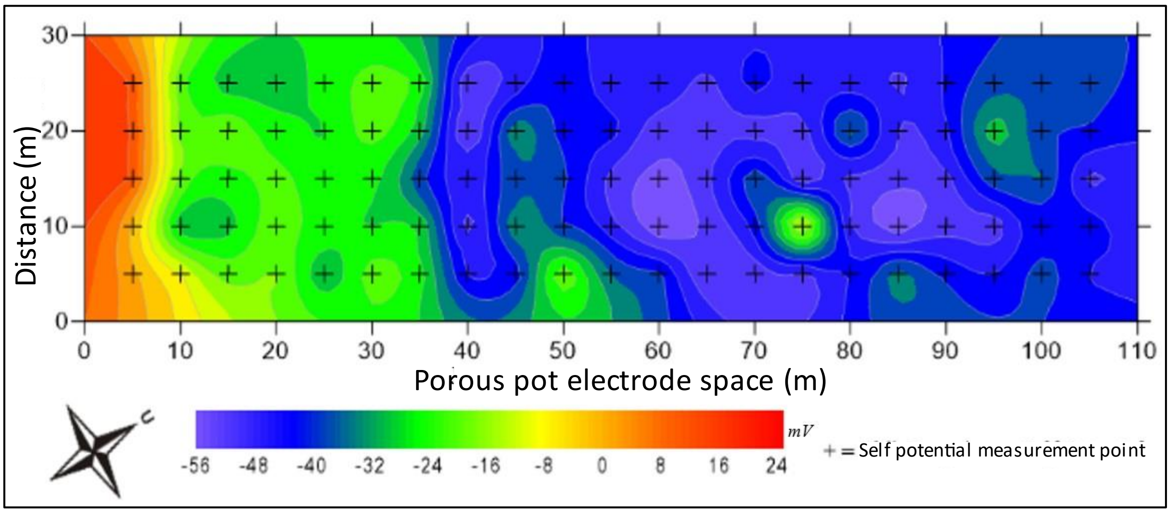


Figure 7. Isopotential contour map of the second location.

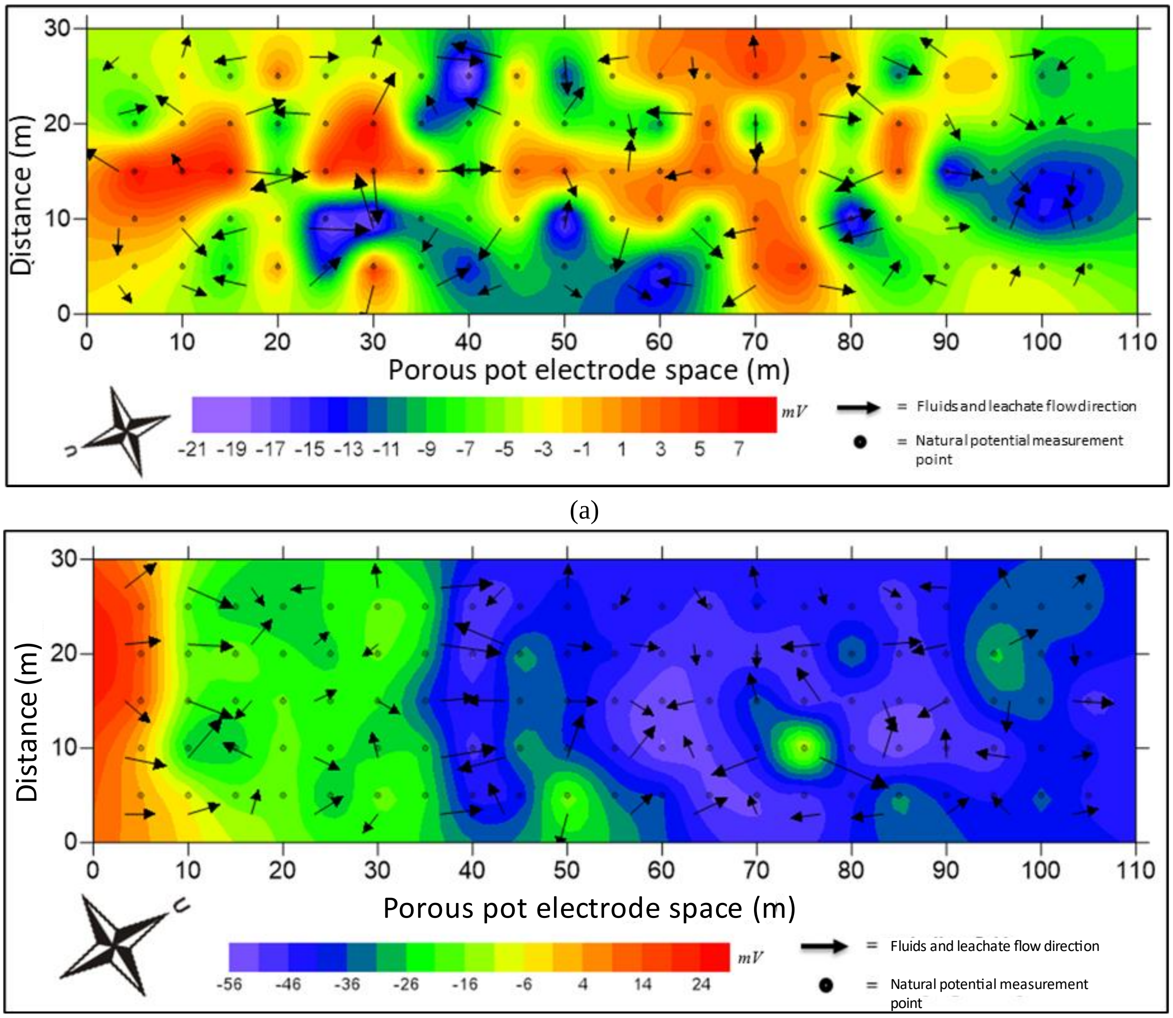


Figure 8. Isopotential and leachate flow contour maps; (a) first location, (b) second location.

The isopotential map and leachate flow direction at the research location can be seen in Figure 8. The qualitative interpretation shows that a black arrow indicates the direction of fluid and leachate flow with a direction perpendicular to the equipotential plane (Rosid et al., 2012). This flow direction results from the difference in potential values as the fluid moves from high potential to low potential. Lower potential values are interpreted as groundwater that is thought to have been contaminated by leachate. Leachate has a relatively lower potential value because it contains metal minerals, so the resistivity value and potential value of leachate become very small. The negative potential value in the measurement area is suspected to be leachate. Leachate flow generally originates from rainwater seepage on waste piles which then spreads to the area around the landfill. The interpretation results show that leachate accumulation from the landfill in the first location has a potential value of -19.62 mV to -13 mV, and in the second location, has a potential value of -55.50 mV to -36 mV.

Fluid flow is affected by electrochemical potential and electrokinetic potential. The movement of electrolytes in leachate water is expected to cause electrochemical potential. The potential value in the leachate area is more negative than in the area that is not contaminated by leachate. Background potentials create electro-chemical processes in the leachate stream so that it can cause anomalous potential values at the identified research location to be more negative. The influence of electrokinetic potential shows that the accumulation of negative values tends to be at a lower topography. It is due to the nature of fluid flow that flows from a higher place to a lower place.

The natural potential values at the first and second research locations differ significantly. In the first location, the distribution of potential values is more varied, allegedly due to activities in residential areas and the slope of the land tends towards the landfill. In the second location, the distribution of potential values is more negative, up to -55.5 mV, presumably due to the influence of leachate water flow caused by the slope of the land and by the flow of ditches originating from the landfill (Bavitra, 2018).

Fluid flow is also closely related to the topographic conditions of the research location. The landfill with a pile of garbage is at a lower elevation than the surrounding area. It is because the load coming from the pile of waste at the landfill location will cause a decrease in the ground surface. The fluid flow tends to follow the slope direction with a lower elevation due to the influence of gravity. This condition will affect the direction of leachate flow at the research location. When it rains, the leachate that is carried away will flow in the direction of the land slope. It causes leachate to be carried away and collected at locations with lower elevations. The measured potential value is dominantly lower at points with lower elevation. It is due to the influence of leachate transported by the fluid flow in the second location. The fluid flow direction around the residential area in the first location was identified as flowing toward the landfill area.

Conclusion

The distribution of potential values at the first location is -19.62 mV to 8.44 mV, and the potential value at the second location is -55.50 mV to 23.26 mV. The interpretation results show that the accumulation of leachate from the landfill in the first location has a potential value of -19.62 mV to -13 mV, and in the second location has a value of -55.50 mV to -36 mV. Based on the isopotential contour map, leachate accumulation in the first location is thought to be in the north to northeast part of the landfill, while in the second location, it is thought to be in the southwest to the west part of the landfill.

Acknowledgements

The authors would like to thank the Laboratory of Geophysics and Geographic Information System (GIS), Universitas Tanjungpura, for facilitating the self-potential equipment in this research.

Author Contribution

Each author has a job in completing this research. Collection of references, data acquisition in the field, and data processing were carried out by Kaharudin. As for interpreting the results and discussion mentored by Yudha Arman and Muhardi. All authors reviewed this manuscript.

Conflict of Interest

In this research, all authors have no financial or personal relationships with other people or organizations, so the author can account for the research results.

References

Bavitra. (2018). Interpretasi Sebaran Aliran Fluida Kontaminan Menggunakan Metode Self-Potential (SP) Pada Tempat Pembuangan Akhir (TPA) Sampah Sarimukti, Kabupaten Bandung Barat. In *Institut Teknologi Bandung*.

Goto, T. N., Kondo, K., Ito, R., Esaki, K., Oouchi, Y., Abe, Y., & Tsujimura, M. (2012). Implications of Self-Potential Distribution for Groundwater Flow System in a Nonvolcanic Mountain

Slope. *International Journal of Geophysics*, 1–10. https://doi.org/10.1155/2012/640250

Handoko, A. W., Darsono, & Darmanto. (2016). Aplikasi Metode Self Potential untuk Pemetaan Sebaran Lindi di Wilayah Tempat Pembuangan Akhir (TPA) Putri Cempo Surakarta. *Indonesian Journal of Applied Physics*, *6*(1), 13–22. https://doi.org/10.13057/ijap.v6i01.1792

Hartini, E., & Yulianto, Y. (2018). Kajian Dampak Pencemaran Lindi Tempat Pemrosesan Akhir (TPA) Ciangir terhadap Kualitas Air dan Udara. *Jurnal Sains dan Teknologi*, *4*(1), 27–32.

Indriana, R. D., Nurwidyanto, M. I., & Haryono, K. W. (2007). Interpretasi Bawah Permukaan dengan Metode Self Potential Daerah Bledug Kuwu Kradenan Grobogan. *Berkala Fisika*, *10*(3), 155–167.

Krisnohadi, A. (2011). Analisis Pengembangan Lahan Gambut untuk Tanaman Kelapa Sawit Kabupaten Kubu Raya. *Jurnal Tek. Perkebunan & PSDL*, *1*, 1–7. https://doi.org/10.1016/j.appet.2016.05.021

Muhardi, Kaharudin, & Anwar, M. (2021). Application of Self-Potential Method to Observe Groundwater Flow in Tanjungpura University Area, Pontianak. *Indonesian Review of Physics*, *4*(2), 17–22. https://doi.org/10.12928/irip.v4i2.4020

Muliadi, Zulfian, & Muhardi. (2019). Identifikasi Ketebalan Tanah Gambut Berdasarkan Nilai Resistivitas 3D: Studi Kasus Daerah Tempat Pembuangan Akhir Batu Layang Kota Pontianak. *Positron*, *9*(2), 86–94. https://doi.org/10.26418/positron.v9i2.34821

Prasetya, I. N., Putra, Y. S., Muhardi, Muliadi, & Perdhana, R. (2022). Interpretasi Sebaran Lindi di Sekitar TPA Salatiga Kabupaten Sambas Menggunakan Metode Self-Potential. *Jurnal Fisika Unand*, *11*(4), 523–530. https://doi.org/10.25077/jfu.11.4.523-530.2022

Pratama, A. A., Bahri, A. S., & Warnana, D. D. (2017). Pemodelan Pola Aliran Fluida Panas Manifestasi Hidrotermal Songgoriti, Kota Batu Menggunakan Metode Self-Potential. *Jurnal Teknik ITS*, *6*(2), 233–236.

Rosid, S., Koesnodo, R. N., & Nuridianto, P. (2012). Estimasi Aliran Air Lindi TPA Bantar Gebang Bekasi Menggunakan Metoda SP. *Jurnal Fisika Unnes*, *1*(2), 54–59. https://doi.org/10.15294/jf.v1i2.1640

Sampurno, J., Muid, A., Zulfian, & Latief, F. D. E. (2018). Characterization The Geometry of The Peat Soil of Pontianak Using Fractal Method. *Journal of Physics: Conference Series*, *1040*(1). https://doi.org/10.1088/1742-6596/1040/1/012044

Siswoyo, H. (2018). Penyelidikan Potensi Air Tanah pada Lahan Pertanian di Desa Bono Kecamatan Pakel Kabupaten Tulungagung dengan Menggunakan Metode Potensial Diri. *Dinamika Rekayasa*, *14*(2), 112–118. https://doi.org/10.20884/1.dr.2018.14.2.219

Soupios, P., & Karaoulis, M. (2015). Application of Self-Potential (SP) Method for Monitoring Contaminants Movement. *8th Congress of the Balkan Geophysical Society*, 1–5. https://doi.org/10.3997/2214-4609.201414147

Telford, W. M., Geldart, L. P., & Sheriff, R. E. (1990). *Applied Geophysics* (Second Edi). Cambridge University Press.

Thanh, L. D., Thai, N. C., Hung, N. M., Thang, N. C., & Huong, L. T. T. (2020). Self-Potential Method for Detection of Water Leakage Through Dams. *Earth Science Malaysia*, *4*(2), 152–155.

https://doi.org/10.26480/esmy.02.2020.152.155

Vaidila, N., Rini, F. P., & Afrari, I. (2015). Survei Struktur Bawah Permukaan Dengan Metode Self Potential Untuk Mengetahui Potensi Panas Bumi (Studi Kasus Obyek Wisata Guci, Jawa Tengah). *Sainteknol: Jurnal Sains dan Teknologi*, *13*(2), 135–142. https://doi.org/10.15294/sainteknol.v13i2.5246