http://journal.uir.ac.id/index.php/JGEET

E-ISSN : 2541-5794
P-ISSN :2503-216X

Journal of Geoscience,
Engineering, Environment, and Technology
Vol 5 No 2 2020

RESEARCH ARTICLE

Geophysical Survey on Open Dumping Landfill for Monitoring Spread of Leachate: A Case Study In Pekanbaru, Riau, Indonesia

Adi Suryadi[1*], Frezy Ukhuah Islami[1], Husnul Kausarian[1], Dewandra Bagus Eka Putra[1]
[1]Department of Geological Engineering, Faculty of Engineering, Universitas Islam Riau, Pekanbaru, Indonesia

* Corresponding author : adisuryadi@eng.uir.ac.id
Tel.:+62 822 8389 6947 ; fax: -
Received: May 29, 2020; Accepted: Jun 20, 2020.
DOI 10.25299/jgeet.2020.5.2.5340

Abstract

Pekanbaru is a city in Indonesia with high population growth. The increasing amount of the population has a parallel relationship with the increasing quantity of waste disposal. This study has been conducted on an open dumping landfill at Pekanbaru that surrounded by residential areas. Waste disposal produces leachate as a threat to surface water and groundwater resources. This study aims to investigate the contamination spread formed by leachate using the geophysical method. Direct Current Resistivity (DCR) has been used to produce 2 D Resistivity subsurface Models. Data acquisition has been done using multi-electrodes (32 electrodes) with spacing 2 m between electrodes. 2D Resistivity model produced, a contaminant from leachate represented by low resistivity value 26.1 - 870 Ωm. The deepest penetration of leachate that detected is around 3 m from the surface. It has been understood that leachate from the landfill of the study area is not contaminated groundwater yet. It confirmed by groundwater analysis at residential around the landfill area. By knowing the spreading of leachate, preventive action can be made to maintain the quality of groundwater resources.

Keywords: *Contamination, Groundwater, Landfill, Leachate, Pekanbaru, Resistivity*

1. Introduction

Geo-electrical survey is a survey that looking the physical parameters which is resistivity value to differentiate subsurface material. Recently, the interest of underground sources of water is increasing rapidly to fulfill the water demand. Pekanbaru is a city that use groundwater as main source of clean water. Parallel with increasing of population in Pekanbaru, waste production also increasing.

The study area is an open dumping landfill at Marpoyan that have potential to produce leachate. As we known that open dumping landfill is a primitive way to dispose the waste without any technology to prevent the contamination through subsurface. The location of landfill become a big problem because it surrounded by residence area (Figure 1). So the aim of this study is to detect the probability of groundwater contamination from leachate leaded by open dumping landfill.

Figure 1. Study area is an open dumping landfill that.

Electrical Resistivity Imaging (ERI) is the most common and successfully used especially in groundwater exploration and environmental problem like soil or groundwater contamination (Azhar et al., 2016; Hamzah et al., 2007, 2008; Jumary et al., 2002; Saad et al., 2012; Adi Suryadi et al., 2019) .By using ERI, resistivity distribution of subsurface will be modelled into two-dimensional image. The model that resulted is showing the apparent resistivity value which can be interpreted as contaminant depend on the value (Akankpo, 2011; N. Nwankwo and O.

Emujakporue, 2012; Okereke and Harcourt, 2012; Surface et al., 2011; A. Suryadi et al., 2019).

2. Methods

ABEM SAS1000 resistivity meter and ABEM Lund ES464 selector system is the equipment that used to collect the resistivity data. The survey employed 61 multi-electrodes with 5 m minimum electrode spacing. The line survey length is reach 400 m that arranged in a straight line. The selector system was connected with all electrodes through multi-core cable (Figure 2) (Hamzah et al., 2008; Loke and Barker, 1995; A. Suryadi et al., 2019). In each measurement the resistivity meter only select four electrodes to activate. Beside of that, coordinate of line survey must be recorded to correlate all the lines taken (Kausarian et al., 2018; Lubis et al., n.d.; Suryadi, 2016).

Apparent resistivity (ρa) calculated by multiple of geometry factor (k) with Voltage (V) and divided by Current (I) injected.

$$\rho a = k\, V/I \qquad (1)$$

Geometry factor (k) is depend on configuration electrode that utilized. In this study configuration used id pole-dipole (Figure 5) that k calculated with formula:

$$k = 2\pi\,(b(a+b))/a \qquad (2)$$

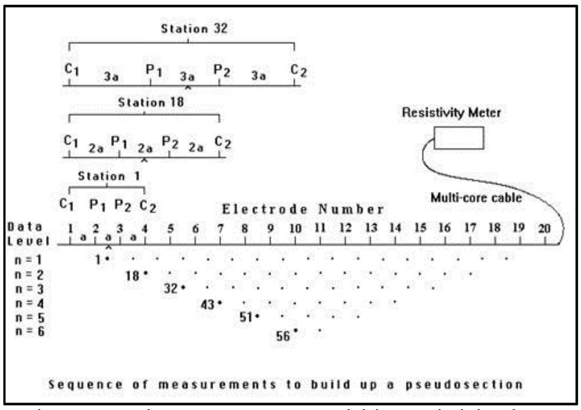

Figure 2. Equipment set up to acquisition resistivity data (Loke and Barker, 1995).

The data collected processed by using inverse modelling software which is RES2DINV. The result of inverse modelling will interpreted based on apparent resistivity and proven by drilling data.

Some supporting data also collected like subsurface condition using hang auger to get the real data of geology. The equipment hand auger is shown at Figure 3. The depth maximum of hand auger only 10 m from the surface. Else from hand auger, another supporting data taken is groundwater elevation and groundwater quality (Figure 4). This data can prove that groundwater already contaminated or not.

Figure 3. Hand Auger equipment to get shallow geological profile.

Figure 4. Equipment for groundwater quality analysis (Ph, temperature, TDS and conductivity).

3. Results and Discussion

Interpretation from 3 survey line shown that contamination from leachate only affected surface. Based on resistivity value there are 3 types of layer (Figure 5) which is low resistivity value (L1), moderate resistivity value (L2) and high resistivity value. Low resistivity value is ranging from 26.1 – 870 Ωm that interpreted as wet clay and sand. Moderate resistivity value has value 269 – 3319 Ωm that interpreted as dry clay. The highest resistivity value is 2276 – 91770 Ωm interpreted as dry sand. From this interpretation dry clay (L2) become the preventer for penetration of leachate. That why in the beginning we mention that contamination only affect surface layer and not yet contaminate the groundwater. This statement also proven by result of hand auger that resulting there is clay layer at depth below 2 meters. The comparison between resistivity result and can be seen at table 2.

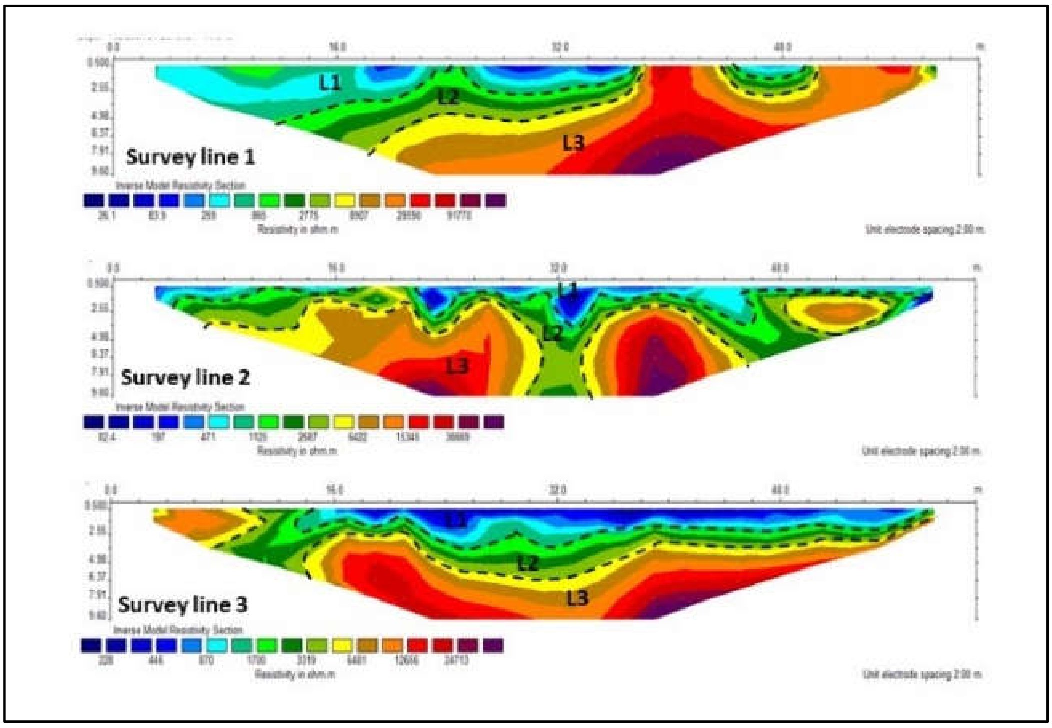

Figure 5. Result of resistivity survey from survey line 1, 2 and 3 that shown there are 3 layers named as L1, L2 and L3.

Table 1. Interpretation of resistivity results.

Survey Line	Layer	Resistivity Value (Ωm)	Depth (m)	Interpretation
Survey line 1	L1	26,1 - 269	0 – 3	Top soil (wet)
	L2	269 – 2775	1 – 6	Dry clay
	L3	2776 – 91770	5 – 9,6	Dry sand
Survey line 2	L1	82,4 – 471	0 – 3	Peat mixed with clay and sand
	L2	471 – 2687	2 – 5	Clay
	L3	2687 – 36669	3 – 9,6	Dry sand
Survey line 3	L1	228 – 870	0 – 3	Peat mixed with clay and sand
	L2	870 - 3319	2 – 6	Clay
	L3	3319 – 24713	3 – 9,6	Dry sand

Table 2. Comparison between resistivity result and hand auger results.

Resistivity Interpretation				Log Profile	
Layer	Resistivityy Value (Ωm)	depth (m)	Interpretation	Depth (m)	Material
L1	26,1 – 870	0 – 3	Top soil	0 – 0,9	Wet clay and sand
L2	269 – 3319	1 – 6	Dry clay	0,9 – 2	Grayish black clay
L3	2776 – 91770	5 – 9,6	Dry sand	2 – 3	Brownish gray sand

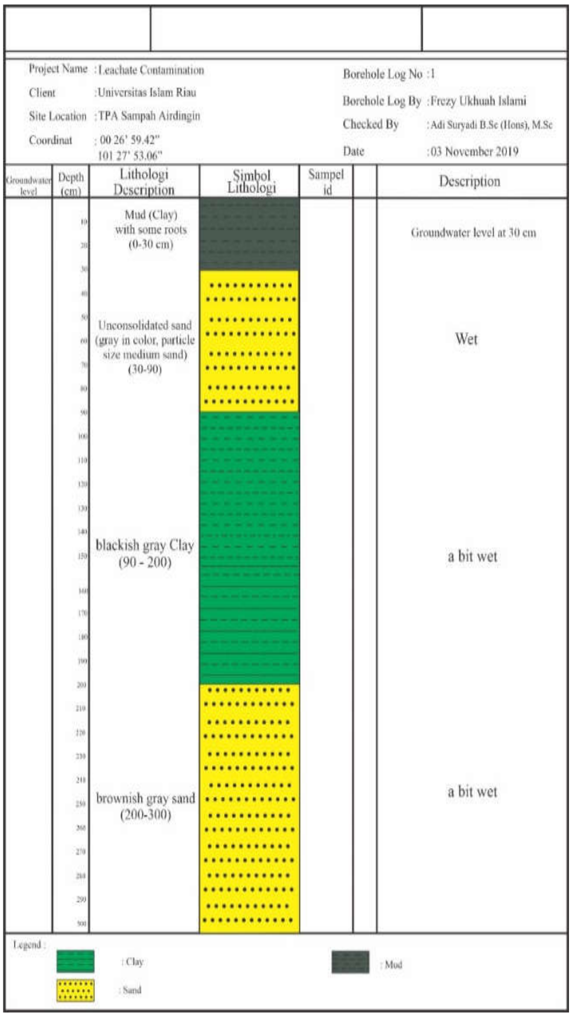

Figure 6. Hand Auger result that shown geological profile of subsurface at study area.

Another supporting data that parallel with interpretation that state groundwater is not contaminated by leachate yet is groundwater quality. As the result from 6 wells sampling (figure 7) around the study area showing 5 wells is in normal condition at variable TDS, Ph, temperature dan conductivity (Table 3). TDS ranging from 35.0 – 81.0 mg/L, Ph ranging from 3 – 7, temperature ranging from 29.4 – 30.2^{0}C and conductivity ranging from 58.6 – 135.5 µs/cm. the well that contaminated only well from landfill area. Contamination clearly shown at variable TDS and conductivity that has very high value (207.9 mg/L for TDS and 344.3 µs/cm. Based on groundwater flow we predict that contamination will migrate to Northeast from study area.

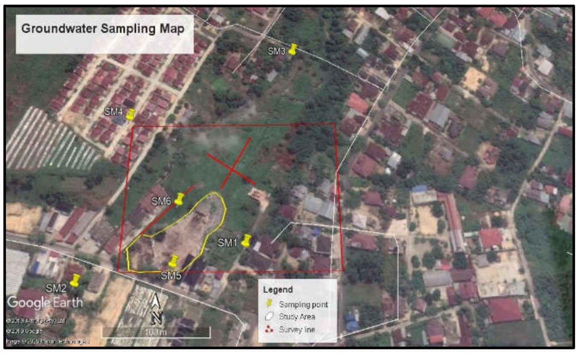

Figure 7. Location of groundwater sampling for groundwater quality analysis.

Table 3. Groundwater quality result.

NO	Well No.	Coordinate	TDS (mg/L)	Ph	Temperature (^{0}C)	Conductivity (µS/cm)
1	SM1	N 00 26' 56.53" / E 101 27' 53.58"	64.9	6.07	29.6 C	108.6
2	SM2	N 00 26' 55.35" / E 101 27' 48.04"	47.2	5.87	30.2 C	79.9
3	SM3	N 00 27' 03.12" / E 101 27' 55.05"	62.6	5.94	29.4 C	104.3
4	SM4	N 00 27' 00.64" / E 101 27' 49.53"	81.0	6.13	29.6 C	135.5
5	SM5	N 00 26' 55.91" / E 101 27' 51.35"	35.0	6.28	29.6 C	58.6
6	SM6	N 00 26' 57.81" / E 101 27' 51.93"	207.9	6.37	29.0 C	344.3
7	Aquades		5.8	6.52	29.0 C	9.7

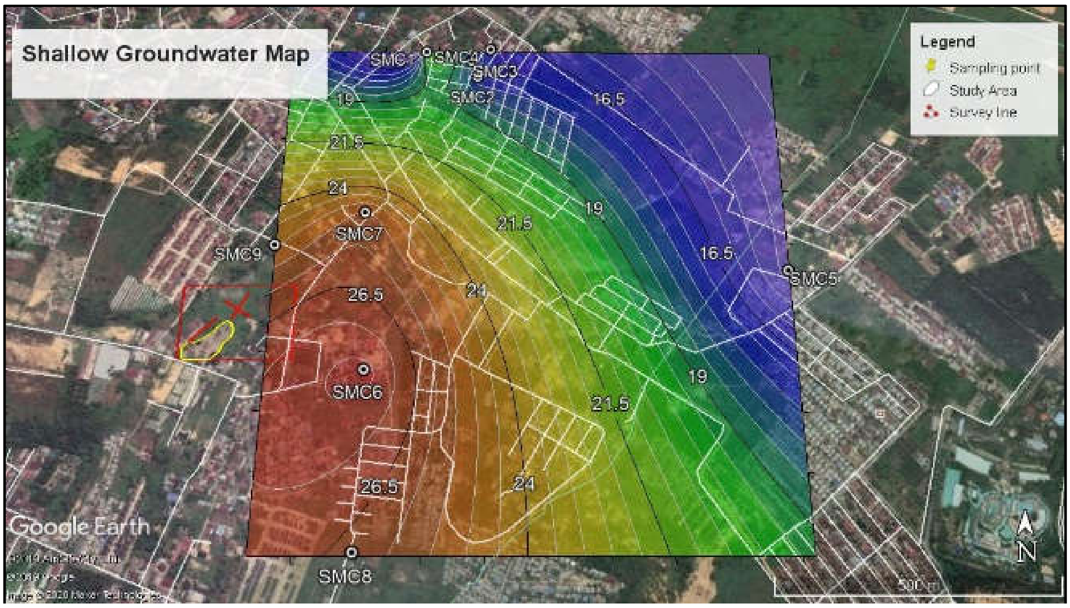

Figure 8. Groundwater elevation map that show the probability of contaminant migrate to Northeast from study area.

4. Conclusion

Technology of sustainable landfill must be apply to all landfill in Pekanbaru to prevent the contamination of groundwater. It very important because majority of society in Pekanbaru use groundwater as the main source of clean water. This study shown that contamination of leachate fortunately prevented by clay layer of study area. That layer is a impermeable media that can't transfer fluid. Beside that, the groundwater quality analysis also shown there is no contaminant detected at groundwater except well at landfill. The contamination of leachate represented by high TDS and conductivity value. The probability of migration contaminant is predicted to northeast from study area.

Acknowledgements

The authors would like to give an acknowledgment to Department of Research and Community Service as funder of this research with contract No. 670/KONTRAK/LPPM-UIR/5-2019. Additional thanks to Geology laboratory of UIR that provide all the equipment of this study and lastly to all our studentsthat help us during data acquisition at field.

References

Akankpo, O., 2011. Monitoring Groundwater Contamination Using Surface Electrical Resistivity and Geochemical Methods. J. Water Resour. Prot. 03, 318–324. https://doi.org/10.4236/jwarp.2011.35040

Azhar, M.A., Suryadi, A., Samsudin, A.R., Yaacob, W.Z.W., Saidin, A.N., 2016. 2D Geo-Electrical Resistivity Imaging (ERI) of Hydrocarbon Contaminated Soil. EJGE (Electron. J. Geotech. Eng. 21, 299–304.

Hamzah, U., Ismail, M.A., Samsudin, A.R., 2008. Geophysical techniques in the study of hydrocarbon-contaminated soil 54, 133–138. https://doi.org/10.7186/bgsm2008020

Hamzah, U., Samsudin, A.R., Malim, E.P., 2007. Groundwater investigation in Kuala Selangor using vertical electrical sounding (VES) surveys. Environ. Geol. 51, 1349–1359. https://doi.org/10.1007/s00254-006-0433-8

Jumary, S.Z., Hamzah, U., Samsudin, A.R., 2002. Teknik-teknik geoelektrik dalam Pemetaan air masin di Kuala (Mapping of groundwater salinity at Kuala Selangor by geoelectrical techniques).

Kausarian, H., Batara, Putra, D.B.E., Suryadi, A., Lubis, M.Z., 2018. Geological mapping and assessment for measurement the electric grid transmission lines in West Sumatera Area, Indonesia. Int. J. Adv. Sci. Eng. Inf. Technol. 8.

Loke, M.H., Barker, R.D., 1995. Least-square deconvolution of apparent resistivity psuedosection. Geophysics 60, 1682–1690.

Lubis, M.Z., Irawan, S., Anurogo, W., Kausarian, H., Pujiyati, S., n.d. EquiSpaced Unshaded Line Array Method For Target Identification Using Side Scan Sonar Instrument.

N. Nwankwo, C., O. Emujakporue, G., 2012. Geophysical Method of Investigating Groundwater and Sub-Soil Contamination – A Case Study. Am. J. Environ. Eng. 2, 49–53. https://doi.org/10.5923/j.ajee.20120203.02

Okereke, I.D., Harcourt, P., 2012. Electrical Resistivity Investigation of Solid Waste Dumpsite at Rumuekpolu in Obio Akpor L . G . A ., Rivers State, Nigeria 1, 631–637.

Saad, R., Nawawi, M.N.M., Mohamad, E.T., 2012. Groundwater detection in alluvium using 2-D electrical resistivity tomography (ERT). Electron. J. Geotech. Eng. 17 D, 369–376.

Surface, E.N., Meeting, E., Geophysics, E., Kingdom, U., 2011. 3D Electrical Resistivity Tomography to locate DNAPL contamination in an urban environment Naudet V., Gourry J.-C., Mathieu F., Girard J.F., Blondel A, Saada A. BRGM , 3 avenue Claude Guillemin, F- 45060 Orleans, France 12–14.

Suryadi, A., 2016. Fault analysis to Determine Deformation History of Kubang Pasu Formation at South of UniMAP Stadium Hill , Ulu Pauh ,. JGEET (Journal Geosci. Eng. Environ. Technol. 1, 1–6.

Suryadi, A., Batara, Amir, S.N., 2019. Electrical Resistivity Imaging (ERI) and Induced Polarization (IP) Survey to Solve Water Drought Problem at Alor Gajah, Melaka, Malaysia, in: IOP Conference Series: Materials Science and Engineering. https://doi.org/10.1088/1757-899X/532/1/012025

Suryadi, Adi, Putra, D.B.E., Kausarian, H., Prayitno, B., Fahlepi, R., 2019. Groundwater exploration using Vertical Electrical Sounding (VES) Method at Toro Jaya, Langgam, Riau. J. Geosci. Eng. Environ. Technol.3,226.https://doi.org/10.24273/jgeet.2018.3.4.2226