Groundwater Exploration using 2D Electrical Resistivity Imaging (ERI) at Kulim, Kedah, Malaysia

Adi Suryadi[1], Muhammad Habibi[2], Batara[3], Dewandra Bagus Eka Putra[1], Husnul Kausarian[1]

[1]*Department of Geological Engineering, Universitas Islam Riau, Pekanbaru, Indonesia*

[2]*GWS Drilling Engineeering Sdn. Bhd., No. 6 Jalan Metro Perdana Timur 11, Kuala Lumpur, Malaysia*

[3]*School of Ocean and Earth Science, Tongji University, Guokang Rd, Yangpu Qu, Shanghai Shi, China*

Keywords: 2D Electrical Resistivity Imaging (ERI), Dipole-Dipole, Groundwater, Resistivity, Kulim, Malaysia

Abstract: Water demand in the study area has been increasing by time but surface water is not sufficient to fulfil the demands. 2D Electrical Resistivity Imaging (ERI) survey was conducted in order to looking for groundwater potential as freshwater alternative resources at Kulim, Kedah, Malaysia. The data acquisition was carried out using 5 meters multi-electrodes spacing with pole-dipole configuration array. The geophysical survey involved both resistivity and chargeability at the same time. The result of 2D Electrical Resistivity Imaging indicated that the groundwater potential area has low resistivity value with range 10 – 100 Ωm. Groundwater potential zone divided into 2 characteristics which is shallow groundwater zone (>75m in depth) and deep groundwater zone (>100m in depth). The groundwater potential zone covered by high to very high resistivity value. Those high resistivity value 200 – 1000 Ωm interpreted as dry top soil at near surface while at deep zone is interpreted as fresh bedrock. Chargeability value of groundwater potential area ranging from 0 up to 8 msec. All interpretation later confirmed by drilling data.

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 fulfilled the water demand(A Suryadi et al., 2019). Electrical Resistivity Imaging (ERI) is the most common and successfully used especially in groundwater exploration and environmental problems(Azhar et al., 2016; Hamzah et al., 2008; Hamzah et al., 2007; Jumary et al., 2002; Saad et al., 2012). By using ERI, resistivity distribution of subsurface will be modelled into two-dimensional image(A Suryadi et al., 2019). The model that resulted is showing the apparent resistivity value which can be interpret depend on the value.

The study area is located at Silterra Malaysia SdnBhd at Lot 8 and 9 in Kulim, Kedah, Malaysia with coordinate N 5024’18.24” and E100035’33.09”. The shortage of piped water supply at headquarters Silterra has caused considerable problems to several activities of the central area. The supply of water to the central area is insufficient due to high demand of water. Long period of dry season also affected to hydrogeology cycle. This water problem is not only caused problem to the factory but it also affected the nearby residential area(Adi Suryadi et al., 2019). So, aim of this study is to locate and delineate groundwater potential zone as alternative water resources at study area.

The area is located about 10 km from Pekan Kulim and about 3 km from Sungai Jarak. Secondary forest and palm oil plantation are covered the study area with almost flat topography (Figure 1). It easily to reach the location by using a car. Nine (9) lines of 2D Electrical Resistivity Imaging (ERI) survey were conducted with length of survey line up to 400 m (Figure 2).

2 GEOLOGICAL SETTING OF STUDY AREA

Geology of Study area is consist of granite and surround by metamorphic rock (slate, phyllite and schist) and sedimentary rock (sandstone, siltstone and shale) (Figure 3). Granite of study area known as Kulim granite that consist of two main types, namely

Suryadi, A., Habibi, M., Batara, ., Eka Putra, D. and Kausarian, H.
Groundwater Exploration using 2D Electrical Resistivity Imaging (ERI) at Kulim, Kedah, Malaysia.
DOI: 10.5220/0009065600350040
In *Proceedings of the Second International Conference on Science, Engineering and Technology (ICoSET 2019)*, pages 35-40
ISBN: 978-989-758-463-3

medium to coarse grained biotite granite and the sparsely porphyritic micro-granite. Both of them are almost similar in mineral contain except the former also contain traces of galena, pyrite and garnet. The essential of mineral in the granite are K-feldspar, plagioclase, quartz, biotite and muscovite. K-Ar mineral ages for biotite sparates from pink porphyritic Penanti granites (north of Bukit Mertajam) defined an age 196±8 Ma. K-Ar mineral ages for biotite and muscovite sparates from the Karangan biotite granite (northeast Kulim) gave an age of 190±10 and 180±10 Ma respectively(Hutchison, 1989).

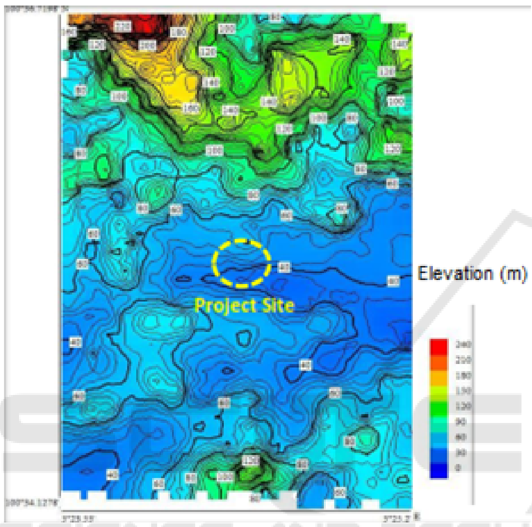

Figure 1: Topography map that show location of study area is almost flat.

Figure 2: Satelite image of study area that shown line survey location.

3 METHODOLOGY

ABEM SAS1000 resistivity meter and ABEM Lund ES464 selector system is the equipment that used

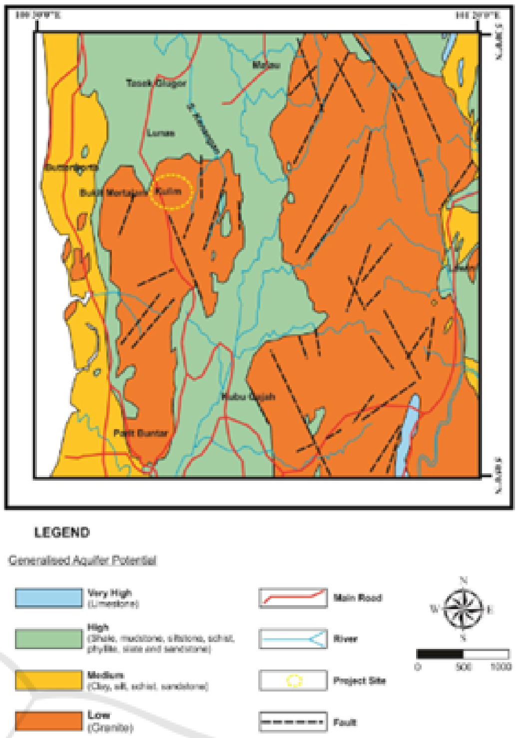

Figure 3: Geological Map of study area that consist of granite and surrounded by sedimentary rock and metamorphic rock(Hutchison, 1989).

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 4)(Loke and Barker, 1995)(Azhar et al., 2016; 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, 2016; Lubis et al., n.d.; LUBIS et al., 2018; Suryadi, 2016)

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

$$\rho a = kV/I \tag{1}$$

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:

$$k = 2\pi(b(a+b))/a \tag{2}$$

a is the distance from P1 to P2; b is the distance from C1 to P1

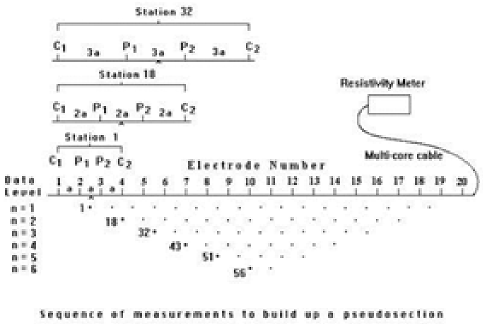

Figure 4: Equipment set up to acquisition resistivity data(Loke and Barker, 1995)

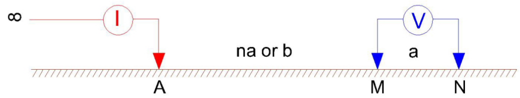

Figure 5: Equipment set up to acquisition resistivity data(Loke and Barker, 1995)

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.

4 RESULT AND DISCUSSION

Nine (9) ERI lines survey data has been processed in order to produce 2D inversion model of resistivity. The resistivity value representing the subsurface condition of study area. There are two typical of groundwater potential zone in this study which are deep groundwater potential and shallow groundwater potential.

Figure 6 is the result of line 6 show the typical 2D ERI result of study area with deep groundwater potential. Generally, resistivity value can be grouped into 3 layers or zones. First zone with moderate to high resistivity value (100 – 1000 Ωm) that represented by colour orange to purple near surface is interpreted as top soil. Usually soil always showing moderate to low resistivity value because it has high moisturized due to subtropical area(N. Nwankwo and O. Emujakporue, 2012; A Suryadi et al., 2019). But in this study top soil showing high resistivity value, this value indicating the condition of soil is dry. Below top soil, resistivity value is extremely high represented by red to dark purple in colour with resistivity range 300 to 2000 Ωm. this layer is interpreted as fresh bedrock layer. Based on geology regional of study area, bedrock of the site is consist of granite. The third layer is located about 100 m in depth from surface with low resistivity profile (10 – 100 Ωm). This layer showed by bright green to yellow in colour. From those resistivity value, the third layer is interpreted as groundwater potential area because water saturated zone are conductive zone that easily to transfer electrical current. From the result of chargeability also support the interpretation with showing low chargeability (2 – 20 msec).

Another typical of groundwater potential zones is representing by result of line survey 7 (Figure 7). This result also divide into 3 layer. The first layer is dry top soil layer with resistivity value range (100 – 1000 Ωm), followed by very high resistivity value (300 – 2000 Ωm) that interpreted as granite fresh bedrock. In granite zone there is an anomaly resistivity value with coning shape at depth 25 to 75 m. This zone has low resistivity profile which is 3 – 100 Ωm interpreted as shallow groundwater potential. It also linear with chargeability result that showing low chargeability value 2 – 8 msec. Table 1 showing all the groundwater potential zone from 9 survey lines.

From the result of 2D Electrical Resistivity Imaging (ERI), some location that has groundwater potential has been drilled to prove either it actually water saturated zone or not. Besides that, drilling data also proven for all geological interpretation based on resistivity value. Table 2 is drilling location coordinate according to groundwater potential zones that has been interpreted.

Table 1: Groundwater potential zone characteristic and location based on 2D ERI

Survey line	Groundwater potential zone			
	Resistivity (Ωm)	Chargeability (msec)	Depth (m)	Location from 1st electrode (m)
Line 1	8 - 110	0 – 2	75 – 125	80 – 180
Line 2	10 – 100	8 – 12	¿ 125	225 – 255
Line 3	2 – 100	2 – 5	75 – 150	80 – 210
Line 4	3 – 100	1 – 5	75 – 125	140 – 265
Line 5	20 – 100	0 – 1	125 – 150	150 – 230
Line 6	10 – 100	2 – 12	100 – 125	140 – 240
Line 7	1 – 100	0.5 – 5	25 – 75	185 – 280
Line 8	20 – 100	2 – 12	50 – 100	215 – 290
Line 9	1 – 100	1 – 2	25 – 50	185 – 220

PDL 6 and PDL 7 are located at survey line 6 and survey line 7. Based on drilling data PDL 6 (Figure 8) from the surface to 6 is consist of top soil with characteristic light yellowish brown in color,soft and slightly silty clay. From 6 m to 12 m the material is firm fine sandy silty clay with color light reddish brown. Hard layer of clay found at depth 12 m up to 30 m. starting from 30 of depth till the end of drilling (300 m) represented by weathered granite. At 100 m and 280 m of depth was identified as fractured zone. In conjunction between 2D ERI result of line 6 and drilling data of PDL 6 can be correlated. The low

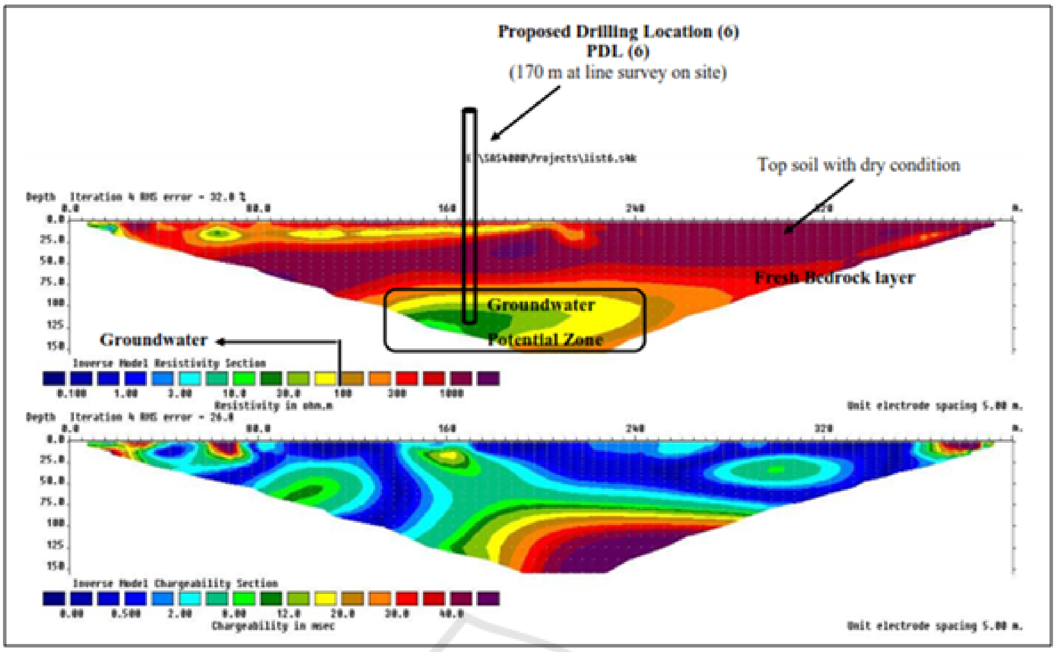

Figure 6: 2D Electrical Resistivity Imaging result of line survey 6

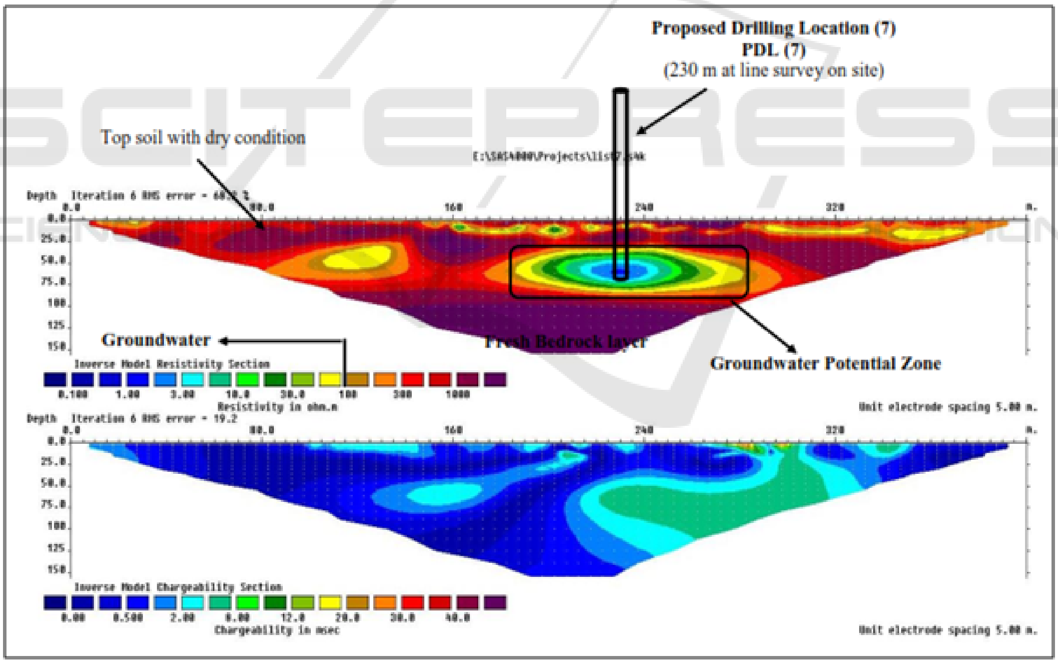

Figure 7: 2D Electrical Resistivity Imaging (ERI) result of line survey 7

resistivity value (10 – 100 Ωm) from 2D ERI result at depth 125 interpreted as groundwater potential zone and it supported by drilling data. According the drilling data, at 100 m of depth found fractured zone of granite that has very high possibility as secondary porosity to preserve groundwater resources.

PDL 6 and PDL 7 are located at survey line 6 and survey line 7. Based on drilling data PDL 6 (Figure 8) from the surface to 6 is consist of top soil with characteristic light yellowish brown in color,soft and slightly silty clay. From 6 m to 12 m the material is firm fine sandy silty clay with color light reddish brown. Hard layer of clay found at depth 12 m up to 30 m. starting from 30 of depth till the end of drilling

Table 2: Coordinate of drilling location

Name	Coordinate	
	Latitude	Longitude
PDL 1	5° 24’ 18.37” N	100° 35’ 30.99” E
PDL 2	5° 24’ 14.66” N	100° 35’ 32.62” E
PDL 3	5° 24’ 17.38” N	100° 35’ 32.08” E
PDL 4	5° 24’ 17.02” N	100° 35’ 29.32” E
PDL 5	5° 24’ 9.63” N	100° 35’ 31.84” E
PDL 6	5° 24’ 8.63” N	100° 35’ 30.23” E
PDL 7	5° 24’ 11.07” N	100° 35’ 30.10” E
PDL 8	5° 24’ 15.95” N	100° 35’ 32.20” E
PDL 9	5° 24’ 15.48” N	100° 35’ 30.02” E

(300 m) represented by weathered granite. At 100 m and 280 m of depth was identified as fractured zone. In conjunction between 2D ERI result of line 6 and drilling data of PDL 6 can be correlated. The low resistivity value (10 – 100 Ωm) from 2D ERI result at depth 125 interpreted as groundwater potential zone and it supported by drilling data. According the drilling data, at 100 m of depth found fractured zone of granite that has very high possibility as secondary porosity to preserve groundwater resources.

5 CONCLUSION

2D Electrical Resistivity Imaging (ERI) Survey has been successfully used in this study to locate and delineate groundwater possibility potential at Kulim, Kedah, Malaysia in conjunction with chargeability data and drilling data. The drilling location was determined by groundwater potential zone that shown from 2D ERI result. The resistivity result show that there are 3 layers or zone within study area. First layer is top soil (clay) in dry condition represented by moderate to high resistivity value ranging from 100 – 100 Ωm at near surface. Another layer is extremely high resistivity value 300 Ωm up to 2000 Ωm thatindicate granite as bedrock of study area. Groundwater potential zone shown by low resistivity value ranging from 1 – 100 Ωm. Potential zone of groundwater divided into 2 based on its depth, shallow groundwater potential with depth 25 m to 75 m from the surface and deep groundwater potential with depth more than 75 m. drilling data was proven all the interpretation of 2D ERI where the groundwater potential zone is fractured zone of granite. Fractured zone become secondary porosity that can be store groundwater.

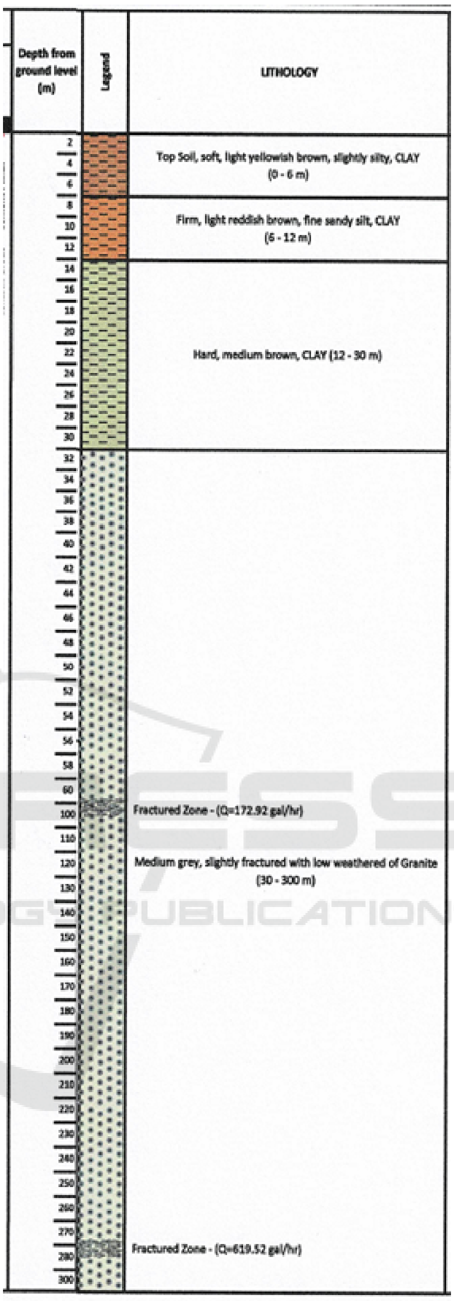

Figure 8: Drilling data of PDL 6

ACKNOWLEDGMENTS

The authors would like to give an acknowledgment to GWS Drilling Engineering Sdn. Bhd. members for their cooperation in data collection that help authors very much in field. The authors also thanks to Silterra Malaysia SdnBhd for the great hospitality at field.

REFERENCES

Azhar, M., Suryadi, A., Samsudin, A. R., Yaacob, W. Z. W., and 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., and Samsudin, A. R. (2008). Geophysical techniques in the study of hydrocarbon-contaminated soil.

Hamzah, U., Samsudin, A. R., and Malim, E. P. (2007). Groundwater investigation in kuala selangor using vertical electrical sounding (ves) surveys. *Environmental geology*, 51(8):1349–1359.

Hutchison, C. S. (1989). *Geological Evolution of South-east Asia*. Clarendon Press, Oxford.

Jumary, S. Z., Hamzah, U., and 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, B., Putra, D. B. E., Suryadi, A., and Lubis, M. Z. (2018). Geological mapping and assessment for measurement the electric grid transmission lines in west sumatera area, indonesia. *International Journal on Advanced Science, Engineering and Information Technology*, 8(3):856–862.

Kausarian, H., Sri Sumantyo, J., Karya, D., Bagus, D., and Abdul Kadir, E. (2016). Geological mapping for the land deformation using small uav, dinsar analysis and field observation at the siak bridge i and ii, pekanbaru city, indonesia.

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

Lubis, M., Anurogo, W., Kausarian, H., Choanji, T., Antoni, S., and Pujiyati, S. (2018a). Discrete equispaced unshaded line array method for target identification using side scan sonar imagery. In *IOP Conference Series: Earth and Environmental Science*, volume 176, page 012025. IOP Publishing.

Lubis, M. Z., Pujiyati, S. R., Pamungkas, D. S., Tauhid, M., Anurogo, W., and Kausarian, H. (2018b). Coral reefs recruitment in stone substrate on Gosong Pramuka, Seribu Islands, Indonesia. *Biodiversitas*, 19(4):1451–1458.

N. Nwankwo, C. and O. Emujakporue, G. (2012). Geophysical Method of Investigating Groundwater and Sub-Soil Contamination – A Case Study. *American Journal of Environmental Engineering*, 2(3):49–53.

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

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.

Suryadi, A., Batara, A., and N., S. (2019). Electrical resistivity imaging (ERI) and induced polarization (IP) survey to solve water drought problem at alor gajah. *Melaka, Malaysia. IOP Conf. Ser. Mater. Sci. Eng. 532*, 532:012025.

Suryadi, A., Putra, D. B. E., Kausarian, H., Prayitno, B., and Fahlepi, R. (2018). Groundwater exploration using Vertical Electrical Sounding (VES) Method at Toro Jaya. *Langgam, Riau. J. Geosci. Eng. Environ. Technol. 3*, 3(226.).