International Journal of Sciences: Basic and Applied Research (IJSBAR)

ISSN 2307-4531
(Print & Online)

http://gssrr.org/index.php?journal=JournalOfBasicAndApplied

Hydrogeological Study of Labuhan Angin Power Station Landfill Site

Mester Sitepu*

Department of Physics, Faculty of Mathematics and Natural Sciences North Sumatra University, Jl. Bioteknologi No. 1 Kampus USU, Medan 20155, Indonesia

Email: mester_s@yahoo.com

Abstract

Hydrogeological study of landfill site of Labuhan Angin power plant was conducted in August 2015. The study is intended to complement the data hydrogeologic of landfill site of Labuhan Angin power plant activities, which is one of the requirements for obtaining permit land filling of hazardous and toxic waste materials originating from own activities. Hydrogeological study of the location of the landfill activities was carried out by using geoelectric method by mean of Wenner - Schlumberger configuration. This method was chosen because the necessary information required is lithologic of rocks and water table conditions at the location of activities. To cover both the location of landfill existing activities and location of the future expansion of the landfill, nine sample traverses were selected. Data of each traverse was processed by Res2DInv, to get a true resistivity of rock under the traverse. The analysis showed that the rock in the location of activities consists of top soil derived from the weathering process, sandy top soil and sea sand. The depth of water table at the site of activities varies from 0.4 m to 2.0 m below ground surface. Difference in depth of water table in this location is due to the topographic difference of the site.

Keywords: hydrogeology; coal ash; landfill; geoelectric; true resistivity.

1. Introduction

Labuhan Angin power plant consists of two units, namely units 1 and 2, with the capacity of 115 MW each. Labuhan Angin power plant has been in commercial operation where the unit 1 has been operating since November 7, 2009 whiles the second unit in operation since April 21, 2009.

---

* Corresponding author.

Both units of Labuhan Angin power plant are using coal as fuel to drive the turbine. The amount of coal ash generated each year, from 2008 up to 2014, is ranged from 15,141,825.44 kg to 3,988,441,400.39 kg (PT. PLN (Persero) Sector Labuhan Angin Plant, 2015). This coal ash waste is dumped in the ash disposal landfill of Labuhan Angin power plant.

Labuhan Angin power plant already has the Environmental Impact Assessment (EIA) documents and has received Environmental Feasibility Decree from the Governor of North Sumatra. However, the landfill site of the ash generated from burning coal is not included in the EIA Document of Labuhan Angin power plant.

The Ministry of Environment and the Government of Central Tapanuli District stipulates that environmental documents that must be completed for the Landfill Activities of Labuhan Angin power plant is the Environmental Evaluation Document.

In obtaining permits of hazardous and toxic waste materials landfill, one of the requirements that must be completed is the hydrogeological study of landfill area. On that basis, the hydrogeological study is intended to complement the requirements submitted by the Ministry of Environment of the Republic of Indonesia. The hydrogeological study was conducted by using the geoelectric method of Wenner – Schlumberger configuration.

2. Materials and Methods

Hydrogeological study is the study of the distribution and movement of ground water in the soil and rocks in the earth's crust. Therefore, hydrogeological studies involving the interaction between ground water flow and geological structures can be very complex [3, 8].

One method that is often used in the study of ground water is by using geoelectric method. In this case the electrical resistivity of rocks, water saturated or not, is mapped in two dimensions to accommodate the change of electrical resistivity laterally and vertically. With this method one can obtain geological structures map and the depth of ground water table saturating rocks [6, 7].

Location of landfill was previously bushes or swamps and secondary forests. Topographic condition of the location can be considered as a flat ground surface since it varies only from 0 m to 2 m above the sea level. The types of soil are generally top soil derived from weathering process, mixture of top soil and sand and sea sand. There is no visible outcrops around a radius of 500 m from the location of activities. This indicates that the lithology above bedrock is sand and top soil. In the vicinity of the location there are also ponds and swamps, however they are not associated with natural seawater channel. This is demonstrated by the fact that volume of water in the ponds and swamps are not influenced by tidal.

Activities while constructing the landfill including dredging for the landfill site and backfilling around the landfill for barrier and also hoarding the way to the landfill site. This activity raises the elevation difference on the landfill sides. North side is higher than the South side, and West sides are also higher than the East side. North and West sides are relatively have the same elevation.

Google map that shows the location of the existing landfill and the planned future expansion of the landfill is given in Figure 1.

In the North and West sides of landfill there are water filled ponds in which live tilapia, cork, catfish and others. While in the East and South sides there are also ponds that live fish. But here there are fishes that are originated from the sea such as julung-julung fish (local name). It shows that during rainy season water in the ponds are associated with sea water from natural sea water channel. The elevation difference of ground surface in the East and South sides is approximately 2 m. based on the geological and environment conditions of the location, the map that can represent hidrogeological condition of the location is the pseudosction map, and the method best fit the geologic and environmental contition is geoelectric method of Wenner – Schlumberger configuration. In order to get the representative lithologic condition and water table in the location, the selected traverses are shown in Figure 1.

Traverse I was taken as a substitute to the traverse that was originally planned as in line with the H traverse. However, because this location is a swamp and geoelectric measurements is imposible then the similar location, at the site of the naval firing range (traverse I), was selected.

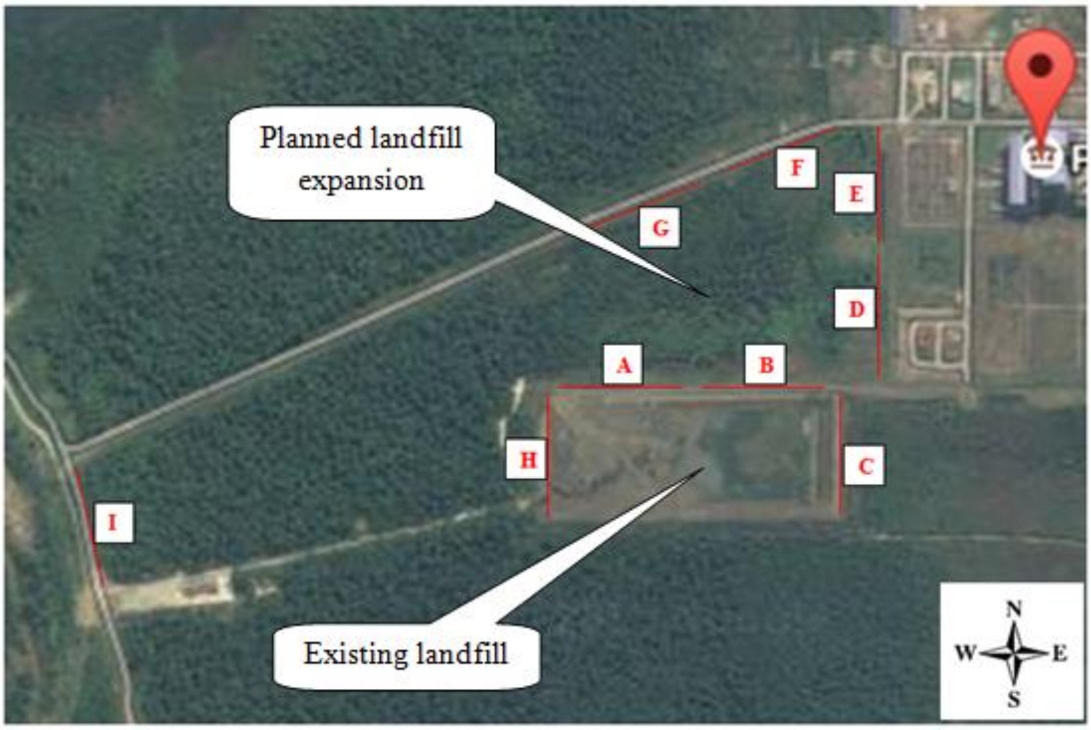

Figure 1: Traverse locations in the landfill area

The tool used in the mapping activities was Resistivity Meter of model ARES-G4.v47 (Automatic Resistivity System). In order the resolution obtained is high then the selected length of each traverse is 155 m and the number of electrodes is 32. In this case, the distance between the electrodes is only 5 m, and the information obtained is up to a depth of 30 m from the surface (20% of the traverse length) [4].

Pseudosection map of the true resistivity of each traverse is given in Figure 2.

3. Results

For the purposes of interpretation, the map used is pseudosection map of the true resistivity obtained using Res2DInv (Figure 2). From the nine sampled traverses in the study area it appears that the true electrical resistivity of rock under the surface varies widely (Table 1). The wide variation of true electrical resistivity is rarely found in a study. The main cause of wide variation of true electric resistivity of rock is determined by the conditions such as dry, wet, cracks, solid, liquid, and also the type of material such as density, porosity, size and shape of the pores of rocks, water content, quality and temperature [7,8]. In addition, other geological factors also determine the electrical resistivity of rock, such as the age of the rock, texture of rocks and geological processes that include alteration, weathering, dissolution and metamorphism [2].

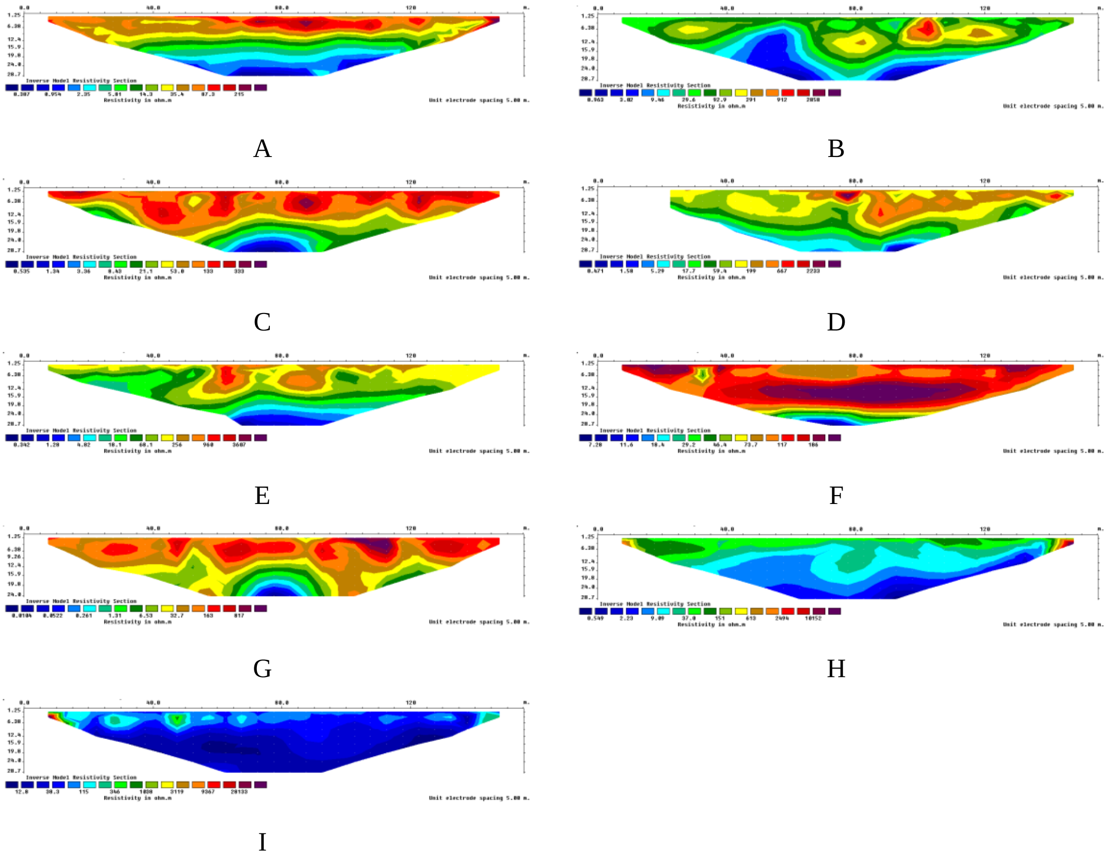

Figure 2: Pseudosection map of the true resistivity of each traverse

The interpretation process is carried out by finding the true resisiviy of rocks from the pseudosection map at the midpoint of the traverse (at a distance of 80 m) as a function of depth [5]. The depth selected were 1.25 m, 6.38 m, 12.40 m, 19.80 m and 24.00 m from the ground surface. Under this method, the value of the true electrical resistivity as a function depth of each traverse is given in Table 2.

Table 1: Minimum and maximum values of true resistivity at each traverse.

Resistivity	Traverse								
	A	B	C	D	E	F	G	H	I
Minimum (Ωm)	0,3	1.0	0,5	0,5	0,3	7,0	0.0	0,5	12
Maximum (Ωm)	200	2500	300	2200	3500	180	800	10000	28000

Table 2: The true resistivity as a function of depth of each traverse.

Depth	**True Resistivity (Ωm)**								
	A	B	C	D	E	F	G	H	I
1,25 m	100	90	100	1000	800	80	150	25	90
6,38 m	80	120	100	150	200	120	250	120	50
12,40 m	20	200	70	75	500	200	50	100	25
19,80 m	4	40	15	50	50	30	0,75	10	15
24,00 m	1	20	5	9	5	20	0,01	7	10

To determine the type of rock that is in agreement with the true resistivity of rocks in Table 2, the true electrical resistivity of rocks in Table 2 is compared with the true resistivity of rocks in the literature [1][3]. In order the type of rocks obtained fits with the geological and environmental condition of landfill area then the type of rock obtained is also compared with the survey results.

By referring to the electrical resistivity of rocks that exist in the literature [1, 3] it appears that the value of the electrical resistivity of these rocks varies from Low to 10s Ωm for top soil and 5 to 40 000 Ωm for sand. If the rock is saturated by seawater or uncontaminated surface water, the electrical resistivity of rock will change according to the total resistivity of rock and fluid saturating it. Note also that the value of the electrical resistivity is also overlap from one to the other. Thus, in the absence of additional information such as outcrops, the physical condition of the location as well as geological maps the interpretation will become very difficult [9].

For each traverse, by comparing the true electrical resistivity of rock obtained from the Res2DInv with the electrical resistivity of rocks in the literature, and also referring to the existing geological map, outcrops and physical condition of the location it was found that there are two types of rocks that are dominant and most representative in this location, namely wet to moist silty soils (Low - 10s Ωm) and sand (5 - $40x10^3$ Ωm). Electrical resistivity variations that occur may also be caused by the presence of seawater (21 Ωm at 18 ^oC) and uncontaminated surface water ($2x10^4$ Ωm).

From Table 2, by correlating the type rocks obtained from each traverse, the depth of water table and type of rock below the surface is given in Table 3. Table 3 shows that the rock found at the existing landfill site and the planned landfill expansion site is the sea sand.

In the undisturbed area the type of rock near the surface is top soil derived from weathering process, and beneath it is found sea sand. Table 3 also shows that the depth of water table at this site varies between 0.4 m to 2.0 m from surface. This variation is corresponding to the topographic level of the ground surface at each traverse.

Table 3: Altitude, type of rocks and depth of water table at each traverse.

Parameters	Traverse								
	A	B	C	D	E	F	G	H	I
Altitude (m)	1,8	1,8	0,5	1,7	1,8	2,2	2,2	1,8	2,2
Rock Type	sand	sand	sand	sand	sand	sand	sand	sand	sand
Water Table (m)	1,6	1,6	0,4	1,5	1,7	1,9	1,9	1,6	2,0

4. Conclusions

From the analysis and interpretation of the results it can be concluded that the rock lithology in this location consists of top soil derived from weathering process, sandy top soil and sea sand. The depth of water table at this site varies from 0.4 m to 2.0 m below ground surface. The difference in depth of water table is due to the topography of the site.

References

[1] Reynolds, J.M., An Introduction to Applied and Environmental Geophysics, Chichester, UK, J. Wiley and Sons, 1997.

[2] Loke, M.H., Electrical imaging survey for environmental and engineering studies: A practical guide to 2D and 3D survey, http://www.terraphus.com., 2000.

[3] Telford, W.M., Applied Geophysics, 2nd Edition, Cambridge University, 1990.

[4] Barker, R.D., “Depth of investigation of collinear symmetrical four-electrode arrays”. Geophysics, vol. 54, pp. 1031-1037. 1991.

[5] Bernstone, C. and Dahlin, T., “Assessment of two automated electrical resistivity data acquisition systems for landfill location surveys: Two case histories”. Journal of Environmental and Engineering Geophysics, vol. 4, pp. 113-122. 1999.

[6] Dey A. and Morrison H.F. “Resistivity modelling for arbitrary shaped two-dimensional structures”. Geophysical Prospecting, vol. 27, pp. 1020-1036. 1979a.

[7] Dey A. and Morrison H.F., “Resistivity modeling for arbitrarily shaped three-dimensional shaped structures”. Geophysics, vol. 44, pp. 753-780. 1979b.

[8] Griffiths D.H. and Barker R.D., "Two-dimensional resistivity imaging and modelling in areas of complex geology". Journal of Applied Geophysics, vol. 29, pp. 211-226. 1993.

[9] D. Khazri and H. Gabtni. "Geophysical Contribution in the Characterization of Deep Water Tables Geometry (Sidi Bouzid, Central Tunisia)", International Journal of Geophysics, Volume 2015, Article ID 239797, 16 pages, 2015.