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Determining Direction Flow of Landfill Leachate (Case Study: Antang Tamangapa Landfill) Makassar, South Sulawesi Province

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ABSTRACT

Landfill at Antang Tamangapa, Makassar is still an active landfill nowadays. It was constructed in 1995 as an open dumping landfill system. However, due to the huge volume of waste disposal from time to time the system is not used anymore. Volume of disposal in Antang landfill until 2014 reachs 13640 M3/day. This condition become an environmental problem that must be handled. The aim of this study is to figure out the influence of environmental and groundwater system in Tamangapa area. Geoelectric method with Wenner's and Schlumberger's configurations is applied and furthermore in RES2DINV 5.54 program in order to analyze in 3-D view. Chemical analysis is used to understand the distribution and quality of groundwater. Groundwater flow analysis shows that the flow direction is Northwest to Southwest. The leachate accumulation is found at the depth of 2 to 8 m. The chemical composition of leachate is nitrate (NO3-N), BOD, COD, and sulfate (SO4).

Keywords: Groundwater, Leachate, Environment, Geophysics.
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1. INTRODUCTION

The effect of population growth in Indonesia, is settlement expansion and public space and other needs utilities. This condition creates a big environmental problem such as is rubbish waste management.

The fact that Landfill that operate now in some Big City is not yet complete criteria as Landfill that secure for the environment. Even some of the landfill must be closed because the location is near to the settlement and air pollution that produced by decomposition unsettle inhabitant.

In addition, some of landfill influence groundwater quality in the surrounding area, and the access road to the location of landfill is not good and the landfill located at flood area, [2]. One of the important aspects of the solid waste, rubbish locates problem. It should be paid attention to minimize the impact both to the groundwater and air pollution. Leachate is liquid or soluble that flows from landfill. It consists of various compositions based on the age of Landfill and kind of a waste. Leachate commonly contains soluble or insoluble bacteria, [1].

In 1995, Tamangapa Landfill has an area of approximately 10 ha and increases to about 15 ha in 2014. This is to accommodate the increasing of household waste volume in Makassar. The increasing of the disposal is very high, in 2001 is 3.900 m^3/day to 13.640 m^3/day in 2014. It is predicted in 2020 the disposal volume reaches 21.450 m^3/day. The increasing of disposal volume gives an impact o the environment, especiayly groundwater contamination. The condition becomes environmental problem that must be handled from now on, [4].

The purpose of this study is:

1. To know geological condition at Tamangapa Landfill.
2. To know groundwater contamination around the Tamangapa Landfill.
3. To analyze the distribution of leachate at

Tamangapa Landfill.

2. THE STUDY METHOD

The method used in this study is geoelectric analysis in 4 (four) lines, field observation of geological condition. Field survey includes morphology, structural geology and lithology consisting this area.

Geoelectric measurement is done by applying multichannel resistivity with software GeoRes v3.1 b14 (Geo Resistivity) at four lines with expansion of 150 meters. The data are analyzed by software Res2dinv [6].

Chemical analysis of groundwater is conducted at Balai Teknik Kesehatan Lingkungan dan Pengendalian Penyakit Kelas I Makassar. The chemical analysis is focused on nitrate (NO3-N), sulfate (SO4), BOD, and COD.

3. RESULT AND DISCUSSION

A. Geological Condition of Tamangapa Landfill

Topography of study area is slightly slope [8], ranging from 2°-4° (Figure 1). Three lithology units consist of the area namely tuff, volcanic breccia and alluvial. They are commonly made up of silica and biotite, poorly sorted.

Petrographic analysis of coarse tuff shows a pyroclastic texture, mineral size ranges from 0,25- 4 mm, Mineral compositions are pyroxene (5%), biotite (5-10)%, quartz (10-15)%, plagioclase (5)%, rock fragment (10%), volcanic glass (50-60)% and iron minerals (5%). Rock named “Vitric Tuff”, [5], (Figure. 2). Structural geology composing of the area is joint and folding with dip 10O toward N48oE.

B. Groundwater Chemical Analysis

Based on the laboratory analyses the chemical composition of leachate is nitrate (NO_3-N), BOD, COD, and sulfate (SO_4).

Figure 1. Showed morphology of location Antang Tamangapa Landfill

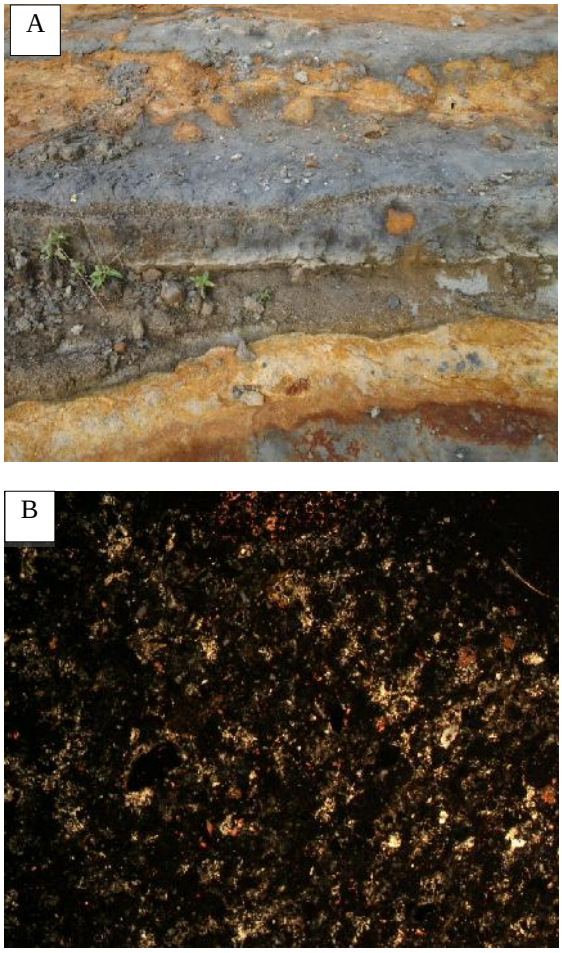

Figure 2. Outcrop view of coarse-grained tuff with colour light grey to yellow (a) and microphotograph view showing the mineral constituent (b).

4. GROUNDWATER CONTAMINATION

Groundwater contamination in the study area is mainly caused by disposal from Tamangapa Landfill. The contaminants are nitrate (NO_3-N), BOD, COD, and sulfate (SO_4). The highest concentration of nitrate is found at station 2 (638.8 mg/l) and the lowest concentration at station 1 (3.1 mg/l). Furthermore, chemical analysis of water from digging well shows a low concentration ranging form 15,795 mg/l to 1,948 mg/l. At the other location (station 2 and 4) leachate contamination of nitrate (NO_3-N) ranges from medium - high (200-638,8 mg/l).

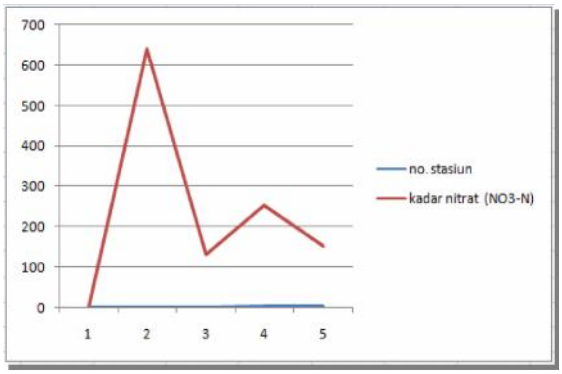

Figure 3. Nitrate Contamination (NO_3-N) at leachate sample

Some places (station 6, 7, 8, 9, 10 and 11) have including in secure zone because have low

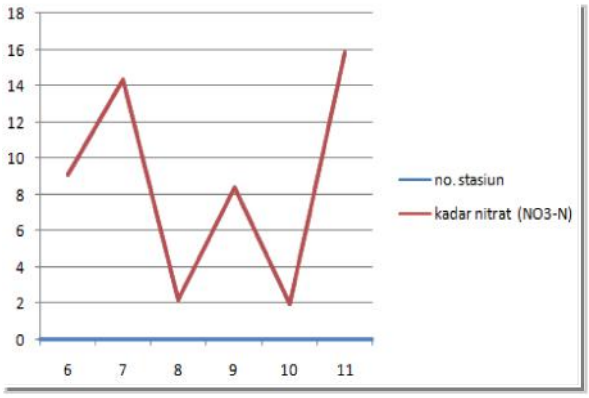

Figure 4. Nitrate Contamination (NO_3-N) at water sample that produced by well

nitrate contamination Based on the regulation of Health Minister, RI value below safety threshold, according to the ketetapan Peraturan Menteri Kesehatan RI. No. 416/Men.Kes/Per/IX/1990 where the limit is 10 mg/l. Direction of nitrate distribution at leachate in the study area is relative to the Northeast that suitable with strike/dip stratification of the lithology, that is tuff. Contamination in the study area around 500 meters from the outer limit landfill had been determined by government.

Table 1. Chemical composition groundwater around the land fill

Sts No	Nitrate (NO3-N) (mg/l)	BOD (mg/l)	COD (mg/l)	Sulfate (SO4) (mg/l)	Explanation
1	3.1	58	78.31	56.243	Waste water
2	638.8	729	1.277,200	3,438.10	
3	130.2	165	456	45.23	
4	251.9	126	403.495	57.41	
5	152.1	88	133.926	49.57	
6	9.091	9.26	11.224	8.58	Water that produced by well
7	14.31	1.52	2.48	13.69	
8	2.193	2.78	3.07	7.29	
9	8.387	6.19	25.233	22.60	
10	1,948	5,32	20,435	9,629	
11	15.795	2.07	4.163	8.58	

Source : Field Data 2014 and Analysis Result Balai Teknik Kesehatan Lingkungan dan Pengendalian Penyakit Kelas I Makassar

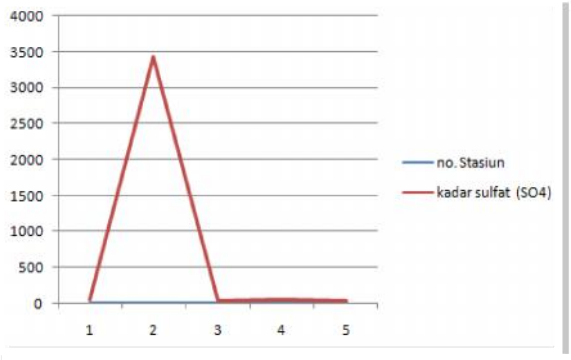

Figure 5. Sulfate Contamination (SO_4) at leachate sample

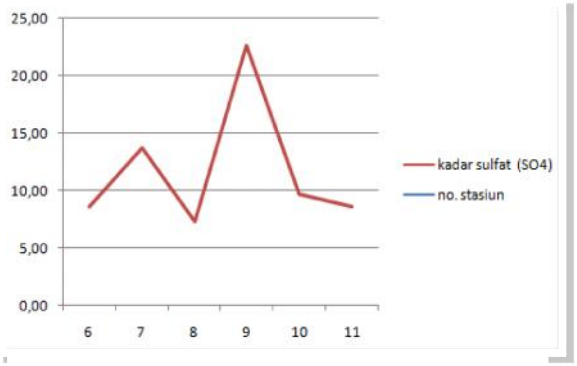

Figure 6. Sulfate Contamination (SO_4) at water sample that produced by well.

C. Contamination Element Sulfate (SO_4)

Leachate analysis at station 1-5 shows the highest SO_4 value at station 2 (3438,1 mg/l) and the lowest at station 3 (45,228 mg/l). Analysis of water produced by dug well at station 6-11 has the highest value at station 9 (22,6 mg/l) and the lowest at station 8 (7,29 mg/l). Accumulation of contamination unsure Sulfate (SO_4) in the study area is at station 2 is an area including highest scale impact, value 3000-3438,063 mg/l this area is danger zone where this station is peak area of the most accumulation of the rubbish. Whereas at station 6, 8, 10, and 11 are the area, including the lowest scale impact, value 7,295446396 - 400 mg/l this area is secure zone.

Water that produced by well at station 6, 7, 8, 9,10 and 11 including secure zone because have a value below safety threshold, according to the ketetapan Peraturan Menteri Kesehatan RI. No. 416/Men.Kes/Per/IX/1990, where the limit is below 400 mg/l. Direction of Sulfate distribution at leachate in the study area is relatively to the southeast, and suitable to the strike/dip of stratification lithology, that is tuff. Contamination is 50 meters from the outer limit landfill had been determined by government.

D. Contamination Element Biological Oxygen Demand (BOD)

Leachate analysis at station 1-5, the highest at station 2 with value 729 mg/l and the lowest at station 1 with value 58 mg/l. Analysis of water that produced by well at station 6-11, the highest at station 6 with value 9,26 mg/l and the lowest at station 7 with value 1,52 mg/l. Accumulation of contamination *Biological Oxygen Demand* (BOD) in the study area is at station 2 is area including highest scale impact, value 600-728,993042 mg/l this area is danger zone where this station is peak area of the most accumulation of the rubbish. Whereas at station 7, 8, 10, and 11 are the area, including the lowest scale impact, value 1,52 0625949-6 mg/l this area is secure zone.

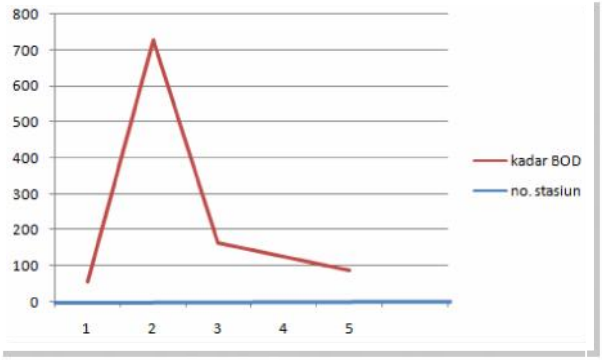

Figure 7. Contamination of BOD at leachate sample

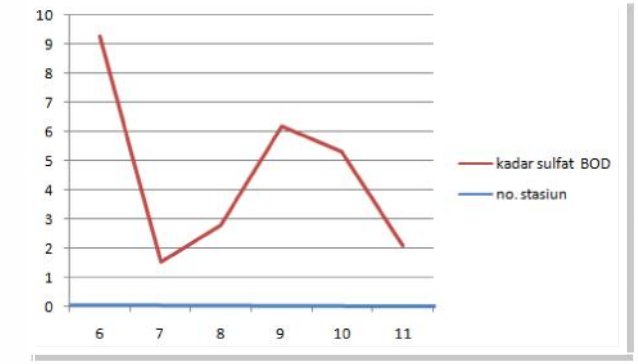

Figure 8. Contamination of BOD at water sample that produced by well

Water that produced by well at station 7, 8, 10 and 11 is a safety zone because it has a value below safety threshold, according to the Ketetapan Peraturan Menteri Kesehatan RI. No. 416/Men.Kes/Per/IX/1990, where the limit is 1,52062 - 6 mg/l mg/l. Direction of BOD distribution at leachate in the study area is relatively to the southeast, and suitable to the strike/dip of stratification lithology, that is tuff. Contamination is 1,5 kilometers from the outer limit landfill had been determined by government.

E. Contamination Element Chemical Oxygen Demand (COD)

Leachate analysis at station 1-5, the highest at station 2 with value 1277,2 mg/l and the lowest at station 1 with value 78,31 mg/l. Leachate analysis at station 6 - 11, the highest at station 9 with value 25,233 mg/l and the lowest at station 7 with value 2,48 mg/l.

Accumulation of contamination *Chemical Oxygen Demand* (COD) in the study area is at station 2-4 are the area, including medium-high scale impact, value 400-1277,18811 mg/l this area is danger zone where this station is peak area of the most accumulation of the rubbish. Whereas at station 7, 8, and 11 are the area, including the lowest scale impact, value 2,481146097 - 12 mg/l this area is secure zone.

Water that produced by well at station 7, 8, and 11 including secure zone because having value below safety threshold, according to the ketetapan Peraturan Menteri Kesehatan RI. No. 416/Men.Kes/Per/IX/1990, where the limit is below 2,481146097 - 12 mg/l. Contamination of COD is higher than BOD because accumulation of anorganic rubbish is more dominant than organic rubbish in Tamangapa Landfill. This condition influences the content of chemical solvent.

Direction of COD distribution at leachate in the study area is relatively to the Northeasrt - southeast, and corresponds to the strike/dip of tuff stratification. Contamination is 1,5 kilometers from the outer limit landfill had been determined by government.

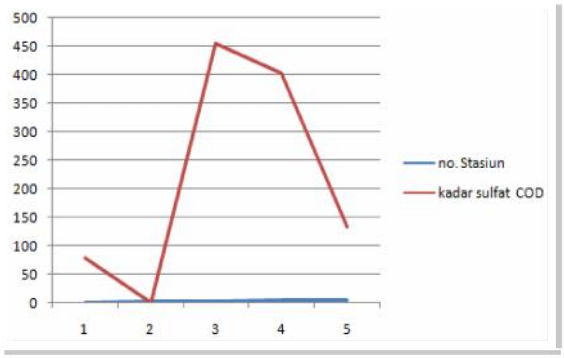

Figure 9. Contamination of COD at leachate sample.

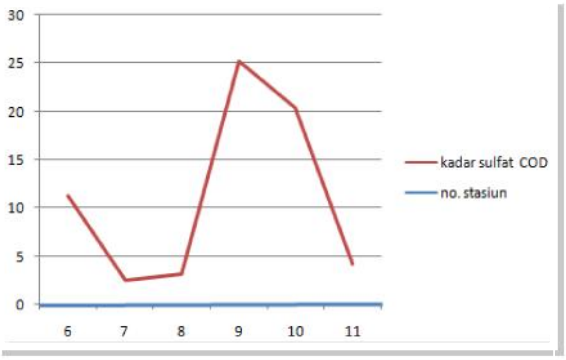

Figure 10. Contamination of COD at water sample that produced by well.

5. GEOELECTRIC MEASUREMENT RESULT

Geoelectric measurement that using multichannel geoelectric equipment, resistivity method, wenner configuration. The result is 4 lines. Every geoelectric measurement have length of line is 150 meters and the space between electrodes is 10 meters. Line 1 consist in 2 lines with direction South Southwest - North Northeast. Line 2 consist in 3 lines with direction West Northwest - East Southeast. Line 3 consist in 3 lines with direction West Northwest - East Southeast. Line 4 consist in 2 lines with direction South Southwest - North Northeast.

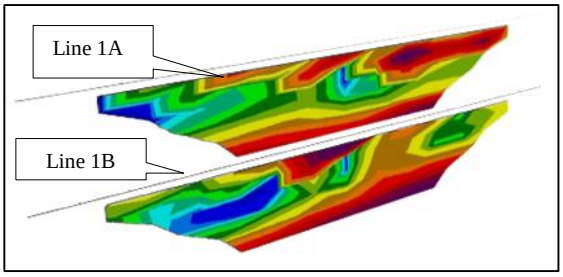

Figure 11. Geoelectric Inversion Section of resistivity line 1A and 1B

Line 1A resistivity value is interpreted that the position of contaminated water accumulation is at depth of 2,5 meters - 18,5 meters with resistivity value ranging from 0,348 Ω.m to 1,62 Ω.m. Meanwhile, at line 1B is interpreted that position of contaminated water accumulation is at depth of 2,5 meters -14 meters with resistivity value ranging from 0,145 Ω.m to 1,34 Ω.m, [7]. According to the resistivity value that found in the field corresponds to lithology of tuff.

Measurement of line 2 located at Northward of Tamangapa Landfill, coordinate 5^o 17' 22.25" - 5^o 17' 30.63" Southern Latitude, 119^o 49' 01.43" - 119^o 49' 16.80" Longitude East, with direction West Southwest - Southeast.

According to the resistivity that appropriate with lithology that found in the line 2, lithology that consist this study area is tuff. Line 2A can be interpreted that position of water accumulation that had been contaminated is at depth 5,5 meters - 22 meters and resistivity value is 1,22 Ω.m until 4,37 Ω.m. Meanwhile, at line 2B can be interpreted that position of water accumulation that had been contaminated is at depth 7,5 meters - 18,5 meters and resistivity value is 0,717 Ω.m until 3,78 Ω.m. And at line 2C can be interpret that position of water accumulation that had been contaminated is at depth 2,5 meters - 9 meters and 7,5 meters-24,5 meters,

with resistivity value is 0,609 Ω.m until 2,49 Ω.m, [7].

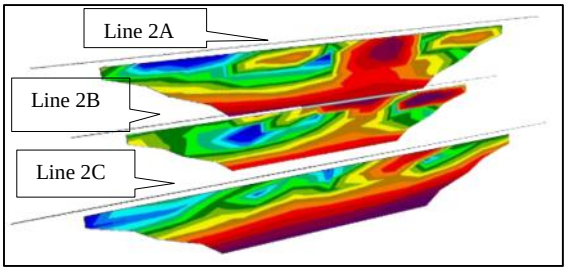

Figure 12. Geoelectric Inversion Section of resistivity line 2A, 2B and 2C.

Measurement of line 3 located at Southwestward of Tamangapa Landfill, coordinate 5° 17' 82.01" - 5° 17' 89.35" Southern Latitude, 119° 48' 01.12" - 119° 48' 88.08" Longitude East, with direction West Southwest – Southeast.

According to the resistivity that appropriate with lithology that found in the line 3, lithology that consist this study area is tuff. Line 3A can be interpreted that position of water accumulation that had been contaminated is at depth 2,5 meters - 12,5 meters and resistivity value is 0,477 Ω.m until 1,58 Ω.m. Meanwhile, at line 3B can be interpreted that position of water accumulation that had been contaminated is at depth 2,5 meters - 10 meters and 7,5 meters-24,9 meters, with a resistivity value is 1,56 Ω.m until 5,33 Ω.m. And at line 3C can be interpreted that position of water accumulation that had been contaminated is at depth 7,5 meters - 13 meters, with resistivity value is 0,624 Ω.m until 99,3 Ω.m, [7].

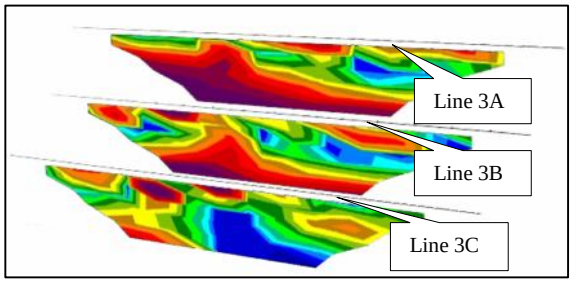

Figure 13. Geoelectric Inversion Section of resistivity line 3A, 3B and 3C.

Measurement of line 4 located at *Pesantren*, southeastward of Tamangapa Landfill, coordinate 5° 17' 76.27" - 5° 17' 65.88" Southern Latitude, 119° 49' 49.51" - 119° 49' 42.85" Longitude East, with direction West Southwest - Southeast.

According to the resistivity that appropriate with lithology that found in the line 4, lithology that consist this study area is tuff. Line 4A can be interpreted that position of water accumulation that had been contaminated is at depth 18,5 meters - 24,9 meters and resistivity value is 0,504 Ω.m until 2,34 Ω.m. Meanwhile, at line 4B can be interpreted that position of water accumulation that had been contaminated is at depth 2,5 meters - 23 meters, with resistivity value is 0,210 Ω.m until Ω.m, [7].

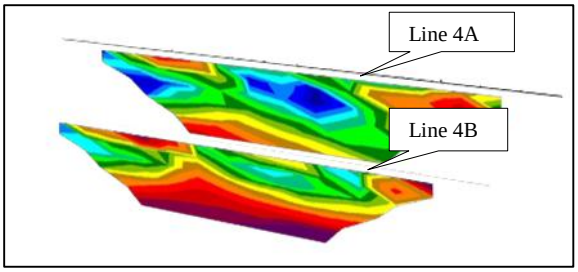

Figure 6. Geoelectric Inversion Section of resistivity line 4A and 4B.

6. 3D MODEL

The geoelectric measurement using multichannel geoelectric equipment, resistivity method, wenner configuration giving the result of 4 resistivity lines, after that with Res2dinv program to analyze the data from all the resistivity lines and show the 3D Model of Tamangapa Landfill (Figure. 7). The leachate, by the advection process follow the groundwater flow relatively Northwest to the Southeast as the 3D Model result show blue colour.

7. CONSLUSION

We have found that the MOPEO-PLA, which is a biodegradable polymeric surfactant,

provided a microemulsion system, which solubilized cytochrome *c* in organic phase with the native form. Cytochrome *c* was successfully microencapsulated in the PLA microcapsules using a MOPEO-PLA microemulsion system and was constantly released from the microcapsules for a long time. This encapsulation system would have a good potential for delivery of various bioactive agents.

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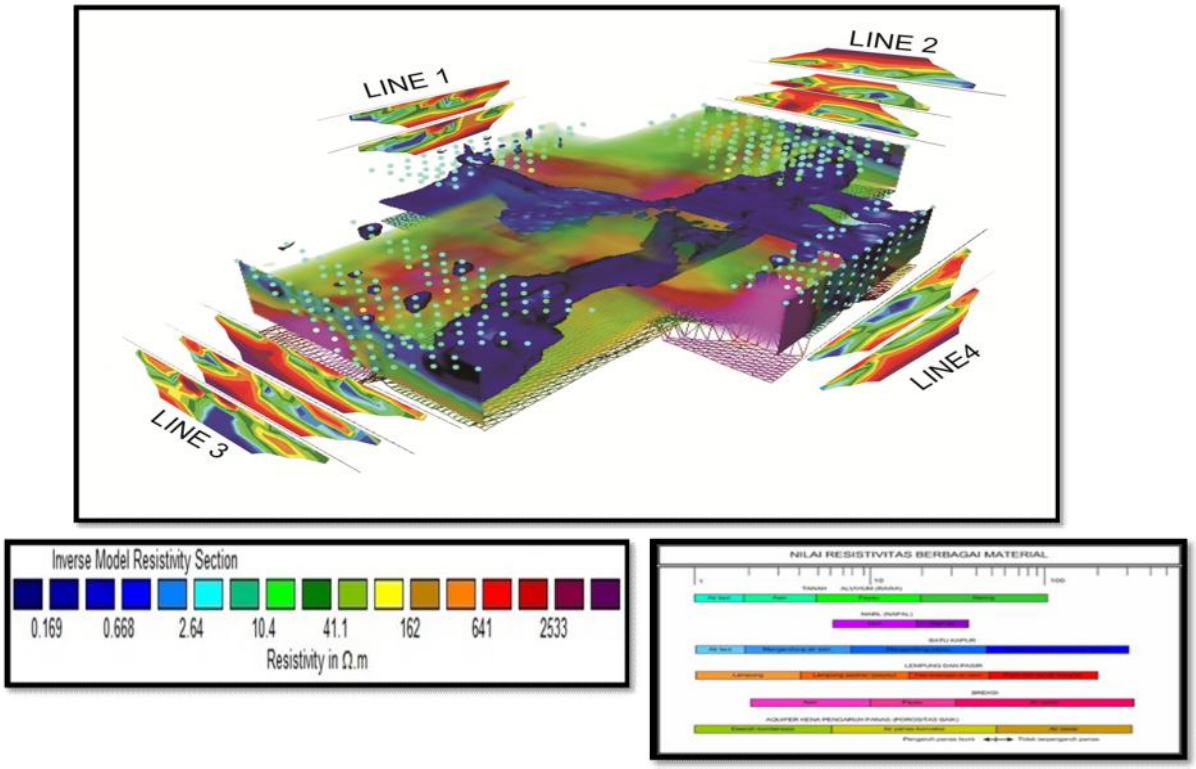

Figure 7. 3D Model the result of processing data at Antang Tamangapa Landfill