Al-Fiziya Journal of Material Sciences, Geophysics, Instrumentation, and Theoretical Physics

Available online at:
Al-Fiziya: Journal of Materials Science, Geophysics, Instrumentation and Theoretical Physics
Website: http://journal.uinjkt.ac.id/index.php/al-fiziya
Vol.5 No. I Tahun 2022, 46 - 55

Identification of Potential Waste Fluid Contamination with Geoelectric Method in Tebing Tinggi Subdistrict, West Tanjung Jabung Regency, Jambi

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Submitted: December 2021; Revised: April 2022; Approved: June 2022; Available Online: October 2022

Abstract. In the study area of Tebing Tinggi Subdistrict, Tanjung Jabung Barat Regency, Jambi Province, there are several companies engaged in the manufacturing, agriculture, and plantation industries. This company uses the Pengabuan River for transportation. Therefore, the study area has the potential to be contaminated by the waste fluid produced by the company. In this study, the Wenner array resistivity geoelectric method was used because this array can detect potential pollution in shallow subsurface. Data processing is done by inversion process using Res2Dinv software to get 2D modelling and Voxler to get 3D modelling. Based on the 2D modelling, it is identified that the contamination is on lines 1, 2, and 4 with a resistivity range of ±0.059-2 Ωm. Also, in the study area, it is identified that there are alternating tuffaceous claystone, claystone, tuffaceous sandstone, sandstone, and shallow aquifer. Based on the 3D modelling, it is identified that there is a potential continuity of contamination between line 3 and line 4, which is at a distance of 0-8 m to the east from line 4 to line 3.
Keywords: *Geoelectric Resistivity Method, Pengabuan River, Tebing Tinggi Subdistrict, Waste Fluid Contamination, Wenner Array*

DOI: *10.15408/fiziya.v5i1.23647*

INTRODUCTION

Water contamination can occur if foreign substances seep into the soil surface entering through the soil pores. This results in causing the soil to become saturated and will cause disturbances to groundwater. In Tebing Tinggi Subdistrict there are several companies engaged in the manufacturing, plantation, and forestry industries. In the transportation route, this company uses the Pengabuan River which is located close to the company's location as one of the transportation routes to transport industrial raw materials [1]. In this case, it is necessary to carry out an investigation to determine the potential for contamination by waste fluid below the ground surface. One of the

P-ISSN: 2621-0215, E-ISSN: 2621-489X

geophysics method to determine the contamination of waste fluid is the geoelectric resistivity method.

The geoelectric resistivity method uses a current source that is injected into the ground through an electrode. Several studies using the geoelectric resistivity method have been studied for surveys of contamination by waste, namely Suhendra (2006), Sri et al (2007), Rahmatun et al (2019). Suhendra (2006) conducted a study in the laboratory by injecting waste into clay, Sri et al (2007) conducted a study in the MIPA Basic Laboratory area, Rahmatun et al (2019) in their study conducted a study in a village located in Mojokerto which is surrounded by several industry companies. Therefore, in this study, the geoelectric resistivity method with the Wenner array is used to determine the potential for contamination by waste fluid which is characterized by the presence of subsurface material anomalies in Tebing Tinggi Subdistrict area.

Regional Geological of the Study Area

Tebing Tinggi Subdistrict is located in West Tanjung Jabung Regency, Jambi. Based on regional geology, Tebing Tinggi Subdistrict is known to have three formations, namely Alluvium (Qa) which is composed of boulders, gravel, sand, and mud with plant remains where the composition is Holocene in age. Then the Swamp Sediment (Qs) which is composed of silt, mud, clay, sand, and plant remains where the composition is Holocene in age. Furthermore, there is the Kasai Formation (QTk) which is composed of tuffaceous sandstone, quartz sandstone, tuffaceous claystone, conglomerate of various materials, tuff, gravel, crushed wood where this formation is Pleistocene-Pliocene age [2].

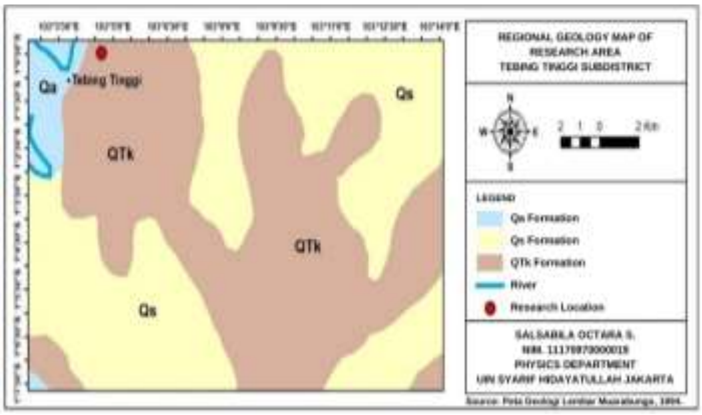

Figure 1. Regional Geological Map of Tebing Tinggi Subdistrict [2].

Waste Contamination

Waste contamination can occur if foreign substances (waste) enter the soil and contaminate the soil. According to [3], liquid waste can be divided into 3, namely industrial liquid waste, domestic liquid waste, and wastewater mixed with groundwater. Industrial liquid waste is liquid waste generated from industrial activities. Domestic liquid waste is liquid waste generated due to daily activities. Meanwhile, wastewater mixed with groundwater can occur if it rains, and then rainwater seeps into the ground and becomes groundwater, then the groundwater meets wastewater which causes groundwater to mix with waste.

The contamination that is not visible below the surface can be investigated by geophysical methods. One of the good geophysical methods used for the investigation of contamination by waste fluid at the subsurface is the geoelectric resistivity method.

Geoelectric Resistivity Method

In the resistivity method, electric current is used which is injected under the surface using an electrode where a potential difference will be generated which will be measured on the surface. The anomaly of the measured potential difference will illustrate the subsurface conditions [4].

Based on the resistivity method, the earth is considered homogeneous isotropic, which means that the flow of electric current in the earth is the same in all directions and each layer of the earth has the same resistivity. In fact, the earth has layers with different resistivities, so the measured resistivity is not the true resistivity, but the apparent resistivity (ρ_a) [5]. The apparent resistivity can be formulated by:

$$\rho_a = K\frac{\Delta V}{I} \tag{2}$$

Where K is the geometric factor of the electrode array used, ΔV (Volt) is the measured potential difference, and I (A) is the measured current.

Table 1. Resistivity of Some Rocks.

Rocks	Resistivity (Ωm)
Sea water	0.2
Groundwater	0.5 - 300
Clays	1 - 100
Alluvium	10 – 800
Sands	1 – 1000
Gravel	100 – 600
Sandstones	200 - 8×10^3

In the resistivity method, there are several electrode arrays, namely Wenner array, Schlumberger array, Dipole-dipole array, Pole-dipole array, and Pole-pole array. Wenner array is good for subsurface investigation for contamination by waste fluid because the Wenner array is good for shallow subsurface surveys and can map shallow subsurface materials well.

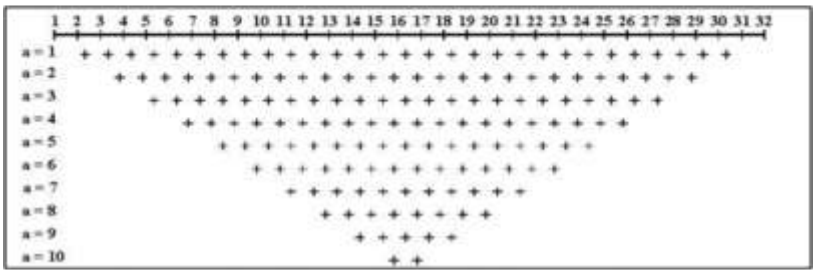

Figure 2. Wenner Array Data Distribution [8].

METHOD

The study was conducted in Tebing Tinggi Subdistrict, West Tanjung Jabung Regency, Jambi using the geoelectric resistivity method. The data used is secondary data belonging to the Center of Technology for Disaster Risk Reduction (PTRRB), Agency for the Assessment and Application of Technology (BPPT) in the form of apparent resistivity and topography data. Secondary data processing starts from January-March 2021.

Data processing was carried out using Res2Dinv software in 2D modelling to determine subsurface conditions and identify subsurface materials in the study area that indicated being contaminated by waste fluid. Meanwhile, to determine the potential for continuous contamination by waste fluid, 3D modelling using Voxler software was carried out on two parallel lines.

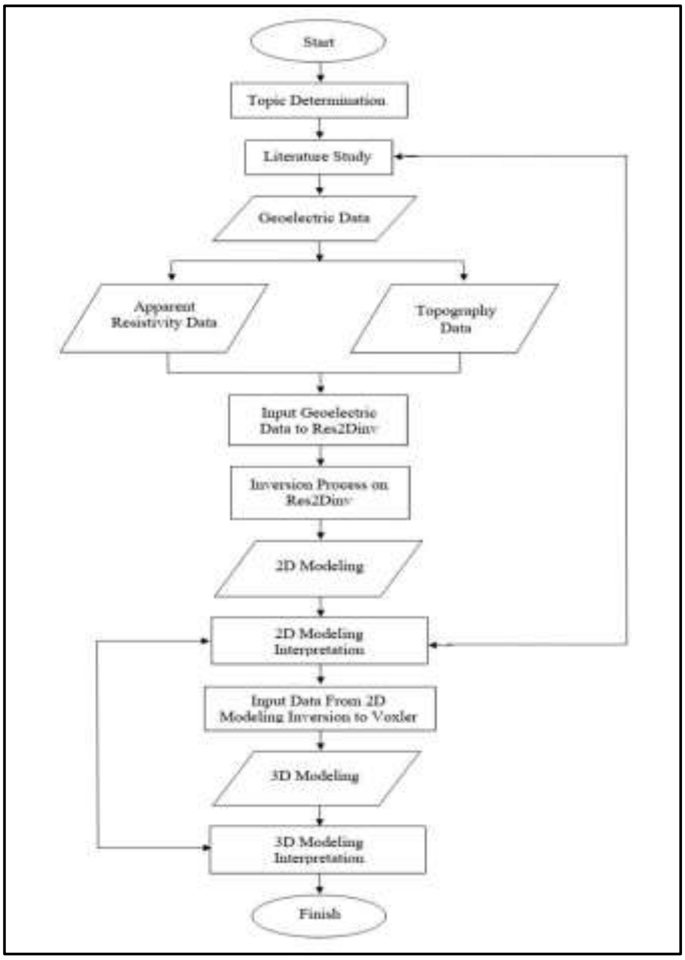

Figure 3. Flowchart of Study Stages.

RESULT AND DISCUSSIONS

This study was conducted in Tebing Tinggi Subdistrict, Tanjung Jabung Barat Regency, Jambi with 5 lines, namely with a length of line 1 and line 2 along 47 m with an electrode spacing of 1 m, and line 3 to line 5 along 24 m with electrode spacing of 0.5 m. In interpreting the results of the subsurface modelling to determine the distribution of contamination, calibrations were carried out using the results of 2D modelling, rock resistivity tables, regional geological maps of the study area, and previous studies.

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P-ISSN: 2621-0215, E-ISSN: 2621-489X

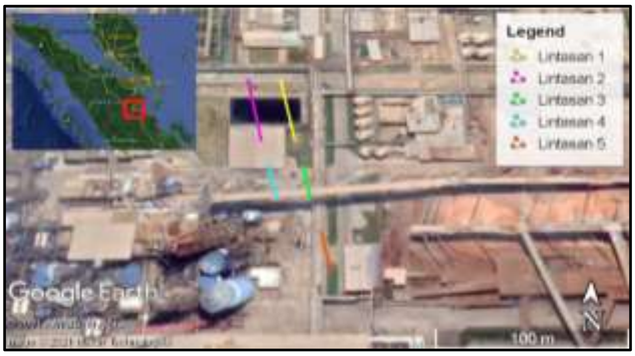

Figure 4. Measurement Line Location.

2D Modeling Results

The subsurface material generated in the 2D resistivity modelling, shows the area that contaminated will have a low resistivity.

Line 1

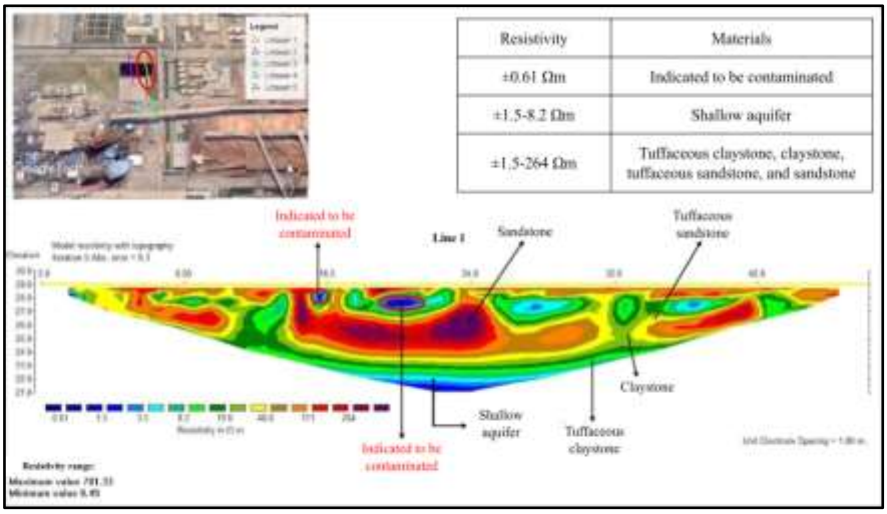

Figure 5. 2D Modeling Results in Line 1.

Based on fig. 5 the results of the 2D resistivity modelling, it can be seen that there are layers of indicated tuffaceous claystone, claystone, tuffaceous sandstone, and sandstone adjacent to each other with a resistivity range of ±1.5-264 Ωm. In line 1, there is a material with low resistivity which indicates an anomaly, which are at a line distance of 15.5 m at a depth of 0.5-1 m and a line distance of 19-21 m at a depth of 1-1.5 m. This material with low resistivity is indicated to be contaminated by waste fluid, with a resistivity of ±0.61 Ωm. In addition, in line 1 there are also identified shallow aquifer, with a resistivity range of ±1.5-8.2 Ωm. Oil and gas are natural resources that are mostly used to meet daily needs and as a contributor to the country's foreign exchange. However, as human needs increase in their daily activities, the consumption of oil and gas energy increases. Meanwhile, the energy sources needed are dwindling due to uncontrolled energy exploitation. Therefore, alternative energy is needed as a substitute for fuel oil and gas, one of which is coal.

Line 2

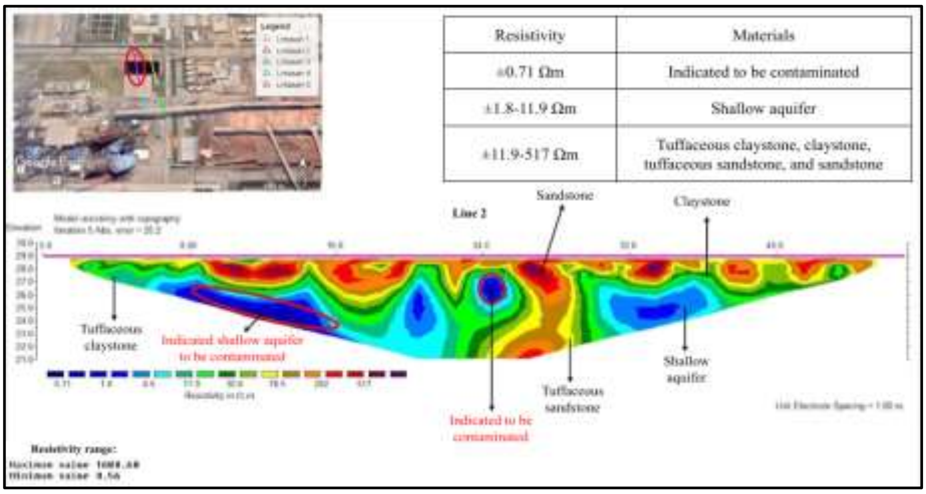

Figure 6. 2D Modeling Results in Line 2.

Based on fig. 6 the results of the 2D resistivity modelling, it can be seen that there are layers of indicated tuffaceous claystone, claystone, tuffaceous sandstone, and sandstone adjacent to each other with a resistivity range of ±11.9-517 Ωm. In line 2, there is a material with low resistivity which indicates an anomaly, which are at a line distance of 8-15 m at a depth of 2-6 m and a line distance of 24-25 m at a depth of 1.5-2.5 m. This material with low resistivity is indicated to be contaminated by waste fluid, with a resistivity of ±0.71 Ωm. In this contaminated layer, it is indicated that the waste contaminates the shallow aquifer which is at a line distance of 8-15 m at a depth of 2-6 m. In addition, in line 2 there is also identified another shallow aquifer with a resistivity range of ±1.8-11.9 Ωm.

Line 3

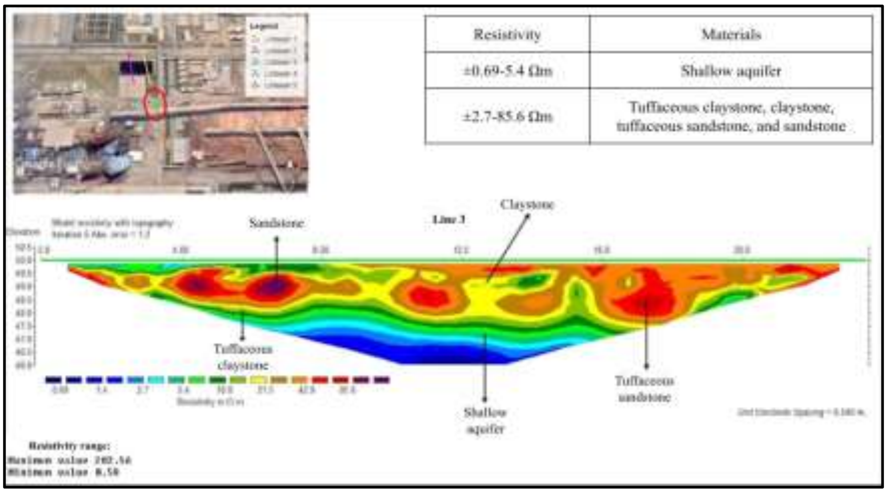

Figure 7. 2D Modeling Results in Line 3.

Based on fig. 7 the results of the 2D resistivity modelling, it can be seen that there are layers of indicated tuffaceous claystone, claystone, tuffaceous sandstone, and sandstone adjacent to each other with a resistivity range of ±2.7-85.6 Ωm. In addition, in line 3 there are also identified shallow aquifer with a resistivity range of ±0.69-5.4 Ωm. In line 3, no identified subsurface material anomaly that indicates contamination by waste fluid.

Line 4

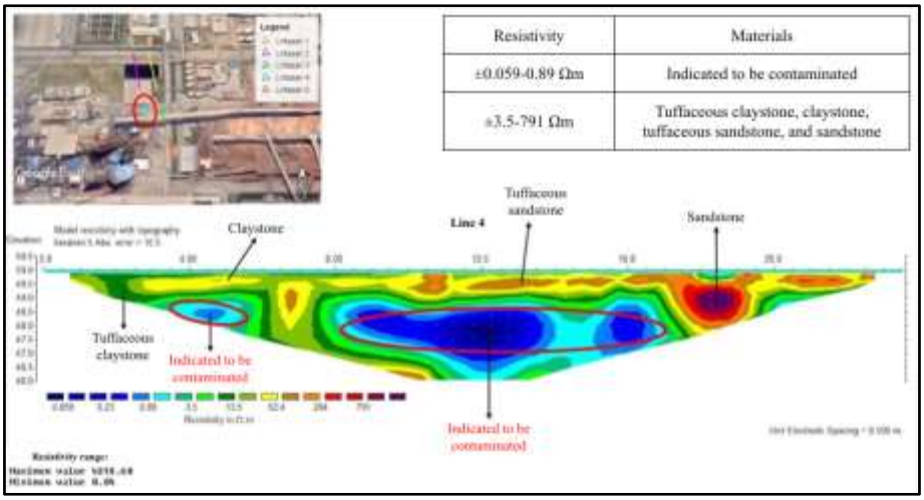

Figure 8. 2D Modeling Results in Line 4.

Based on Fig 8 the results of the 2D resistivity modelling, it can be seen that there are layers of indicated tuffaceous claystone, claystone, tuffaceous sandstone, and sandstone adjacent to each other with a resistivity range of ±3.5-791 Ωm. In line 4, there is a material with low resistivity which indicates an anomaly, which are at a line distance of 3-5.5 m at a depth of 1-2.5 m and a line distance of 8-17 m at a depth of 1-3.5 m. This material with low resistivity is indicated to be contaminated by waste fluid with a resistivity range of ±0.059-0.89 Ωm.

Line 5

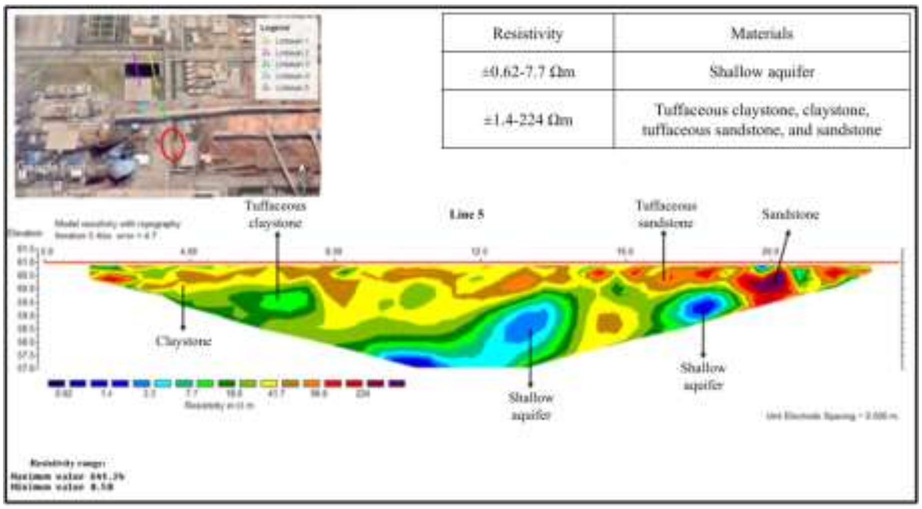

Figure 9. 2D Modeling Results in Line 5.

Based on fig. 9 the results of the 2D resistivity modelling, it can be seen that there are layers of indicated tuffaceous claystone, claystone, tuffaceous sandstone, and sandstone adjacent to each other with a resistivity range of ±1.4-224 Ωm. In addition, in line 5 there are also identified shallow aquifer with a resistivity range of ±0.62-7.7 Ωm. In line 5, no identified subsurface material anomaly that indicates contamination by waste fluid.

Based on the results of the 2D modelling of the five lines, the classification of the material based on the range of resistivity of the material is presented in table 2.

Table 2. Classification of Subsurface Materials in Study Area Based on Resistivity Values.

Resistivity Range (Ωm)	Materials
±0.059-2	Contaminated material
±0.62-11.9	Shallow aquifer, tuffaceous claystone
±1.4-100	Claystone, tuffaceous sandstone
±200-4318.6	Sandstone

3D Modeling Results

The 3D modelling in Voxler only focuses on the potential of continuous contamination by waste fluid, so that the resistivity of the subsurface material is limited to only the range of 0-100 Ωm, where for materials with resistivity >100 Ωm are marked with the same color as materials with resistivity of 100 Ωm. The 3D modelling results correlated with the 2D modelling results. From 3D modelling, to find out the potential for continuous contamination, it is divided into 6 sections for 2 lines that are parallel (line 1 and line 2, line 3 and line 4), each section is 4m apart, so that it is known at what distance there is potential for continuous contamination from each line.

Line 1 and Line 2

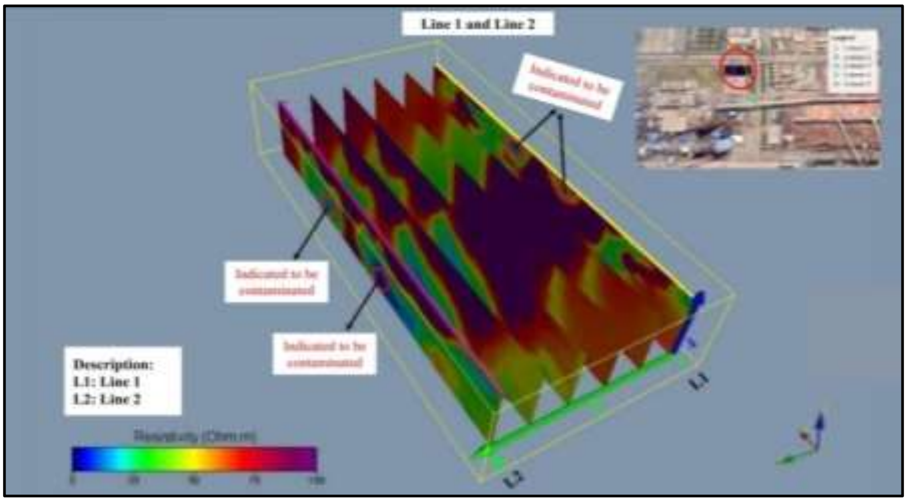

Figure 10. Line 1 and Line 2 Combined 3D Modeling.

Based on Fig 10, areas with indications of contamination are marked with dark blue color and low resistivity, which for the combination of line 1 and line 2 with a resistivity range of ±0-0.71 Ωm. Based on Figure 10, there is a possibility of continuous contamination from line 2 to line 1 seen from the location and pattern of contamination on each line, but from the 3D modelling carried out there is no continuous contamination in the area between line 1 and line 2. This is because data processing in the area between line 1 and line 2 is done only with estimates by software, so the resulting model is less accurate. Therefore, it is necessary to collect data in the area between line 1 and line 2 to obtain a more accurate 3D model to determine the continuity of contamination.

Line 3 and Line 4

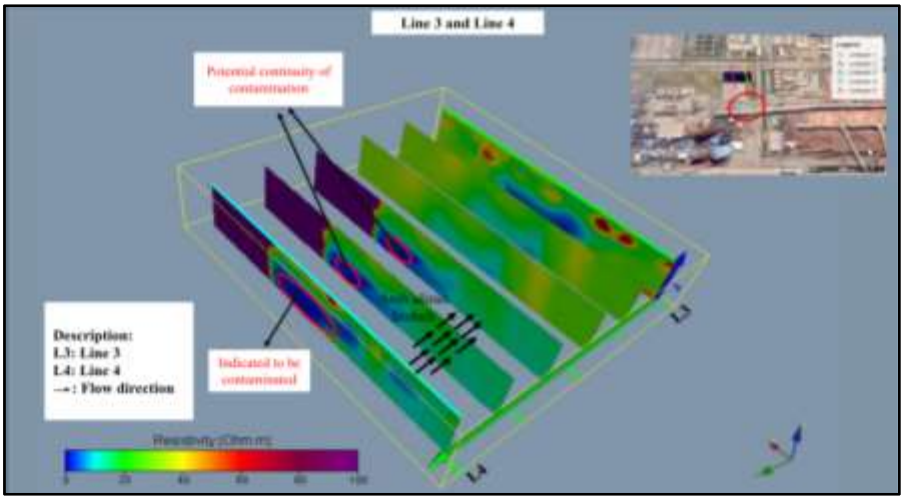

Figure 11. Line 3 and Line 4 Combined 3D Modeling.

Based on the fig. 11, areas with indications of contamination are marked with dark blue color and low resistivity, which for the combination of line 3 and line 4 with a resistivity range of ±0-0.89 Ωm. In the 3D modelling that has been carried out for the combination of line 3 and line 4, it is found that there is a potential continuity of contamination which is indicated by a low resistivity or dark blue part between the two lines. Indications of continuous contamination by waste fluid are identified as being at a distance of 0-8 m to the east from line 4 to line 3, with the location of contamination being at a line distance of ±12-14.5 m and at a depth of ±2-3.5 m. This contamination indication is indicated to be a continuation of the contamination on line 4.

Based on the results of the 3D modelling between the 2 parallel lines, the detailed interpretation of the potential for continuous contamination based on the 3D modelling is presented in table 3.

Table 3. Interpretation of the Potential for Continuous Contamination Based on 3D Modeling.

Line	Continuity	Description
1 and 2	Indicated exists	It is indicated that there is continuity, but it is not seen in the 3D modelling results. More study is needed to determine the continuity of contamination between line 1 and line 2.
3 and 4	Exists	Continuity of contamination is found at a distance of 0-8 m from line 4 to line 3 at a line distance of ±12-14.5 m and at a depth of ±2-3.5 m.

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CONCLUSION

Based on the study that has been done, the following conclusions are:

1. The results of the 2D modeling on the five lines show that under the surface of the study area there are alternating tuffaceous claystone, claystone, tuffaceous sandstone, and sandstone. In addition, shallow aquifer is identified, which on lines 1, 2, 3, and 5. In the study area, an anomaly of subsurface material that indicated contamination is identified and it has a resistivity ranging from ±0.059-2 Ωm which the contamination is identified to be on lines 1, 2, and 4. In addition, the 2D modeling shows that there is a certain pattern in the material that is indicated to be contaminated.
2. Based on the 3D modeling, it is identified that there is an indication of continuous contamination between line 3 and line 4. This continuity is indicated to be a continuation of the contamination on line 4, which is at a distance of 0-8 m to the east from line 4 to line 3 at a distance line of ±12-14.5 m and a depth of ±2-3.5 m.

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