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Research Paper

Application of 2-D Resistivity Method in Mitigation of Environmental Impacts (a case study of a lubricant oil waste disposal area at Locomotive Depot of Semarang Poncol Train Station)

E. S. Indriani[1], T. Yulianto[1], D. P.Sasongko[1]
[1]*Department of Physics, Faculty of Science and Mathematics, Diponegoro University*

ABSTRACT:*Waste oil is included in the Hazardous and Toxic Material waste whose handling is regulated in the Government Regulation of the Republic of Indonesia number 22 of 2021. Semarang Poncol Station Locomotive Depot is a place to maintain train locomotive engines, daily activities at this location produce lubricant oil waste which can pollute the environment. This can be seen from the amount of waste that is scattered, plants are difficult to grow, and the smell of oil is very pungent. This study aims to determine the distribution of used lubricant oil waste that seeps into the soil in the area. The 2-Dimensional Dipole-Dipole array of the Resistivity method is used to identify potential distribution of waste oil below the surface of shallow soils, and data processing uses res2div. The results of the modeling and interpretation of the data found alleged lubricant oil waste pollution with a resistivity value range of 1.51-10 m with a depth of 0.256-5.36 meters. Used oil that enters the soil which can be detected with a resistivity value is in the southern part which is an area close to the source of the pollutant.*

KEYWORDS: *Poncol Semarang Railway Station Locomotive Depot, Waste Oil, Dipole-Dipole, Resistivity*

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I. INTRODUCTION

Geophysics has been shown to be effective in identifying areas contaminated by waste disposal, contributing to the greater efficiency of soundings programs and the installation of monitoring wells. The geophysical methods used enabled the identification of geophysical anomalies, which characterized the contamination produced by the trenches filled with lubricant oil waste[1]

Along with the times, there are complex environmental problems, especially in the industrial and domestic fields, namely waste pollution. Based on the characteristics, waste is divided into several types, one of which is liquid waste. Liquid waste is composed of liquid containing waste or the result of a production process with water. This type of waste is easy to find in everyday life because this waste comes from industrial and domestic aspects [2]. According to [3] after the use of oil as a lubricant ends, the used oil will contain more hydrocarbons, metals, and polycyclic aromatic hydrocarbons (PAHs) which are mutagenic and carcinogenic. This metal content that seeps into the soil will cause the rock resistivity value to become smaller because the used oil waste has been mixed with metals that have conductive properties.

One way to identify subsurface structures contaminated with waste is by using the resistivity method. This method is a method in geophysics that produces quite accurate values, especially in shallow survey research. Utilization of electric current, both active and passive, will get a resistivity value that shows the presence of waste and a picture of the subsurface structure. According to [4], the 2-D resistivity method with the Dipole-Dipole configuration is one of several geoelectrical methods used to determine the resistivity (R) value of the object under study. This method can be applied for the purpose of obtaining subsurface images on objects whose penetration is relatively deeper than other sounding methods such as the Wennerarray and the Schlumberger configuration. The research that has been carried out [5] has succeeded in proving that this method can identify the accumulation of waste seepage and there are still many studies that are able to prove it.

II. RESISTIVITY METHOD

One of the geophysical methods whose application uses the earth's electrical phenomena is the resistivity method. This method is very effective when used for shallow geophysical surveys. This is because the stretch of cable is only effective for penetration to a depth of 200 meters, if it is more than that, the current flow will be weak and unstable because the stretch is getting bigger. By flowing direct current or Direct Current (DC) through the electrodes, you will get a voltage value (V) which will produce an apparent resistivity value in each soil layer [6].

The resistivity method assumes that the earth is homogeneous isotropically, that the measured resistivity value is the actual value and is not affected by the electrode distance. However, the fact is that the earth is composed of various layers that have different resistivity values. Therefore the measured resistivity value is called the apparent resistivity value (ρ_a) [7].

$$\rho = 2\pi\left[\left(\frac{1}{r_1}-\frac{1}{r_2}\right)-\left(\frac{1}{r_3}-\frac{1}{r_4}\right)\right]^{-1}\frac{\Delta V}{I} \qquad (1)$$

$$\rho_{a=K}\frac{\Delta 1}{I} \qquad (2)$$

$$K = \frac{2\pi}{\left[\left(\frac{1}{r_1}-\frac{1}{r_2}\right)-\left(\frac{1}{r_3}-\frac{1}{r_4}\right)\right]} \qquad (3)$$

ρ is the apparent resistivity in ohms (Ω), ρ_a is the apparent resistivity in ohm meters (Ωmeter), r_1, r_2, r_3, and r_4 is the distance between the current and potential electrodes in meters, ΔV is the voltage in volts (V), I is the current using munits of amperes (A), and K is the geometric factor is the position correction between the potential electrode and the current electrode [7].

In 2-D and 3-D resistivity surveys, the Dipole-Dipole configuration is one of the configurations that is often used. The position of the electrode placement in this configuration is that the current and potential electrodes are placed a distance apart. While the current and potential electrodes are placed on the inside and separated by a distance na, where n is an integer [8]. The distribution of the electrodes is as shown in Figure 1.

Then to get a certain depth, variations of the value of n are used, the greater the value of n, the greater the depth value obtained. In this configuration, the sensitivity level is affected by a and variations in the value of n [9].

Figure 1 Dipole-Dipole Electrode Configuration

The 2-D modeling of the geoelectric method generally uses the Res2Dinv software. This software is not only used in the Dipole-Dipole configuration, but can also be used for other configurations such as Wenner, Pole-Pole, Pole-Dipole, and Wenner-Schlumberger configurations. This software applies the inverse method in determining rock layers in subsurface structures. The input obtained is a resistance value (R), and the output obtained is a resistivity value (ρ). The resistivity value which is processed with the Res2Dinv software, the results will be interpreted by matching the resistivity table with the geological conditions in the study area so that an overview of the subsurface structure of the study area is obtained [10].

III. WASTE AND ITS TYPES

Waste is the result of the disposal of the production process, such as industrial and domestic (household) production [2].

Along with the increasingly concentrated industrial growth, the frequency of waste disposal is also increasing. If waste is discharged into an environment, it will certainly affect the surrounding environment [11].

Based on the characteristics there are several wastes, namely:

1. Liquid Waste is the result of disposal of production in the form of liquid.
2. Solid Waste is the result of disposal of activities in solid form. Usually this type of waste is found in domestic waste such as the results of livestock activities, agriculture, and others [12].

To identify the type of waste, table 1. Waste Resistivity Value is used

Table 1: Waste Resistivity Value

Type	Resistivity (Ωm)	References
Waste on the sand	41,61-81	[13]

Wasteon the ground	10,4-31,9	[13]
Waste on the composite	17,4-62,7	[13]
Waste oil on sand	2,09-4,36	[14]
Sand Pollutants	89,3-457	[5]
Clean water	10-100	[6]

This study refers to the resistivity value of waste oil in the table, which is 2.09-4.36 ohm-meters.

Quoted from [15] that Hazardous and Toxic Materials abbreviated as B3 are substances, energy, or other components having properties, concentrations, or amounts, which can pollute or damage the environment and endanger the environment, health, and survival of humans and other living creatures. Lubricating waste (oil) is included in the category of hazardous and toxic waste (B3). The characteristics of B3 waste that refer to this research include:

1. Explosive
2. Reactive
3. Toxic
4. Corrosive
5. Harmful to the environment.

The corrosive nature of waste lubricant (oil) is what causes waste lubricant (oil) to be included in the B3 waste group.

In general, there are 2 types of used oil, namely used industrial oil (light industrial oil) and black oil (black oil). Used industrial oil is relatively cleaner and easier to clean with simple treatments, such as filtering and heating. Black oil comes from automotive lubrication. This oil in use gets a higher thermal and mechanical load. Black oil contains metal particles and combustion residues. Oil contains chemicals, including hydro carbon and sulfur, because it works to lubricate metals, used oil also contains residual fuel, copper, iron, aluminum, magnesium and nickel and others [16].

According to [17] hydrocarbon compounds in used vehicle oil are a hazardous and toxic waste which is the impact of the use of motorized vehicles.

IV. METHODS

This study carried out data collection and processing/interpretation using the Naniura NRD 22 S tool. Where before taking data, a survey was carried out on the area that would be the place of research. The survey was conducted to determine the topographical conditions of the research area using GPS so that the measurement points (mapping) will be obtained. After that, the data collection process can be carried out.

The apparent resistivity data were processed with RES2DINV software [18], which uses the field data to automatically determine a two-dimensional‘ model of resistivity for the medium. The RES2DINV is an inversion program for resistivity and induced polarization (smoothing modeling).

Figure 2 Research Location

V. RESULTS AND DISCUSSION

At the Poncol Station Locomotive Depot, there are 2 types of oil used, namely, Pertamina Meditran SMX SAE 15W-40 for diesel engine lubricants and Pertamina Masri RG 68 ISO VG 68 for gear lubricants (attachment). The SAE and ISO VG codes indicate the international standard of viscosity or viscosity of that type of oil. The level of viscosity or viscosity is a standard of how much resistance a liquid can flow. The thicker the liquid, the harder it is to flow. Based on appendix IX in [15], waste oil has the code B105d with the danger category being 2. This category of B3 waste has a toxicity that tends to be sub-chronic or chronic (long term).

Based on the geological map, the research location is composed of alluvium deposits. Clay, silt, sand, and gravel are constituents of alluvial deposits. This is also indicated by the low resistivity value obtained. So from this it can be explained that the subsurface conditions of the research location have a high conductivity value. However, due to the various waste resistivity values obtained, the waste resistivity values used to analyze the research data use the resistivity reference values for the type of waste.

By adjusting the results of field research with geological maps as well as references to journals and previous studies, waste oil can reduce the value of rock resistivity. This is because, waste oil has metallic properties brought about by its use as engine lubricant. Metal is one object that has a high conductivity value (good conductor). This conductivity value is inversely proportional to the resistivity value. The greater the conductivity value, the smaller the resistivity value [19].

Liquid or solid wastes are generally conductive, so they have a low resistivity. This is because the waste contains various types of heavy metals that are conductive. Hazardous wastes are containing different harmful elements such as Cr, Pb, F, As, Cu, Ba, Zn, etc., which are heavy metal elements. It indicates that hazardous waste is conductive or has low resistivity[20]

The measurement results for line-1 in Figure 2 are modeled based on resistivity values as shown in Figure 3, waste oil in sand media has a resistivity value of (2.99-4.95) Ωm which is imaged in green. However, the distribution of waste varies as follows:

1. At a stretch of 8-26.9 meters, waste oil is at a depth of about 0.256-5.36 meters.
2. At a stretch of 27-32 meters, waste oil is at a depth of about 2.75 meters.

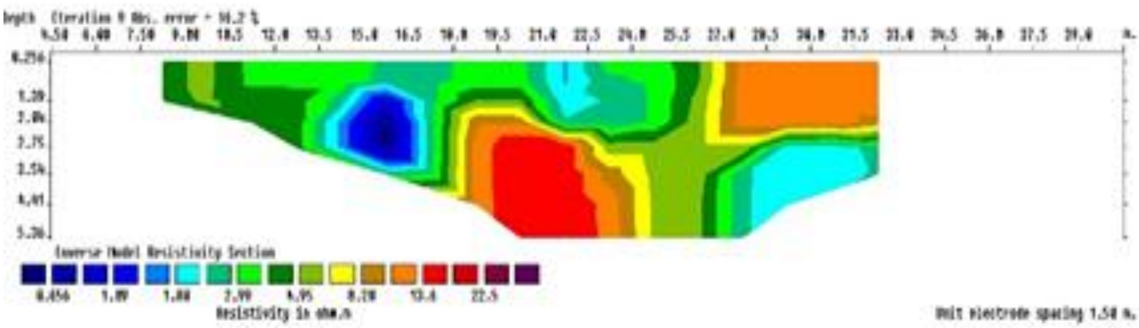

Figure 3 Resistivity Results of Line-1

The measurement results for line-2 in Figure 2 are modeled based on resistivity values as shown in Figure 4, waste oil in sand media has a resistivity value of (4.32-10,0) Ωm which is imaged in green. However, the distribution of the waste varies as follows:

1. At a stretch of 8-16.5 meters, waste oil is at a depth of about 0.256-5.36 meters.
2. At a stretch of 22.5-25 meters, waste oil is at a depth of about 2.75-5.36 meters.
3. At a stretch of 27-28.5 meters, waste oil is at a depth of about 2.04-5.36 meters.

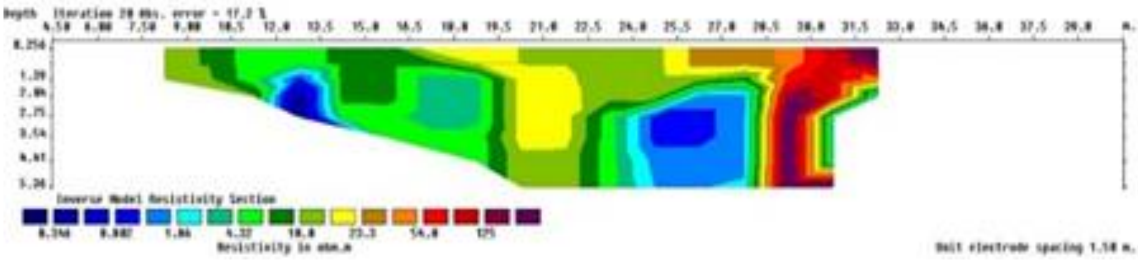

Figure 4 Resistivity Results of Line-2

The measurement results for line-3 in Figure 2 are modeled based on resistivity values as shown in Figure 5, waste oil in sand media has a resistivity value of (1.61-3.12) Ωm which is imaged in green. However, the distribution of the waste varies as follows:

1. At a stretch of 15-17.5 meters, waste oil is at a depth of about 0.256-2.75 meters.
2. At a stretch of 22.5-30.0 meters, waste oil is at a depth of about 0.256-2.04 meters.

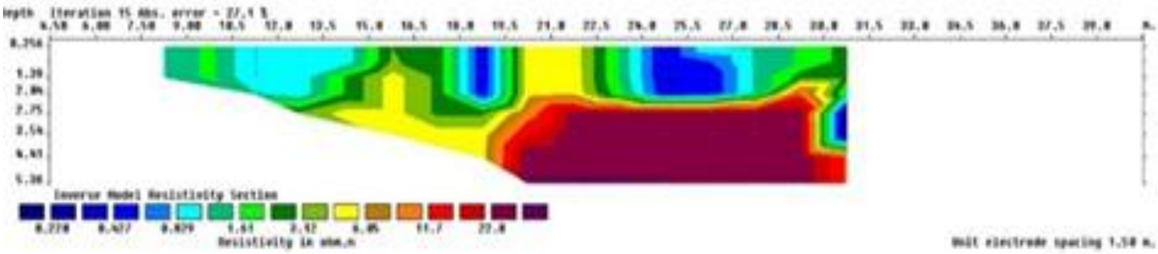

Figure. 5 Resistivity Results of Line-3

The measurement results for line-4 in Figure 2 are modeled based on resistivity values as shown in Figure 6, waste oil in sand media has a resistivity value of (1.27-2.65) Ωm which is imaged in green. However, the distribution of the waste varies as follows:

1. At a stretch of 9-18 meters, waste oil is at a depth of about 0.256-3.43 meters.
2. At a stretch of 19.5-22.5 meters, waste oil is at a depth of about 0.256-5 meters.
3. At a stretch of 25.5-30.0 meters, waste oil is at a depth of about 0.256-2 meters.

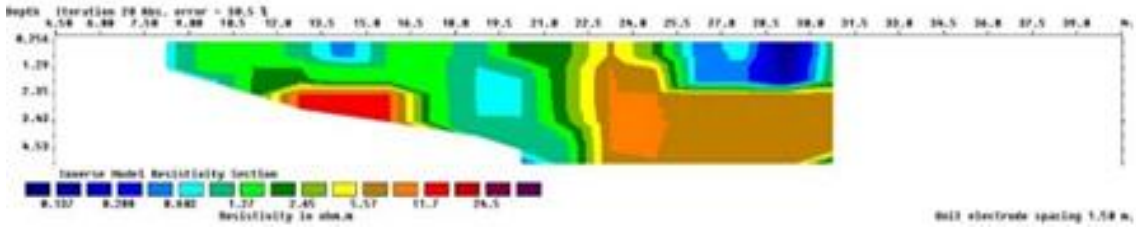

Figure 6 Resistivity Results of Line-4

VI. CONCLUSION

It has been found the distribution of waste oil due to the activities of the Locomotive Depot Semarang Poncol Station, especially in the research area because the area is a temporary storage place for barrelsused oil. The distribution of used oil waste is found at a depth of 0.256-5.36 meters with a resistivity value range of 1.51-10 Ωm.

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