Geoelectric Investigation on Distribution of Metal Waste and Its Implication to Groundwater Condition in Pesarean Village, Adiwena Sub-district, Tegal Regency, Central Java

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Abstract

The research location is located in Pesarean Village, Adiwerna Sub-District, Tegal Regency, Province of Central Java. Pesarean is a famous village for its home industry, especially in the manufacturing such as household appliances, electronics, and vehicle equipment. Environment in this research area has been polluted by heavy metal waste. The waste generated from smelting and casting metal. Thus, the purpose of this study is to obtain an information of the metal waste spreading below the Earth’s surface by identified the resistivity contrast value and determine the amount of waste dumps located at the sites. Through desk study, based on geological condition in research area can be determined there are seven line of 1-dimension and six line of 2-dimension geoelectrical measurement. After field measurements, all data will be analyzed in the laboratory using RES2DINV and Progress software. The research area is dominated by alluvium and sandstone, therefore rocks in this area generally have low conductivity. Polluted waste represented by low resistivity values where spreading from North-South trending with a various depth. Around the middle and western Pesarean areas dominated by contaminants waste spreading.

Keywords: waste, resistivity, wenner, tegal

Introduction

The research area is located in the Pesarean Village, Adiwerna Sub-district, Tegal Regency, Central Java, at the coordinates 49 M 263448, 9234414 - 49 M 293568, and 49 M 293341 9234424, 9234278 - 49 M 293502, 9234852 as shown by figure 1.
Pesarean is a famous village for its home industry, especially in the manufacturing such as household appliances, electronics, and vehicle equipment. Environment in this research area has been polluted by heavy metal waste. Based on the survey from BPPT, waste pollution in this area included in the severe category. From the results of sample tests in 2011 by government of Central Java towards 50 villagers, recorded 46 people contaminated with lead (Pb), and 12 people in danger condition.

Many geophysical method can be applied to detect pollutants in the soil, but due to the waste characteristic as liquid and seeps into the ground, it can contaminate groundwater, the geoelectric method used to determine groundwater and detect the pollutants (Reynolds, 1998). Thus, the purpose of this study is to obtain an information of the metal waste spreading below the Earth's surface by identified the resistivity contrast value and determine the amount of waste dumps located at the sites.

**Geoscience Framework**

One of methods used in define subsurface condition is a geophysical method. Utilization of geophysical methods to get an overview of quantitative and qualitative subsurface conditions according to physical properties that are used in related methods. Various physical properties were owned by the subsurface materials utilized to obtain subsurface anomalies as exploration targets were done. Through combination between geology and geophysical method can be define the earth condition in the surface or subsurface.

Geoelectric method is one of geophysical methods to investigate subsurface conditions, by studying the properties of electricity in the rocks below the earth's surface and how to detect it at the earth's surface. The investigation concerns the detection of the magnitude of potential geoelectric, electromagnetic, and electric current flowing in the earth either natural (passive method) or due to current injection into earth (active method) from the surface.

**Material and Method**

Resistivity geophysical survey widely used in hydrogeology, mining, geotechnical and many more. Resistivity surveys utilizing various electrical resistivity of rocks below the surface to detect geological structures or formations of rock layers (Priyantari and Wahyono, 2005 in Sehah and Sugito, 2011). The research area composed of pyroclastic rocks units of Mount Slamet consist of lava, with volcanic boulder composed of andesite-basalt and alluvium sediment unit which composed of gravel, silt, clay, as stream sediment and beach (Djuri et. al., 1992). This research using 1D and 2D resistivity survey with Wenner configuration. 2D resistivity survey with the Wenner configuration can be applied to observe subsurface hydrogeological conditions (William, 2003 in Sehah and Sugito, 2011).

Wenner configuration commonly use four electrodes, which consists of two current electrodes and two potential electrodes. The
measurement mechanism is injecting electrical current into the earth through the electrode current, then the current strength and potential difference that occurs in the Earth’s surface is measured (Sule et al, 2007 in Sehah and Sugito, 2011).

Figure 2. The Basic Configuration Of Electrodes Using Wenner Electrode (Tellford And Sheriff, 1982)

Theoretically, every rocks have own electrical conductivity and resistivity value. The same rocks do not necessarily have the same resistivity value. Some factors that influence are lithological composition, condition of rocks, mineral composition, liquid content and other external factors (Sultan, 2009). Metal content in the research area have an essential impact on rock resistivity value. Some aspects that influence rock resistivity value are:
- Sedimentary rocks which is loose have a lower resistivity value when compared with sedimentary rock solid and compact
- Igneous and metamorphic rocks have a high resistivity value
- The rocks are wet and contain water have low resistivity value and become lower again when it contains brackish or salt
- The content of metals in the research area have an essential impact on rocks resistivity value.
- External factors such as cables, power lines and pipelines metal can affect the results of measurements in the field.

Waste is a material residue of an activity or production process which is no longer useful. The waste is usually disposed of into the environment and will affect the environment in which the waste is disposed of (Mahida, 1981). The parameters are used as indicators in assessing the quality of waste is on biological oxygen demand (BOD) and chemical oxygen demand (COD). Some forms of pollution materials are: Mercury (Hg) causes nerve paralysis, Flour (F) causes floarosis, nitrate (NO₃), Salenium (Se), Chromium (Cr), Cadmium (Cd), Barium (Ba) which cause poisoning. Industrial waste can be classified into three groups: liquid waste, solid waste and gases waste that can pollute the environment around the plant (Djajadiningrat and Harsono, 1990). Industrial waste often contain dissolved metals so these pollutants when seeping into the ground have high conductivity. Groundwater which contaminated by pollutants generally have high electrical conductivity or low resistivity (Vogelsang, 1995).

Based on previous research, water impurities commonly caused by the presence of a mixture of three kinds compound which are HCl for acidic compounds, NaOH for basic compounds, and NaCl for salt compound. Figure 4 shows the relationship between concentrations of the compound with water resistance values based on
experiments conducted by A. C. Bevilacqua, 1988.

![Figure 4. The Relationship Graphic Between Concentration of Acids, Bases, and Salts, with The Value of Resistivity (Bevilacqua, 1998)](image)

**Results and Discussion**

The result of field measurements will be processed to be digital model using Res2DINV and progress software. Then, the model will be analyzed to determine an information of the metal waste spreading below the Earth’s surface by identified the resistivity contrast value and determine the amount of waste dumps located at the sites.

These are the 1D model from Progress software:

![Figure 5. The data processing of geoelectric 1-D at point TGL-1](image)

![Figure 6. The data processing of geoelectric 1-D at point TGL-2](image)
Figure 7. The data processing of geoelectric 1-D at point TGL-3

Figure 8. The data processing of geoelectric 1-D at point TGL-4

Figure 9. The data processing of geoelectric 1-D at point TGL-5

Figure 10. The data processing of geoelectric 1-D at point TGL-6
Based on the models above, each point generally shows resistivity value between 0 - 370 \( \Omega \text{m} \) with details as follows:

a. Layers of rock with resistivity values between 0-5 \( \Omega \text{m} \) suspected as an indication of soil pile (top soil) and fine sandstone with good porosity that has been contaminated by the waste metal waste and carried away by the flowing fluid in the sandstone cavity. On the surface looked as the form of a dark-colored earthen embankment. Weathered soil from various rocks also can be encountered on the surface with various thickness in different places or as fine tuff layers encountered at various depths. In the area of research, this layer has a thickness varying between 0.5 to 3 meters.

b. Rock layers with resistivity values between 5 to 20 \( \Omega \text{m} \) suspected as sandstone, fine-grained to medium sized, in the north block and south block of the research area have various rock thickness in the different depths.

c. Rock layers with resistivity values between 20 and 380 \( \Omega \text{m} \) suspected as rocks with relatively high densities, interspersed with sandstone, impermeable layers that are not easily penetrated by fluid. The whole area of research have various rock thickness and found at various depths.

There are 2D resistivity model which generated from software RES2DINV (enclosed).
Conclusion

From all of information that we have got, such as desk study, geological condition, field measurements, also identification and analysis, we can conclude the result as below:

1. Commonly, the conductivity value in this area is low until medium. This is because of the geological condition that dominated with sandstone and alluvium in upper layer and relatively consolidated in lower layer.
2. Generally, the morphology area is plain or flat. The height of this area is between 30 m until 50 m above sea level.
3. Polluted waste found in variation depth, in surface as an accumulation and continue until 20 m below the surface.
4. The existence of waste is continue, spreading from South to North.
5. The 1D resistivity measurements indicate the spreading of the waste vertically based on the resistivity value from field measurements.
6. The dominant spreading of the waste found in the middle and western of Pesarean Village.

References


Figure 13. Result of resistivity 2-D measurement of Line 1

Figure 14. Result of resistivity 2-D measurement of Line 2

Figure 15. Result of resistivity 2-D measurement of Line 3

Figure 16. Result of resistivity 2-D measurement of Line 4
Figure 17. Result of resistivity 2-D measurement of Line 5

Figure 18. Result of resistivity 2-D measurement of Line 6