Study of Industrial Liquid Waste Pollution Using Geoelectrical Method in Sukaregang, Garut, West Java

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Abstract. The rapid development of industry causes more and more waste to be produced and can lead to pollution. One of those is the pollution of the leather tanning industry in Sukaregang, Garut, West Java. Tannery waste is disposed of directly into the river area. Seepage of waste below the surface from river flows results in groundwater contamination which affects the availability of clean water. In this study, measurement of the geoelectric method was carried out to determine the distribution pattern of subsurface groundwater pollution based on variations in the resistivity value. Data retrieval was carried out on three parallel lines using the Wenner configuration. The distance between the measurement line is 5 m with the distance between the electrodes as long as 4 m. Results showed that resistivity values varied from 0.1 to 181.9 Ωm. These values are associated with clay rocks with different densities. On the three lines, there is a low resistivity anomaly of less than 8.61 Ωm which is thought to be part of the contaminated seepage of liquid waste. Allegedly polluted areas on the three tracks are at the measurement point of ±10 to ±20 m with a depth of about 0–8 m.

Keywords: Geoelectrical · Resistivity · Wenner Configuration · Liquid Waste

1 Introduction

Clean water is one of the primary needs of humans. One of the causes of clean water pollution is waste. Waste is a residual substance produced from a process, both industrial and domestic. Waste can cause pollution and have a negative impact on human health [1]. In line with the increasing population growth and rapid industrial development, many sources of clean water are starting to be polluted. Industrial waste that is dumped directly into the river without prior treatment can cause pollution around the disposal area [2]. Hazardous content contained in well water contaminated with sewage can cause various diseases and is very dangerous if consumed sustainably [3]. One of the industrial wastes that are a factor in environmental pollution is the leather tanning industry. Due to the increasingly promising prospect of the leather tanning industry, the higher the volume of waste generated during the production process [4].

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One of the hazardous substances contained in the leather tanning industry waste is chromium heavy metal. The leather tanning process uses materials that contain chromium salts. This salt is used to remove the hair on the animal's skin [5, 6]. Chromium is a type of contaminant that is carcinogenic and toxic. The soluble nature of chromium and its high mobility in the environment can make it highly toxic [7].

The leather industry center in the Sukastreg region, Garut is one of the leading industries in the area. This industrial activity in addition to increasing local revenue but also causes problems. The problem that occurs is related to waste that is disposed of directly into the Ciwalen river without prior treatment which can pollute the area around the river. Indications of this pollution can be felt directly through the pungent smell and black color of the Ciwalen river water which is used as a waste disposal site. Based on previous research, Ciwalen river water contains heavy metal chromium with concentrations above the threshold value of quality standards. River water containing chromium heavy metal above this quality standard can enter groundwater and can contaminate people's wells along the Ciwalen River [7].

Most residents around the location of the waste disposal river are not aware of the possibility of groundwater contamination due to the infiltration process or seepage of leather tanning liquid waste. This is because the seepage process is difficult to observe directly because it occurs below the earth's surface [8]. So research is needed to detect the spread of waste contaminants so that local residents can be more alert and prevent the dangers that will occur.

One way to detect waste seepage below the surface is to use the geoelectric resistivity method [9]. The principle of this method uses the concept of electric current propagation in the earth's medium. The ratio between the measured potential difference and the amount of electric current injection will represent the subsurface based on variations in resistivity values [10]. Liquid waste usually contains dissolved metals so that it will have a high conductivity value or low resistivity [11, 12]. Based on the description that has been presented, research was carried out by acquiring resistivity data around the Ciwalen River areas, Sukanggang, Garut to analyze the pollution of the tannery industry liquid waste. The method used is the resistivity geoelectric method with Wenner configuration.

The resistivity geoelectric method is carried out by flowing a high-voltage direct current into the ground through two current electrodes. The resulting response is in the form of a potential difference measured at two potential electrodes using a certain configuration [13, 14]. The value of the potential difference obtained can be used to calculate the variation of the resistivity value by using Eq. (1) as follows.

$$\rho = k\frac{\Delta V}{I} \tag{1}$$

where ρ = resistivity (Ωm)
ΔV = potential (Volt)
I = current (A)
k = geometry factor

The geoelectrical measurement scheme used in this study is the Wenner configuration to analyze the distribution of liquid waste pollution laterally (mapping). The Wenner configuration has the same electrode spacing (current and potential) at each measurement

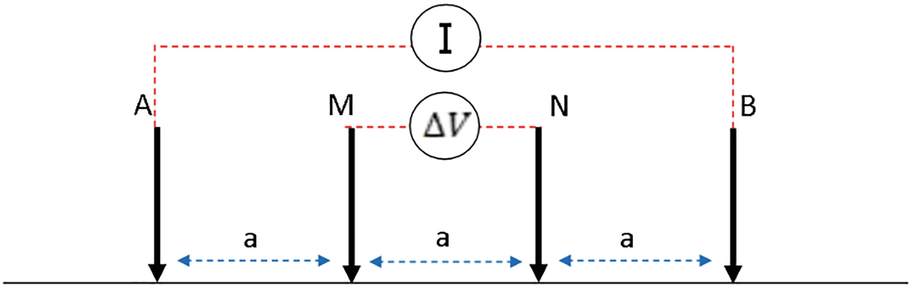

Fig. 1. Wenner configuration of current and potential electrodes

point. The following is an illustration of the position and spacing of the electrodes for the Wenner configuration.

Based on Fig. 1, a is the space between the electrodes, AB is the current electrode while MN is the potential electrode. The geometry factor for the Wenner configuration arrangement is shown in Eq. (2) below.

$$k = 2\pi a \tag{2}$$

So Eq. (1) can be written as follows.

$$\rho = 2\pi a \frac{\Delta V}{I} \tag{3}$$

The presence of waste distribution can be indicated by the large resistivity value of the subsurface rock. Areas polluted by industrial waste will usually contain metals from waste chemicals, which will cause the conductivity value to be higher or the resistivity to be lower. Therefore the polluted area (soil/ aquifer) will have a low resistivity value, which is around 1–20 Ωm [15, 16], and or around 1.33–8.61 Ωm [17].

2 Location and Method

The location of data collection is located at coordinates 7°13′02″S 107°54′47″E, around the Ciwalen river, Sukanggang, Garut as shown in Fig. 2. In this study, 3 lines were taken with the length of lines 1 and 2 being 60 m while line 3 was 75 m. The distance between the lines is 5 m. The configuration used is the Wenner configuration so that the spacing between the electrodes is the same. The space between the electrodes used is 4 m for lines 1 and 2 and 5 m for line 3.

Geoelectric measurements in this study use a main-unit multichannel resistivity with 16 electrodes to inject current and read potential differences. Other tools used are cables to connect the electrodes to the main unit, a meter to measure the length of the line, a 12 V battery as a power source for the main unit, GPS to show the coordinates of the data collection point, and hammer to help stick the electrode into the ground. The data collection scheme in this research tool is shown in Fig. 3 below.

The measurement data is processed using Res2Dinv software. Furthermore, the data that has been proceed is modeled using Surfer 13 software. The results of data processing that have been modeled are interpreted based on the resistivity table.

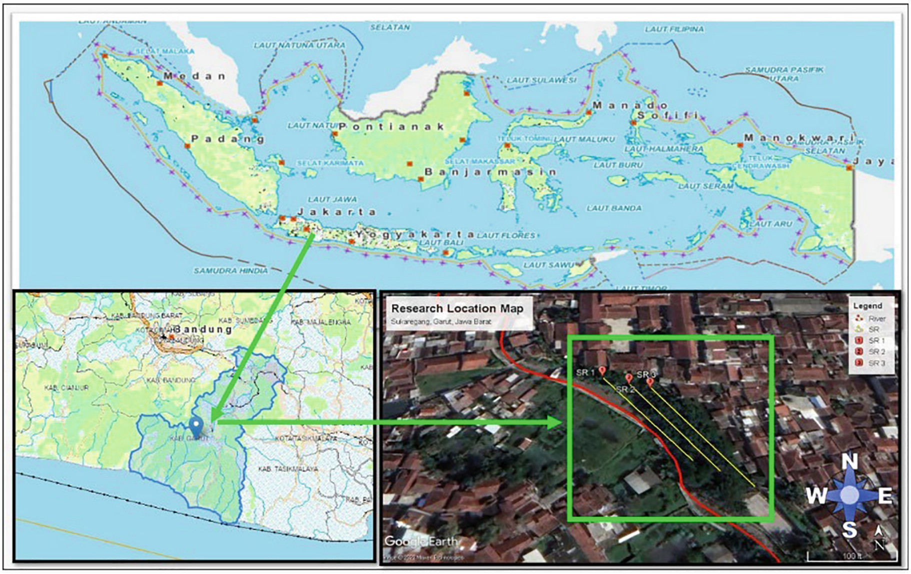

Fig. 2. The map of the research location with red lines represents the flow of the Ciwalen river, the Location of data collection Geoelectric measurement lines around the Ciwalen river, measurement line is marked with a yellow line.

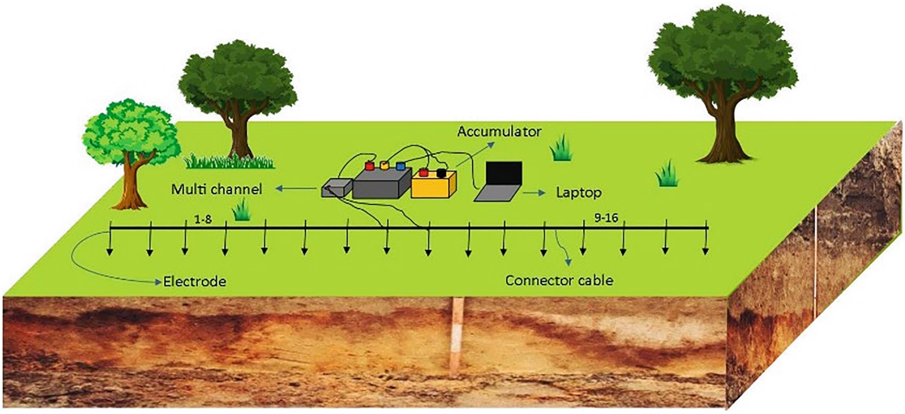

Fig. 3. Illustration of geoelectric measurement and its components.

3 Results and Discussions

Geoelectric measurement results are processed using the inversion analysis method with the help of Res2Dinv software. The resistivity value of the 2D vertical section shows a value that varies in each line. The effective depth can be reached from the measurement results is about 10.7 m for SR-1 and SR-2, while on line SR-3 is around 13.4 m. The interpretation of the constituent rock types and the analysis of the estimation of wastewater infiltrating the subsurface layers are based on the modeling results as shown in Fig. 4. The following are the results of the processed data and the interpretation of the geoelectric data from the three lines.

Variations in resistivity values obtained ranged from 0.11–252.4 Ωm. Variations resistivity values associated with clay and sand rocks [18, 19]. This is in accordance with the geological conditions of the research area, the lithology of this area at a depth of around 0–20 m is a silty clay consisting of a layer of soft to stiff clay and there are solid sand inserts [20–22]. The error percentage on SR-1 line is 6.5% with 25 iterations, while the SR-2 line is 6.8% with 25 iterations. The error percentage on the SR-3 line is 7.8% with 25 iterations. Based on the rock resistivity table, the condition of soil and

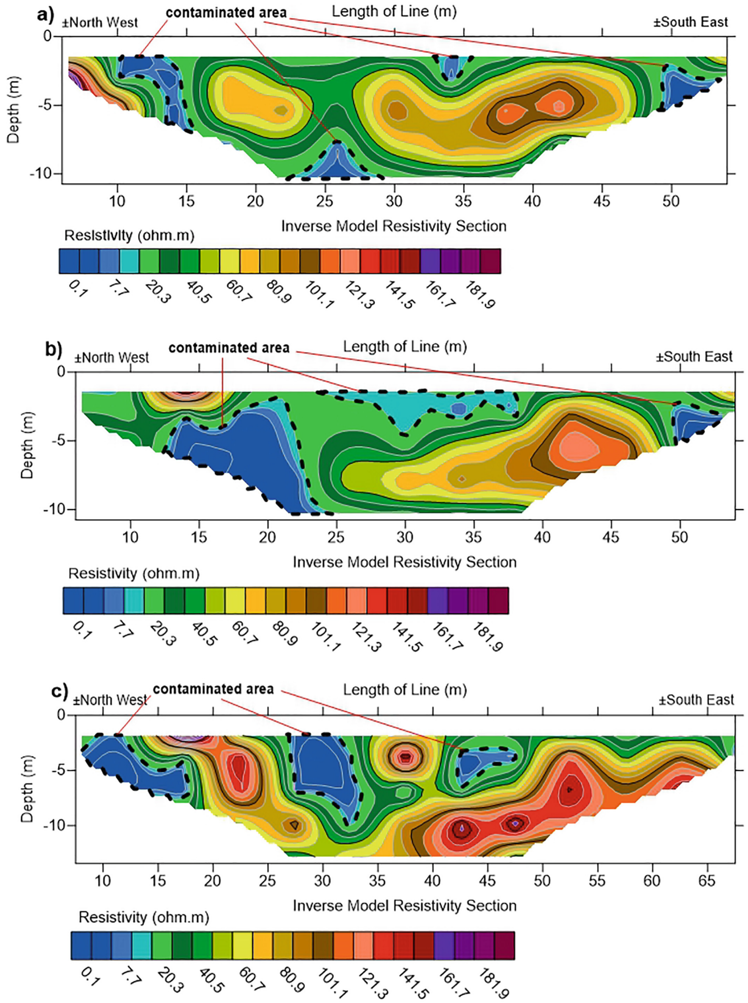

Fig. 4. Cross section of the 2D model resistivity distribution for (a) line SR-1, (b) line SR-2, (c) line SR-3

groundwater contaminated with liquid waste is characterized by a layer that has a low resistivity, which is between 1.33–8.61 Ωm [17]. This is because industrial wastewater often contains dissolved metal elements that have high conductivity/electrolyte properties. Figure 4 shows the presence of a layer with low resistivity between 1.33–8.61 m which is marked in dark blue to light blue. This layer is thought to be a layer of soft clay contaminated with liquid waste. Liquid waste associated with subsurface layers can cause a decrease in resistivity values.

Figure 4. a) shows the SR-1 line which has a resistivity value variation ranging from 0.61–209.31 m. The liquid waste seepage zone on the SR-1 line is localized in several places. The point of the SR-1 line zone which is suspected to be contaminated with liquid waste seepage is at 10–15 m from the starting point with a depth of 0–7 m, at a distance of 23–29 m from the starting point with a depth of 7–10 m, and at a distance of 50–54 m from the starting point with a depth of 3–7 m.

Figure 4. b) shows the SR-2 line which has a resistivity value variation ranging from 0.39 to 198.68 m. The point of waste pollution on the SR-2 line laterally is almost like the point of contamination of the SR-1 line. Liquid waste that infiltrates the SR-2 line is thought to be at 12–25 m from the starting point with a depth of 2–10 m, at a distance of 25–39 m from the starting point with a depth of 0–5 m, and at a distance of 50–55 m from the starting point with a depth of 3–7 m.

Figure 4. c) is a subsurface picture for the line SR-3. The SR-3 line has a resistivity value ranging from 0.11 to 252.49 m. The point of the alleged pollution zone on the SR-3 line is almost the same laterally as the SR-1 line and SR-2 line pollution points, namely at a distance of 0–18 m from the starting point with a depth of 0–8 m, at a distance of 27–33 m from the starting point with a depth of 0–10 m, and at a distance of 41–49 m from the starting point with a depth of 2–7 m. Industrial wastewater is thought to have the same seepage point for all three routes, where the waste infiltrates laterally evenly from the SR-1 line area closest to the river to the SR-3 line.

At a distance of 10 m, 23 m, and 50 m there are patterns of low resistivity anomalies that are oriented vertically from a depth of 0 to 10 m. This anomaly is thought to be a seepage zone that makes it possible for liquid waste to penetrate deeper layers. This seepage zone can occur due to the presence of fractured or porous structures in the clay layer due to the non-solid clay constituents [12].

Figure 5 shows a 3-dimensional view of resistivity calculated from 2-dimensional inversion for all lines. The purple blobs in Fig. 5 are zones that have a resistivity of 1.33–8.61 Ωm. The purple blobs in Fig. 5 in each lines are the liquid waste seepage zones.

The distance between the first line of SR-1 and river water where the waste dumps is <1 m, at shallow depths <3 m there is a low resistivity anomaly which is suspected as seepage of river water that has been polluted by liquid waste. The allegation of seepage of liquid waste in the next layer (SR – 2 line and SR – 3 line) which is deeper is due to the seepage of waste in the first pass that infiltrates the next pass.

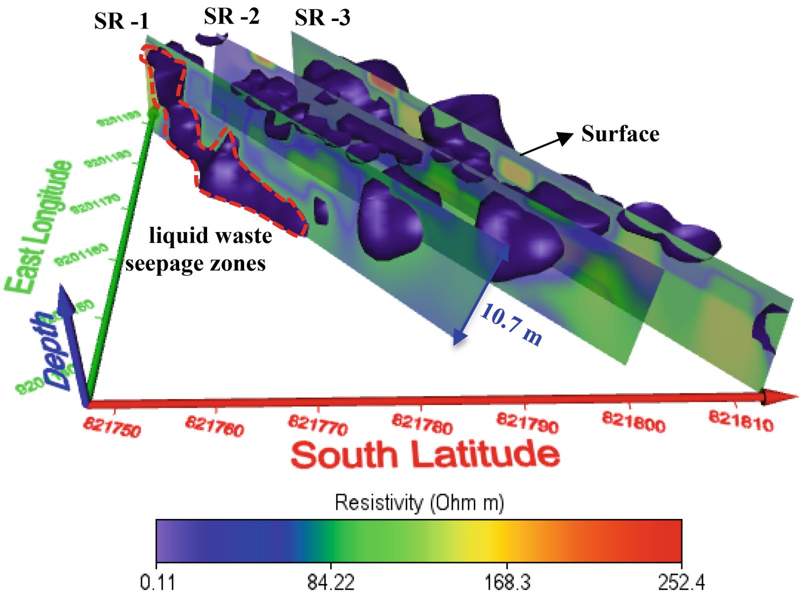

Fig. 5. Liquid waste seepage zones distribution based on correlation of three lines measurement in a 3-dimensional view

4 Conclusion

The results of the 2-dimensional modeling show the alleged distribution of industrial wastewater pollution with varying depths. Based on the results of 2D subsurface resistivity modeling, it is suspected that the seepage of liquid waste on the SR-1 line is shallower than on the SR-2 and SR-3 lines. This is because the waste infiltrates from the SR-1 track which is closer to the waste disposal river. In further research, to obtain more comprehensive data and analysis related to this pollution, additional data is needed as resistivity supporting data, one of which is in the form of soil sample testing or in situ surface water sampling.

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