Geoelectrical Method for Detecting the Limit of Liquid Waste Flowing Below the Surface at Piyungan Landfill

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Abstract. Increasingly limited residential land in urban areas results in residents looking for and making settlements around landfills. This affects people's lives in fulfilling their daily needs, clean water. To meet the demand for clean water, some residents use well water as the primary drinking water source. Judging from the condition of the residential areas located in the landfill area, there may be an effect of waste, especially liquid waste, on well water sources. For this reason, research is carried out using the geoelectric method by combining two configurations, namely Schlumberger and dipole-dipole. So that it can provide an overview of the boundaries of liquid waste contaminants in the soil, which are associated with conductive fluids that affect the quality of clean water from residential areas around the landfill. In this study, it was found that the fluid flow associated with liquid waste has a lateral movement to the right with a depth of 24.5 meters.

1. Introduction

Human activity in utilizing nature always leaves some leftover goods or food that is considered useless anymore. This often causes problems in the form of imbalances in the environment. Similarly, the number of human populations is increasing every day, resulting in changes in housing. Therefore, along with these changes, many dwellings are found around the landfill, which consequently damages the quality of human life and the environment [1,2]. The limited landfill capacity resulted in debris becoming degraded to the decay stage, which will later cause the effect of liquid waste of toxic waste and enter the soil [3,4].

A landfill is an open area where diseases are caused by bacteria, organisms, and other living things that have decayed [1]. Therefore, it is advantageous if the waste can be recycled again so that it can reduce the volume and benefit humans and the environment [5]. However, the capacity of waste carried to landfill sources increases, making it unaffordable in carrying out sanitary system processes that result in the decay of garbage and will become a source of bacteria [6,7].

In meeting the living needs of water, residents around landfills make wells. Water supply, surface water, and groundwater have a vital role in meeting the collection of clean water needs useful for other
purposes. However, the existing wells are affected by decaying waste and undergoing waste removal and disposal. This process cannot be observed because the result of the decay of garbage that turns into liquid waste seeps into the earth's surface [8]. To find out about the waste, some studies only identify biological and chemical analyses of liquid waste [9,10]. However, for the limit of liquid waste flow carried out in this study, this is because if the liquid waste spills to the boundary of the aquifer area, it is possible to contaminate the wells of the residents who are around the landfill.

To solve the problem, a way is needed to know the limits of the liquid waste. One of the geophysical methods used in this case is the geoelectric method of prisoners of this type [8,11–14]. This method applies the injection of an electric current into the earth with the obtained measurable potential value and electric current to create imaging of subsurface models [15–17]. Based on the sub-surface imaging results, it appears that the liquid waste will be categorized with a low resistivity value. This is because liquid waste is included in conductive trash with heavy metals [18,19]. Therefore, it is necessary to mitigate efforts in observing the environmental pollution caused by liquid waste to well residents' water quality around the Piyungan Landfill.

2. Methodology

2.1. Geological setting

This research is in Piyungan Landfill with the coordinates of 8°33’70” LS dan 115°20’40” BT. The landfill area is mostly on quarter-old rocks dominated by volcanic deposits of Young Merapi Mount. The stones in this area have an old Lower Central Miocene age and are in the Breed Formation. The type of lithology in the research area consists of a unit of tufa clay stone – sandstone, andesite breaks unit, buoyancy stone breaks, and the presence of fluvial deposits [20]. As seen in Figure 1. Besides, the geological condition of the research area is also composed of quarter aged rocks consisting of a group of volcanic rocks from Young Merapi in the form of ash, tuff, and agglomerate breaks as well as the presence of a cross between floating rock and clay rock resulting in the formation of alluvial deposit [21].

Figure 1. The geological map of the Piyungan Landfill area is in Bantul Regency with a very tight contour that shows its location in the altitude area
2.2. Geoelectrical method

The geoelectric method is widely used in various shallow and deep sub-surface studies to determine lithology, groundwater, distribution of rocks, and boundaries of soil layer contaminated by liquid waste caused by garbage [11,13–15,22,23]. This geoelectric method is based on the guessing of materials with different resistivity and is flowed by electric current. The resistivity of rock is defined as the physical properties to be used as the ability for stones to be bypassed by electric current, where if the stone is burdensome to flow through the electric current, then it has a considerable resistivity value [24]. The geoelectric method has a method of use by injecting an electric current into the earth through an electrode and then measuring the potential difference from electrodes [25]. The geoelectric method uses an approach system in injecting electric current into the earth by assuming that the layer beneath the surface is all isotropic homogeneous, which means that the rock layer has one layer and the resistance is the same [15].

In this research, data were obtained using geoelectric methods with a combination of configurations, namely Schlumberger and dipole-dipole (Figure 2).

![Figure 2. Research map and measurement point for Schlumberger and dipole-dipole configuration.](image)

This is because it can obtain a heterogeneous sub-surface layer with deeper rock lithology [15]. In Schlumberger configuration, the space between two potential electrodes is created equally, but the two current electrodes are fickle (magnified). Schlumberger electrodes' arrangement adjusts the distance between each electrode (Figure 3a), where potential MN electrodes are always placed between AB current electrodes so far until the measurement point of data retrieval on line A-B ranges from 200 meters. Also, the study used a dipole-dipole configuration, this method using a pair of current electrodes, namely C1 and C2, as well as a couple of potential P1 and P2 electrodes with the same arrangement in Figure 3b. In this configuration using a trajectory length of 380 meters, this measurement uses a space of 20 meters and uses geometry factor (n) ranging from 1 to 6, the first measurement n = 1.
3. Results and discussion
From the results of data processing, sub-surface resistivity results from Schlumberger and dipole-dipole configurations.

3.1 Schlumberger configuration results
In addition to the research area located in the middle of Piyungan landfill, which consists of a Brees formation with the dominance of volcanic rocks that include tuff, volcanic breaks, and andesite, which is a sediment of Merapi, also obtained soil weathering marks from volcanic rocks in the form of alluvium with large grains from the size of clay to fine-grain sand. From the results of the geoelectric method obtained (Figure 4). For resistivity values and depth, each layer can be seen in Table 1.
Table 1. Resistivity value and depth of each layer of a research area

| Layers | Resistivity (Ωm) | Depth (meter) | Interpretation       |
|--------|-----------------|---------------|----------------------|
| 1      | 12.2            | 0.675         | Topsoil (alluvium)   |
| 2      | 2.5             | 0.582 - 1.26  | Sand                 |
| 3      | 16.6            | 1.19 - 2.44   | Tuff (clay)          |
| 4      | 3.44            | 22.1 – 24.5   | Tuff (sand)          |
| 5      | 22.9            | > 24.5        | Bed rock             |

The coating that is considered topsoil in the form of alluvium will only be passed by liquid waste but in the absence of accumulation. In contrast to the second layer of sand, there is an accumulation of molten debris due to the porosity of the large sand [15,27,28]. In the tuff layer in the form of clay grains, this layer has a low porosity value and small permeability; so this layer cannot accumulate fluid properly, only to the extent that the next fluid will influence the Earth's gravitational forces downwards. This has a difference with the tuff containing sand. Due to the thickness of the sand greater than the layer above it, there may be an abundant supply of the sedimentation process and the absence of low resistivity value in this layer. Therefore, this layer is interpreted as a layer that stores the accumulation of liquid waste resulting from the spill from the layer above it. Anomalies evidence this in the wells of surrounding residents with a depth of 10 m. Similarly, in the fifth layer that is under the grainy tuff of sand to a new center downwards, it is thought to be a clay-grained tuff that is more compact than the coating – the layer above it so that its porosity and permeability value is so small it even tends to be impermeable. This layer is thought to be the bed rock of the measurement site.

The fluid flow associated with liquid waste will flow downwards to a depth of 24.5 m, after which liquid waste tends to move laterally. It is because below 24.5 m depths are found in impermeable layers that are difficult to penetrate by liquid wastewater.

3.2. Dipole-dipole configuration results
Geoelectric measurements of dipole-dipole configurations provide a two-dimensional cross-section, which can be correlated with the results of geoelectric measurements of Schlumberger configurations, depth of well monitoring, and observation of rocks on the surface (Figure 5).

![Figure 5. Sub-surface resistivity cross-section of dipole-dipole configuration](image-url)
High and low resistivity contacts can be seen on a 60 m trajectory with a value of 42.3 – 817 Ωm interpreted as volcanic rock and value of 2.19 – 9.62 Ωm as a cross of fine-grained tuffs and clay-grained tuffs. At the 240 meter track is obtained a resistivity value equal to that of the 60 m way with the absence of fine tuff crosses and clay tuffs, but for its high resistivity is received an amount of 817 – 69401 Ωm, where the presence of volcanic rocks the size of kerakal until chunks are inserted between clay matrix which is thought to be strong as rocks with low porosity and low permeability, so that fluid flow cannot penetrate these rocks properly [21].

4. Conclusion
The accumulated liquid waste research area’s location is located at a depth ~ 90 – 120 meters, with a resistivity value of 2.19 Ωm – 9.62 Ωm, which are marked in dark blue–light blue. The fluid flow associated with liquid waste will flow downwards to a depth of 24.5 m to the right of the landfill site, after which liquid waste tends to move laterally. This is because below the center of 24.5 m, and there is an impermeable layer that is difficult to penetrate by the liquid wastewater.

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