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Application Of The Self-Potential Method To Determine The Distribution Of Leachate In The Manggar TPA Balikpapan

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ABSTRACT
The Manggar Final Processing Site (TPA) is a TPA located in the city of Balikpapan by implementing a sanitary landfill system. In this system, the waste is piled up into a mountain so that leachate generated from the waste will enter the layers below the surface due to rainwater. To detect the presence or distribution of leachate below the surface, an investigation was carried out using the Self Potential (SP) Method. The results of the data processing obtained are isopotential maps. From this map, we can see the distribution of leachate based on the potential difference value. Based on the slicing data from the anomaly, the value of the potential difference between 31 mV and -50 mV is found, which is scattered towards the north. This can be indicated as a leachate anomaly.

INTRODUCTION

The growing population and industrial sector growth in an area will impact the increase in waste produced by households and industry. This increase in the amount of waste will cause problems in the environment if it is not accompanied by efforts to improve and improve the performance of the solid waste management system [1]. The direct impact experienced by the problem of increasing the amount of waste is the impact on environmental pollution, from soil pollution, water pollution, and air pollution [2]. The direct impact can also cause many diseases. Meanwhile, the indirect impact of pollution is the occurrence of flooding due to large piles of garbage in urban and river drainages. The problem of waste disposal is one of the problems we often hear about in society. The amount of waste is proportional to the level of consumption of goods used daily. The volume of waste, which is getting bigger and bigger every day, can pollute the soil, water, and air. Garbage can also disturb health and also pollute the surrounding environment if it is not managed properly [3].

Landfills for final waste are very much needed so that the activities of the surrounding community are not disturbed by the presence of garbage which can cause unpleasant odours produced by the waste. The final process of waste management ends at the TPA (final disposal site) or what is now called the final processing site [4]. The accumulation of waste that occurs in (TPA) if not properly managed will cause various problems. Piles of garbage can produce greenhouse gas emissions, such as emissions of carbon dioxide (C02) and methane (CH4) [5]. The composition of waste, in general, is more wet waste than dry waste [6]. Wet waste itself is often said to be an organic waste. This waste is quickly broken down and can usually be used as compost. Wet waste is rubbish that quickly decomposes and can easily be decomposed due to the activity of microorganisms [7]. Thus, waste managers usually want speed in the process of collecting, processing and transporting them. The decomposition of this garbage can produce an unpleasant odour. With the condition of wet waste, which has a lot of water content, it will produce large leachate. Leachate produced by wet waste can pollute the environment considering that leachate itself is wastewater that contains ammonium, organic matter, and salt in high concentrations [8].

TPA in big cities must be planned according to the sanitary landfill method, or it can be called the sanitary landfill method [1]. Making a good landfill certainly requires a lot of evaluation processes to identify the best disposal location. This location must meet government regulatory requirements and, at the same time, reduce economic, environmental, health, and social costs. One of the cities in Indonesia implementing this system is Balikpapan City in East Kalimantan. TPA Manggar is one of the final processing facilities located in Balikpapan City. The leachate treatment system at TPA Manggar uses the sanitary landfill method [2]. The leachate discharge that enters the treatment plant is so large that the collection tub may not be able to withstand the leachate flow rate during the rainy season. As a result, the leachate that enters will overflow and spill onto the ground. Leachate can seep through the ground and cause contamination of groundwater in the landfill site [9]. Leachate is a liquid that seeps through waste containing dissolved and suspended elements [8].

The impact of waste pollution has made it difficult for us to get groundwater that meets health standards for consumption. Surface groundwater has been heavily polluted by waste, so it is increasingly difficult to obtain groundwater that is suitable for use [9] [10]. The demand for water in these areas is, of course, standard water used for residents that can be used for drinking and other household needs or also for other industrial or business and service interests. To determine the direction of the distribution of leachate wastewater and the extent to which it has spread and to map the areas at high risk of contamination, measurements are made using the geophysical Method [11]. To obtain accurate data information about the position of groundwater below the surface is to conduct geophysical surveys carried out in a programmed and sustainable manner to protect the ecosystem and minimize all risks of disturbance and damage caused by a lack of knowledge of the area's environment [12] [13] [14].

One of the geophysics that can be used to analyze below the surface (leachate distribution) is the self-potential Method (SP) [4] [15]. The Method (SP) is a method that utilizes the natural potential that occurs below the earth's surface [10] [16] [17]. The causes of self-potential on the earth's surface are electrochemical and mechanical activity. The working principle of SP is to measure the statistical voltage on the earth's surface using two porospout electrodes [18] [19]. Both electrodes are used with a multimeter, and a potential difference is obtained at the measurement point. The advantage of the SP method compared to other geophysical methods is that it is simple, relatively inexpensive, fast, and uses a porous electrode in order to see the polarization effect during measurement [20]. Another advantage of this Method is that it is very responsive to subsurface conductive targets such as metal minerals and sulfide minerals and can be applied to areas with rugged topography [3] [13] [21]. Based on this, measurements were taken to see the distribution of leachate using the self-potential (SP) method.

METHOD

The geophysical Method used is the self-potential (SP) method to obtain information about natural static stresses in the group of points on the ground [11]. This SP method obtained subsurface data which later can be known as the direction of the fluid below the surface. The self-Potential Method is a geophysical survey method that can be used to explore subsurface natural resources [22]. This method is potentially self-based on the measurement of sediment mass of rock in the earth's crust without having to inject electrical current into the ground, like other geoelectric Methods. Initially, the SP method was used to determine areas containing metallic minerals [23]. Furthermore, this method is used to search for metallic minerals associated with sulfides, graphite, and magnetite. Based on this, geophysicists reveal the mechanism of self-potential in mineral areas. In the 1960s Sato and Mooney stated that the mechanism of spontaneous electric polarization in mineral regions could be understood [15] [24] [25]. They say that in the mineral body, there is an electrochemical half-cell reaction, where the anode is below the surface of groundwater. At the anode, an oxidation reaction occurs so that the anode is a source of sulfide currents that are underground. In the half-cell cathode, no reduction substances in the solution gain electrons, whereas at the anode cell, an oxidation reaction takes and releases electrons. The function of the mineral zone itself is only to carry electrons from the anode to the cathode [16] [26]. The magnitude of the overall effect of SP is determined by the difference between the oxidation potential of the solution at two half-cells [20]. This mechanism is illustrated, which shows the flow of electrons and ions leaving the top surface of the negatively charged, while the lower positive charge is modelled by forwarding modelling and inverse modelling, namely the self-potential (SP) method. The goal is to find out how much the fit is between the model made and the actual model [27].

The Self Potential method is a passive method, where the difference from the natural potential of the earth is measured between two electrodes embedded in the earth's surface [28]. The measured potential can range from less than one millivolt (mV) to greater than one volt, and the value marked as positive (+) or negative (-) of the measured potential is an important factor in the interpretation of the Self Potential anomaly [18] [20]. Self Potential is generated from natural sources, although the natural processes that occur cannot be clearly explained [25] [29]. But several things can be categorized, and in the table below, some examples of the sources and types of Self Potential anomalies are given.

Table 1. Sources and types of Self Potential anomalies [18]

Source	**Anomalies type**
Sulphide	Negative ≈ 100 mV
Graphite	
Magnetise, coal	
Quartz veins	Positive ≈ 10mV
Pagmatites	
Fluid Streaming, Geochemical Reaction	Positive +/- negative ≤ 100 mV
Bioelectric	Negative,≤ 300 mV
Topography	Negative up to 2 V

The Self-potential data acquisition method has several steps that must be carried out before and when data acquisition is in progress. The stages before data acquisition include making a survey design map for measuring points and preparing equipment. Meanwhile, the stages when data acquisition takes place include tool calibration and data collection in accordance with the predetermined survey design map. The aim is to calibrate accurate field data [18] [21]. Non-polarization electrode calibration is done by planting the two electrodes on the ground at a relatively close distance. Then, the potential value measured by the results obtained should be ≤ 2 millivolts [20]. If the potential value is ≥ 2 millivolts, then the two porous pot electrodes must be cleaned. This research has been conducted at TPA Manggar, Balikpapan City (Fig. 1)

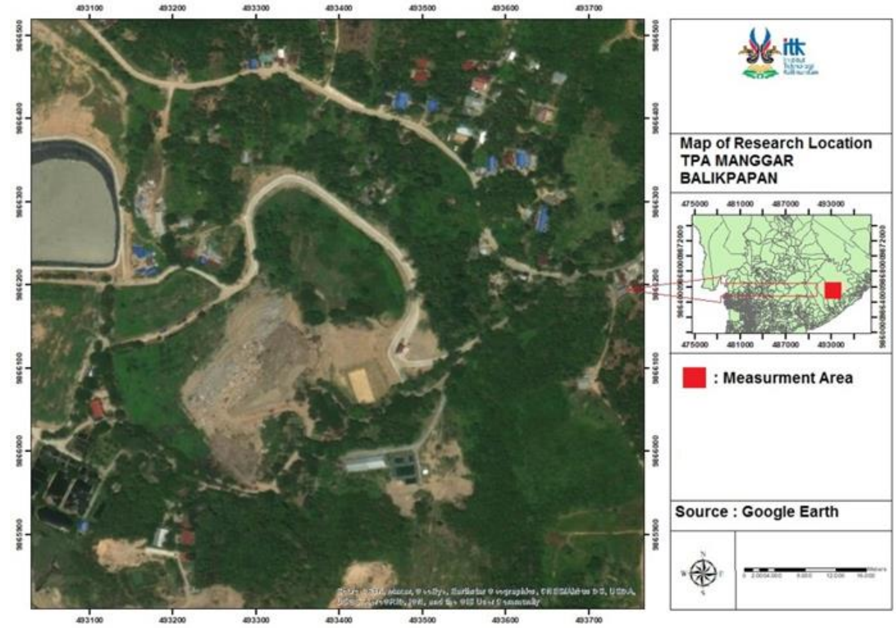

Fig 1. *Map of Research Location*

The tools and materials used in this study were two porous electrodes, CuSo4 solution as an electrolyte solution, copper wire as a conductor, two CD800a digital multimeters with a resolution of 0.1 mV, and an input impedance of 100 M ohms to measure the potential difference value, four cables to connect the electrodes with the multimeter, GPS to calculate the coordinates of each measurement point, a measuring tape to measure the length of the path and the distance between the electrodes, and a crowbar to dig the electrode placement holes [7] [10] [30]. Data measurement is done by taking 4 trajectory lines, with a length of each 80 meters with a distance between electrodes of 5 meters on all trajectories. Measurement technique using the fixed-base technique (Fig. 2). Measurement data in this study was carried out using a digital millivoltmeter, which has a high input impedance to ignore the current from the earth during the measurement process.

After data acquisition is carried out, it is innovative to make data corrections. Data correction is covered by a variation of daily corrections, daily corrections, and reference corrections [31]. The data processed using maping software namely Surfer 10. The results obtained are isopotential maps**.**

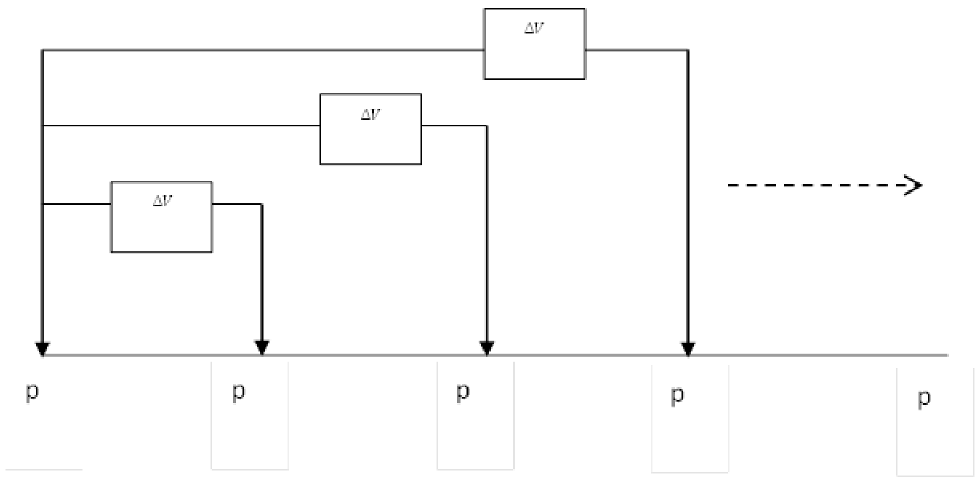

Fig 2. *Technique of Data Acquisition of Fixed Base Configuration* [18]

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RESULTS AND DISCUSSIONS

The first step is to look for geological information (field conditions, soil structure) and the waste management system and the types of waste found in the Manggar TPA. After that, the data collection process is carried out using the SP method. In research, the technique used in collecting self-potential data is the fixed electrode method (Fixed-Base). The instrument used in this survey is a voltmeter with a large input impedance, capable of measuring positive and negative potentials, has sufficient accuracy (and is compact for operation in the field. This voltmeter instrument is generally sold as a geoelectric instrument. Porouspot is a contact electrode with the earth made of metal covered by a solution, placed in a porous container. Small and long cables Small cables because they are light enough, and the length is adjusted according to needs. Measurement with a fixed base requires one stationary electrode (fixed base) and the other electrodes moving along the planned potential points. The cables needed, of course, become longer according to the length of the designed path. The data acquisition process is carried out on four measurement lines with 64 measuring points spread over the study area, with the distance between the porous pot electrodes being 5 meters if the data acquisition process in the research area is carried out, it is necessary to process the data for interpretation. At each measurement point, three potential data were taken, and then the average was taken. The results of the calculation of the average are then calculated for corrections. The desired data is the potential value at a point, while the measured variable is the potential difference. So that we need a way to change the value of potential difference into potential, which is ready to be obtained next. The SP correction is a time function if the number of measuring points is much more than the electrodes and instruments available, and the desired data is time change-free data (position function only). Corrections are carried out on the baseline principle at a certain time for the entire measurement time. The corrections made in this self-potential data processing are daily corrections (a function of time) and reference corrections. The corrected data is then made into a contour map consisting of isopotential contour maps. Contour map-making was done using Surfer 10 software. The corrected self-potential data were interpreted qualitatively. Qualitative interpretation is carried out using Surfer 10 software to obtain isopotential contour maps. Based on this contour map, it can be interpreted the distribution of leachate in the study area, and the direction of fluid flow in the study area can be determined. As seen in Figure 3.

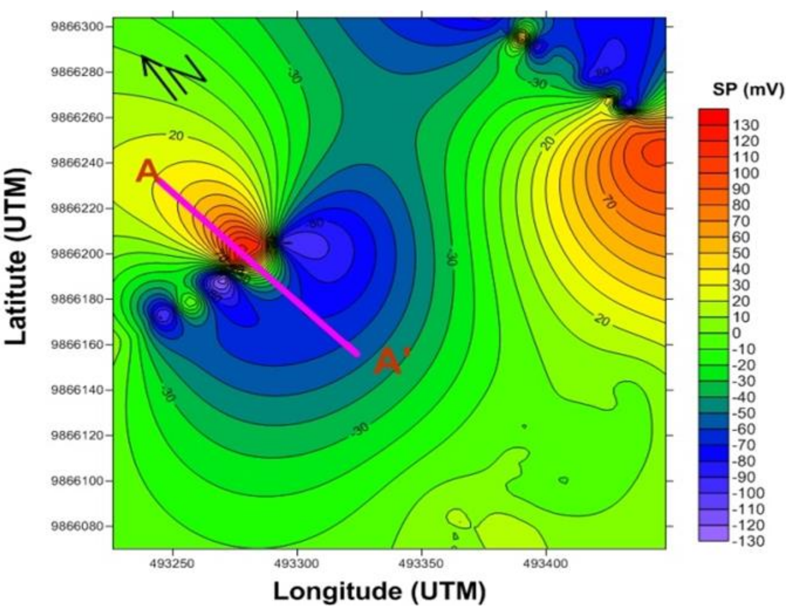

Fig 3. *Isopotential contour map represents the distribution of potential values, line for slicing (A-A')*

This isopotential map illustrates the distribution of self-potential values corrected in the Manggar TPA area. The potential value obtained in the study area ranges from 110 mV to -107 mV. Based on these results, it can be seen that there are three potential values, namely low with a value of less than 0 mV or negative, medium with a value of 0 mV to 50 mV, and high with a value of more than 60 mV. On the isopotential contour map, there are areas where the potential value decreases, which are marked by a contour pattern of blue and purple towards the south, while in areas with yellow colour, there is an increase in the potential value towards the north. With the change in the value of this potential difference, it is an anomaly of self-potential in the research area, so slicing is carried out in this area. This anomaly can be indicated as fluid movement (leachate distribution) below the surface.

The results of the slicing process obtained data on the potential anomaly value of the distance of each electrode. The potential anomaly data and the distance are presented in the form of a profile curve, namely the potential anomaly curve concerning distance. After determining the cut lines that have been sliced, this study uses one slicing data from north to south (A-A ') (Figure 4).

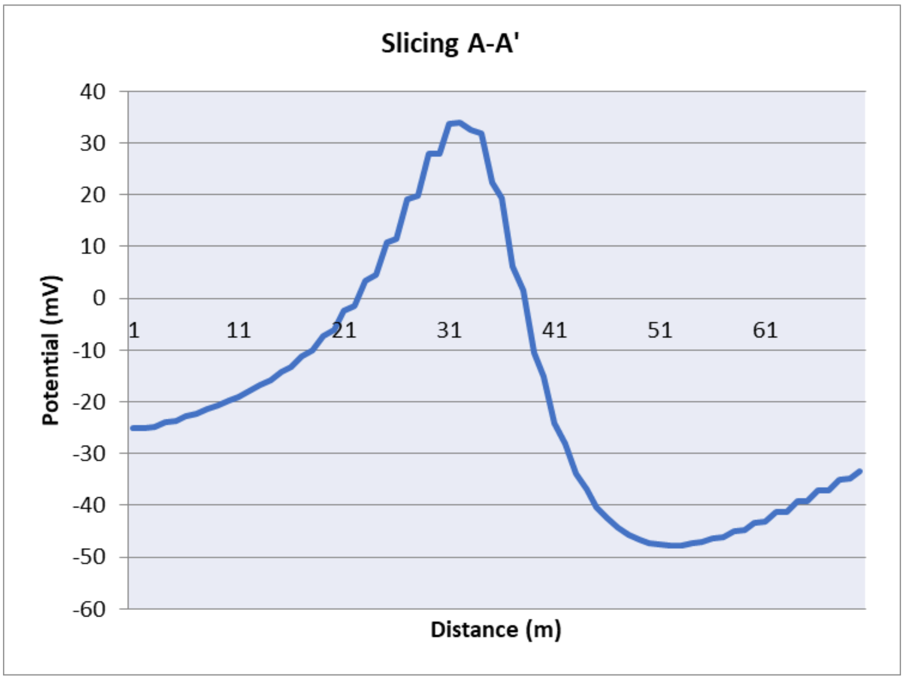

Fig 4. *Profile cross-sectional curve (A-A')*

The cross-section of the self-potential anomaly of the A-A' line is taken based on the anomaly contour pattern, where the A-A' line runs from north to south which is parallel to the waste pile that is no longer active (passive zone). Positive anomalies are located at a distance of 17 meters to 39 meters, and negative anomalies are located at a distance of 0 meters to 16 meters and 40 meters to 66 meters. The length of the A-A 'line is about 69 meters, with anomalous self-potential values varying from 31 mV to 50 mV. Based on the cross-sectional profile of A-A '(Figure 4), a sharp profile can be observed. A sharp profile display indicates a deep source. A decrease in the potential value which is indicated by a sharp profile, indicates a subsurface fluid flow.

CONCLUSION AND SUGGESTION

Based on isopotential contour maps, self-potential anomalies vary between 31 mV to -50 mV. With a decrease in the potential value, which is indicated by a sharp profile, indicates that there is a subsurface fluid flow (leachate distribution). On the isopotential contour map, there are areas where the potential value decreases, which is indicated by a contour pattern of blue and purple towards the south. In contrast, in areas with yellow colour, there is an increase in the potential value towards the north.

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