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Identification of Contamination Plumes in the Peremana Landfill in the city of Santarem-Par ´ a, using Electroresistivity

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Summary

The use of geoelectric methods in soil and groundwater contamination studies yields satisfactory results in both the preliminary assessment and monitoring and remediation phases. Therefore, the relevance of this study lies in its potential contribution to environmental protection, seeking to offer new perspectives and solutions to the challenges associated with contamination in landfills. During the acquisition campaigns, electrical resistivity surveys were conducted using the dipole-dipole electrical pathing technique, with data acquisition in strategic profiles. The application of electrical resistivity demonstrated its effectiveness in identifying leachate and is an essential tool for environmental impact studies, with the ability to map subsurface resistivity variations.

Introduction

Urban solid waste management represents one of the greatest contemporary challenges for environmental sustainability. This challenge is exacerbated by the increasing waste production in recent years, a result of several factors. Notable among these are population growth in urban areas, increased consumption, and the increased volume of packaging used in manufactured products (ABRELPE, 2023; CEMPRE, 2022). These elements contribute significantly to the accumulation of waste and reinforce the need for more sustainable approaches to solid waste management. Waste production is an inevitable byproduct of our daily activities, and the expansion in volume results in the liquid that originates from the decomposition of organic materials, known as leachate.

In this context, geophysical methods emerge as efficient tools for environmental research, offering versatile applications, accurate results, and agile evaluation. These methods have shown promise in the investigation and characterization of environmental problems, and in the monitoring of contaminated areas, particularly due to their non-invasive nature, which allows for detailed characterization without the need for drilling or excavation. They are widely used in the investigation and monitoring of underground pollution. Furthermore, they are non-invasive, meaning they do not alter the physical environment (Bortolin and Malagutti, 2009).

The use of geoelectric methods in soil and groundwater contamination studies yields satisfactory results in both the preliminary assessment and monitoring and remediation phases. The final results minimize field costs and identify the most suitable locations for monitoring wells, in addition to providing geological and hydrogeological information about the area (Braga, 2016). This work focuses on the application of Geophysics, specifically the electric walking technique, in the investigation of contamination plumes in areas of solid waste deposition at the Perema landfill, in the city of Santarém-Pará.

Methodology

In this study, the Electrical Resistivity (ER) method was applied. This method is fundamentally based on Ohm's Law. By knowing the injected direct current (*I*), the potential difference (ΔV), and the relative positions of electrodes A, B, M, and N, it is possible to calculate the resistivity (ρ) of the investigated materials. The main equation of the method is given by the following expression:

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

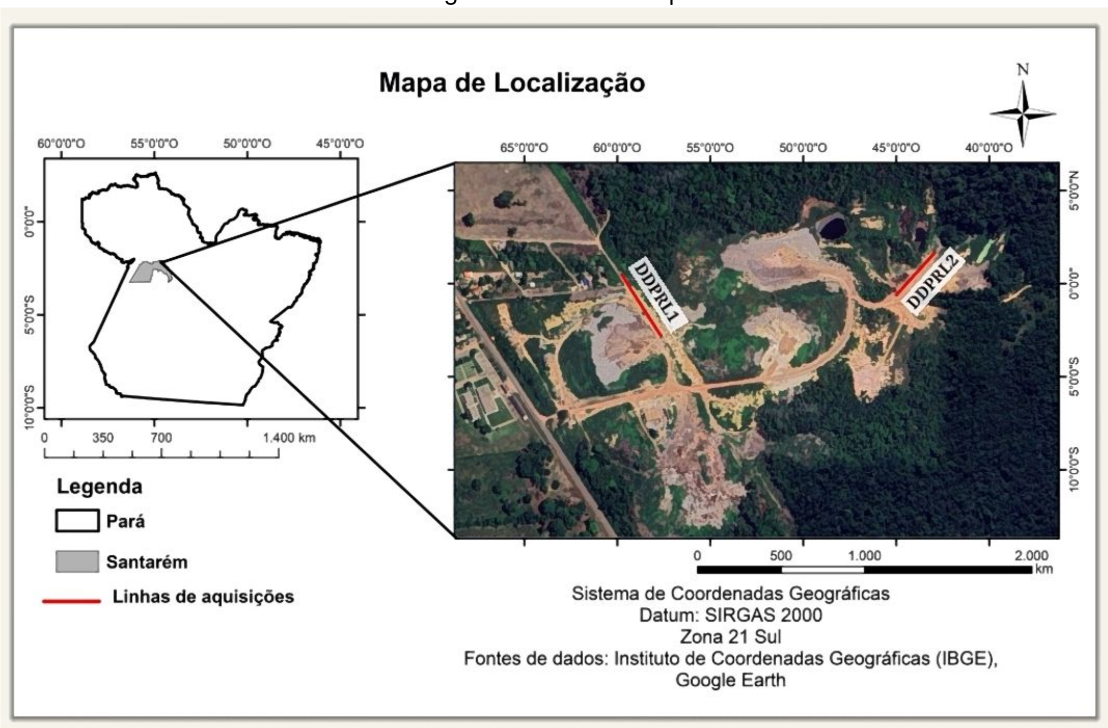
in which:

$$k = 2\pi\left(\frac{1}{AM} - \frac{1}{BM} - \frac{1}{AN} + \frac{1}{BN}\right)^2, \tag{2}$$

This is referred to as the geometric factor, which depends on how the current electrodes (A and B) and the potential electrodes (M and N) are arranged. During the data acquisition campaigns, geo-electrical surveys were conducted using the electrical imaging technique through the dipole-dipole array, with data acquisition performed along strategic profiles: one upstream (DDPRL1, with 5-meter spacing between electrodes) and one downstream (DDPRL2, with 3-meter spacing between electrodes) within the dumpsite. The dipole-dipole array offers many advantages, justifying its widespread use. It is certainly the most commonly used among the various existing configurations and is widely applied in different fields such as mining, groundwater prospecting, and environmental studies. The spacing “a” between the two current and potential electrodes remains fixed throughout the survey, and this spacing is defined according to the purpose of the investigation (Gandolfo and Gallas, 2007).

Results

Figure 1: Location Map.

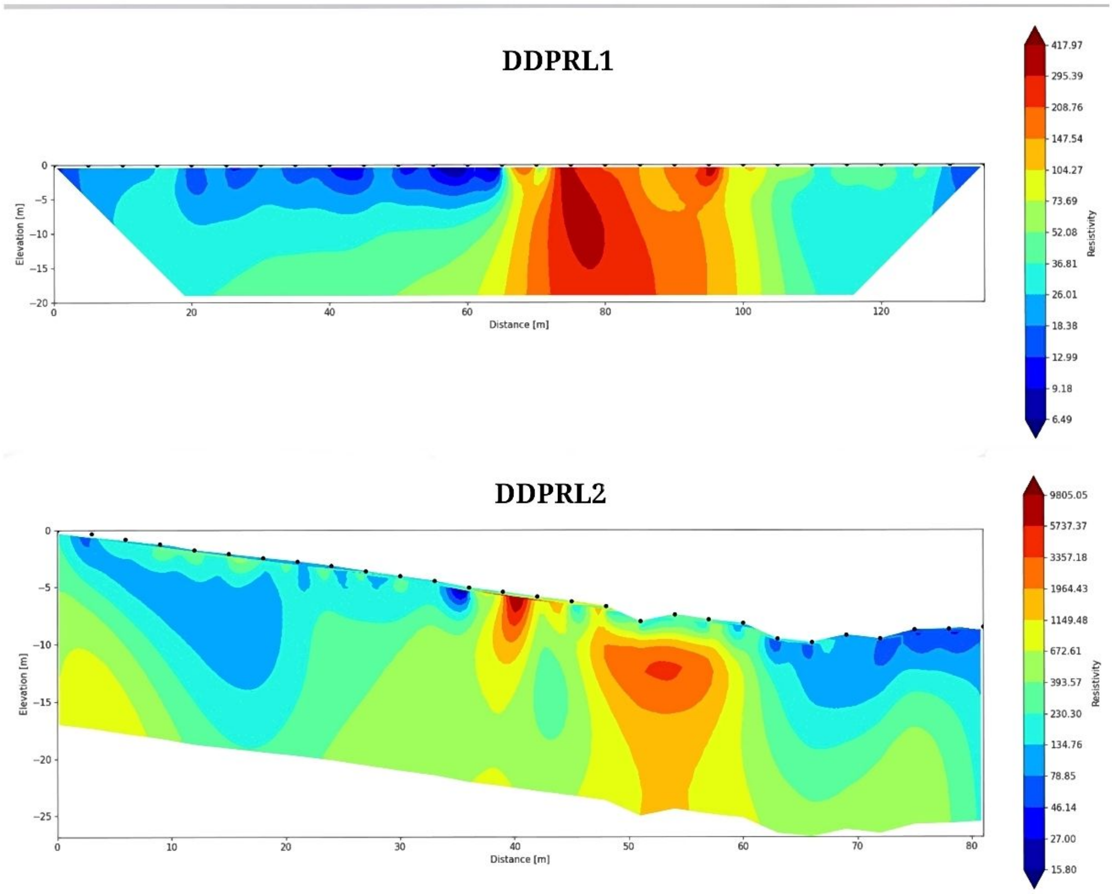


Source: Santos, 2025.

The data obtained at the location shown in Figure 1 were processed using the ResIPy software Guillou-Frottier et al. (2021) to better visualize the distribution of possible soil contamination zones.

The interpretation was carried out considering variations in electrical resistivity and their correlation with the presence of contaminants. The figure 2 presents the results obtained. The DDPRL1 profile shows a color variation indicating different subsurface resistivity levels. Cold colors indicate low-resistivity material, usually associated with the presence of percolated liquids (leachate), which is an indication of preferential pathways for the flow of this substance and a strong indicator of areas most impacted by leachate.

Figure 2: Acquisition Lines.



Source: Santos, 2025.

Line DDPRL2 shows a lateral distribution along the measurement profile. In this region, no highly conductive zones were identified, indicating that up to the investigated depth, no regions with the possible presence of contaminants were observed.

Conclusion

The application of the electrical resistivity method demonstrated its effectiveness in identifying possible regions of soil contamination in the studied area, being an essential tool for environmental impact studies. Periodic monitoring of this area is essential to prevent further contamination and ensure the preservation of water resources for communities residing around the waste disposal site.

This reinforces the need for public policies aimed at the proper management of urban solid waste, encouraging pollution prevention and environmental remediation practices.

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