Geophysical Investigation of the Weidenpesch Waste Site in Cologne, Germany

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1 Introduction

Landfills, designated sites for the disposal of waste materials, have significantly impacted the environment due to the assortment of materials discarded within them. They serve as repositories for various types of waste, including but not limited to household refuse, construction debris, industrial byproducts, hazardous chemicals, and organic matter (Tezkan, 1999; Ibrahem et al., 2019). The presence of such diverse materials in landfills poses significant environmental challenges and potential risks to groundwater resources, air quality, and overall environmental health. The consequential effects of landfills extend beyond their physical presence, influencing factors such as soil contamination, water pollution, greenhouse gas emissions, and the potential for long-term ecological disturbances (Ibraheem et al., 2021). Geophysical methods, encompassing techniques like magnetic, Electrical Resistivity Tomography (ERT), and Time-Domain Electromagnetic (TEM) surveys, play an important role in assessing and monitoring landfills and their environmental impact (Nienhaus et al. 2020, 2021; Ibraheem et al. 2020, 2022). Using these techniques, environmental scientists can gain a comprehensive understanding of landfill dynamics, enabling more informed decision-making for containment, remediation, and the protection of surrounding ecosystems and water resources (Kirsh, 2009, Soupios & Ntarlagiannis, 2017; Ibraheem et al., 2021).

2 The Weidenpesch landfill characterization

The studied landfill is situated in Weidenpesch, within the city of Cologne, Germany. The subsurface geology of this region is characterized by a superficial layer of Pleistocene/Holocene floodplain fines, measuring approximately 2 to 3 meters in thickness, which overlies a deeper stratum of Pleistocene gravely sand, extending to depths ranging from 18 to 25 meters. Further below, the geological sequence comprises Tertiary sand, clay, and brown coal layers. Historically, the site was utilized as a sand and gravel quarry, commencing in 1959. Subsequently, in 1976, operations ceased, and the site was covered with an uneven layer of silty fine sand, varying in thickness from 0.5 to 2.5 meters. Over time, a variety of materials, including soil, construction debris, household waste, and particulates resulting from the grinding of stone materials, were disposed of within the site.

3 Methodology

At the site under investigation, magnetic gradient surveys, ERT, and TEM techniques were employed to analyze and define the landfill structure and its impact on the surrounding hosting layers. Magnetic survey was effective in delineating the extent of buried waste and detecting ferrous materials (Figure 1), while ERT provided valuable insights into subsurface resistivity variations, aiding in the identification of potential contaminant plumes and structural anomalies within landfill sites (Figure 2). TEM techniques offered a means to investigate the electrical conductivity of subsurface materials, aiding in the characterization of landfill composition and the extent of leachate migration as shown in the result of Occam inversion (Figure 3).

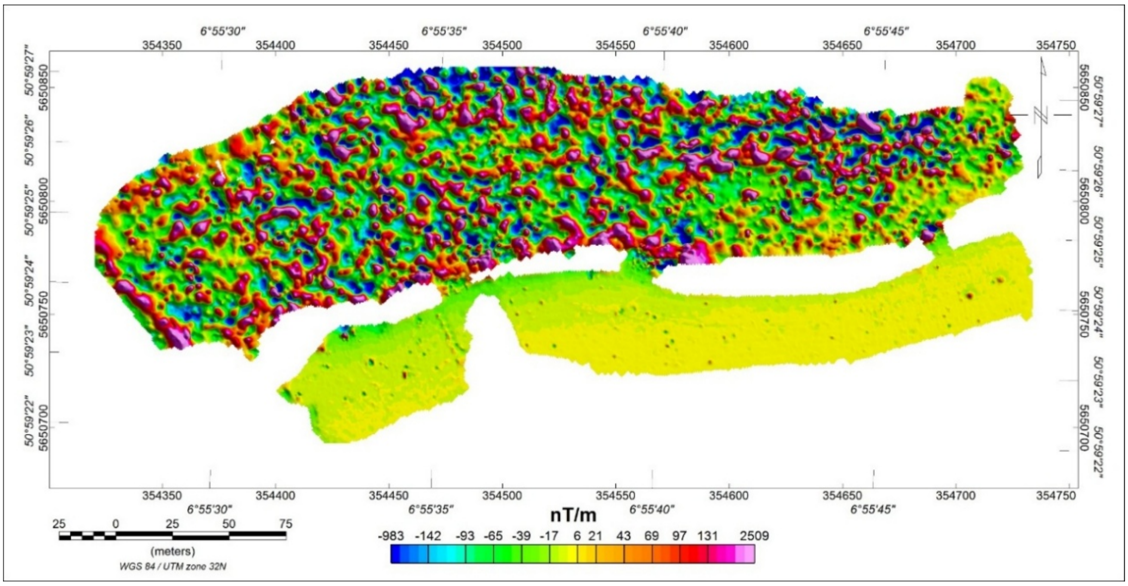

Figure 1: The vertical gradient magnetic map of the study area.

4 Results

The landfill's lateral and vertical boundaries were successfully identified, where the waste body extends to a depth of 8-10 meters. Variations in resistivity values between the western and eastern sections of the landfill imply the deposition of distinct materials in these regions. Beneath the landfill, a highly conductive layer was detected compared to the surrounding area, indicating the potential for downward contaminant seepage. The outcomes derived from the diverse investigative methods exhibit a high degree of agreement and consistency.

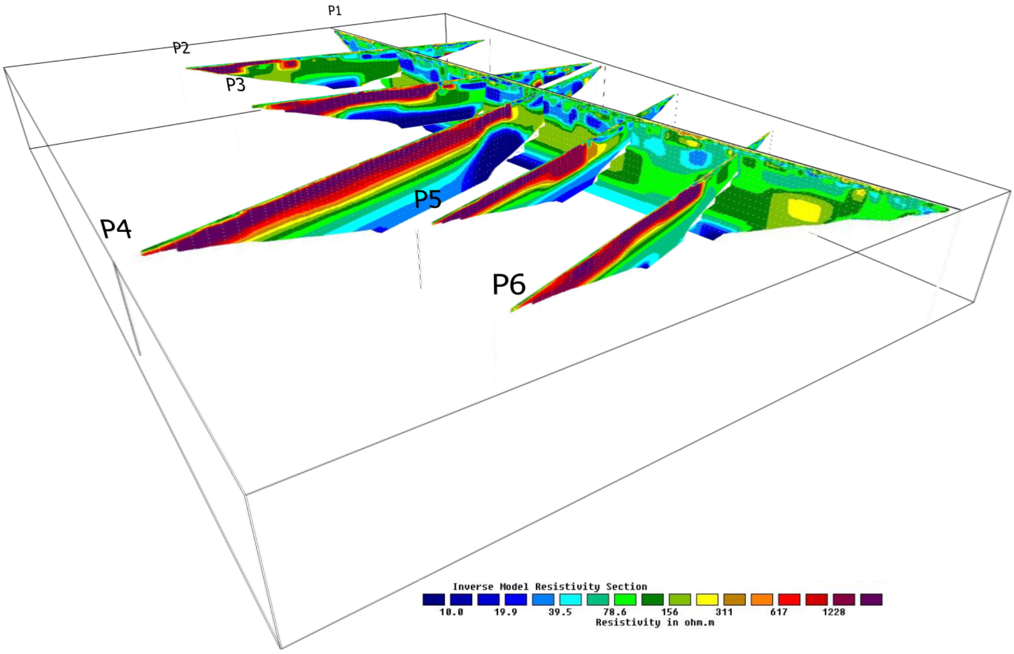

Figure 2: The result of ERT survey in the study area.

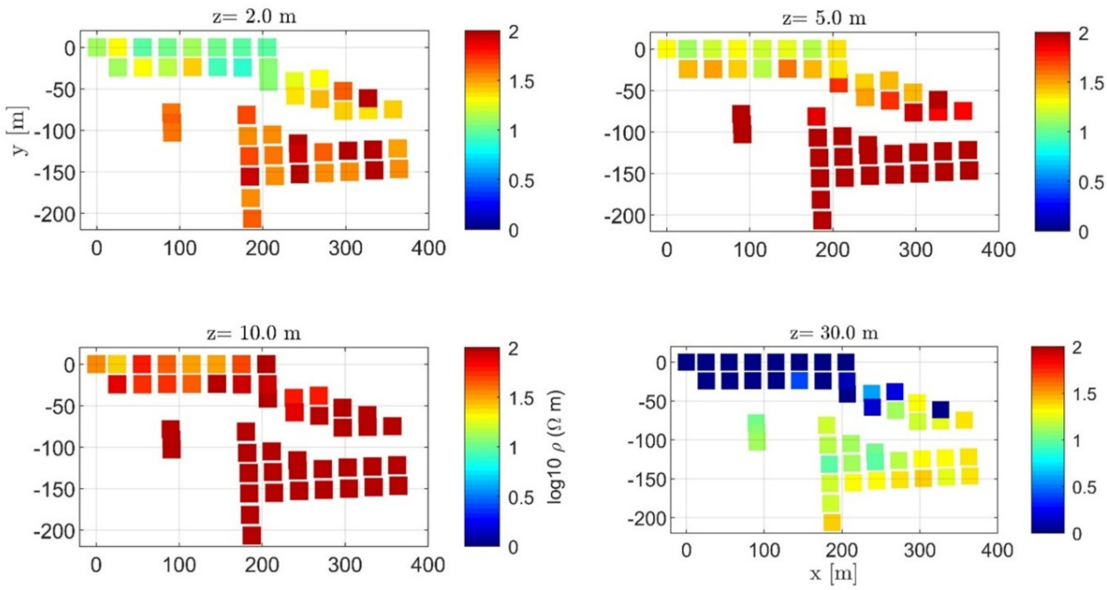

Figure 3: The result of 1D Occam inversion of the TEM data in the study area.

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