LANDFILL CHARACTERIZATION AND LEACHATE PATHWAYS DELINEATION AT A WASTE DISPOSAL SITE IN COLOGNE, GERMANY USING GEOPHYSICAL TECHNIQUES .

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Introduction

Landfills are the most common places for the elimination and storage of huge amounts of domestic and industrial wastes of heterogeneous properties. They represent one of the most critical and serious environmental problems all around the world. Generally, this process has happened in an uncontrolled manner without any indication on the surface. These kinds of waste sites constitute a serious risk for the environment and can represent a main source for groundwater contamination. The investigated landfill is found in an area close to Cologne city, Germany. The study made use of two geophysical techniques; magnetic and ERT. Eight 2D-ERT profiles (Fig. 2) were designed based on the results of the magnetic survey to perform the geoelectrical measurements.

Geology of The Study Area

The geological information of the area where the waste site located was inferred from a geological cross-section passing about 1 km to the west of the site (Fig. 1). The lithology of the area includes the topmost thin surface Pleistocene/Holocene floodplain fines layer with a thickness of 2 to 3 m overlying a Pleistocene gravely sand layer with a depth of approximately 18 m to 25m. Tertiary sand, clay and brown coal layers constitute the base of the sequence. The groundwater table has an average depth of 10 m.

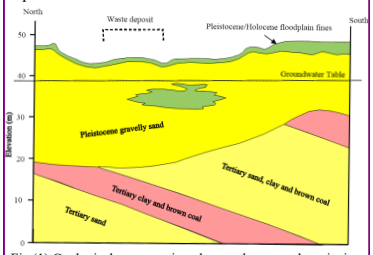

Fig (1) Geological cross-section close to the waste deposit site.

Magnetic Survey

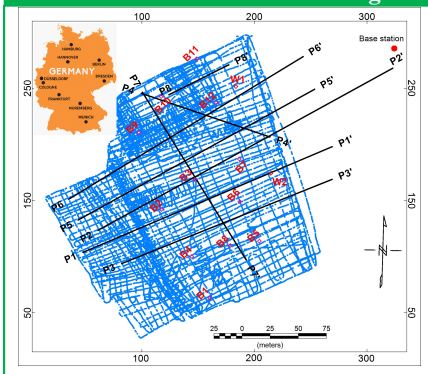

Fig. 2 Map of the investigated waste site, north-west of Cologne, Germany, showing magnetic stations and ERT profiles. Boreholes (W1,W2, B1-B12) are also presented.

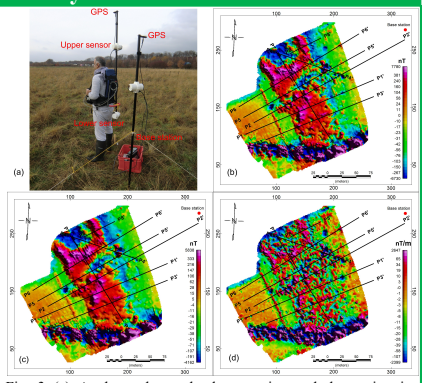

Fig. 3 (a) A photo shows the base station and the roving in gradiometer configuration. Magnetic anomaly map measured at (b) upper sensor, and (c) lower sensor. (d) Vertical gradient map.

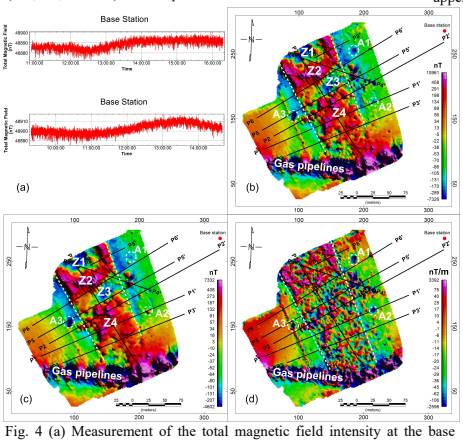

Fig. 4 (a) Measurement of the total magnetic field intensity at the base station during 2 days of the magnetic survey. RTP magnetic map of (b) lower sensor, (c) upper sensor, and vertical gradient map.

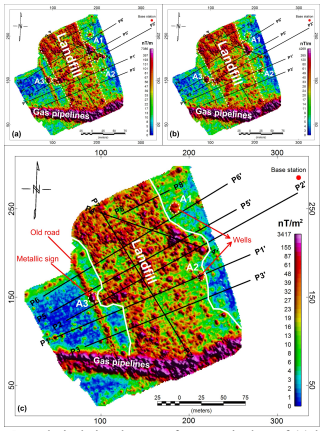

Fig. 5 Analytical signal maps of magnetic data of (a) lower sensor, (b) upper sensor, and (c) vertical gradient.

ERT Survey

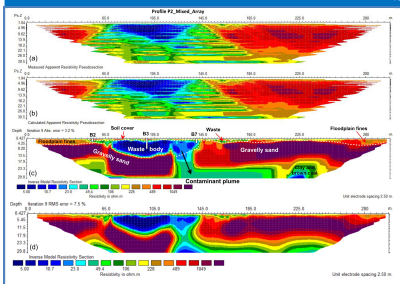

Fig. 6 2D ERT inversion results along profile P2 using robust (c) and smoothness-constrained least-squares (d) inversions.

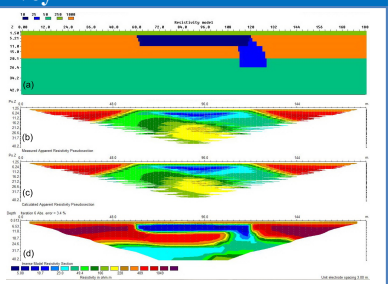

Fig. 7 (a) Synthetic 2D model representing the landfill site and a pathway of a leachate plume. Measured (b) and calculated (c) apparent resistivity pseudosections. (d) The inverted 2D resistivity model using robust inversion.

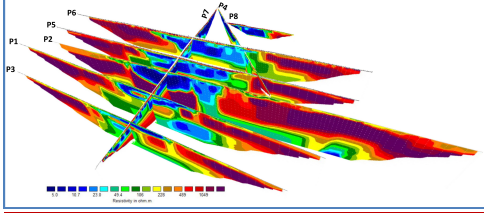

Fig. 8 3D subsurface resistivity distribution in the landfill area and its surroundings. Contamination plumes can be seen at the eastern boundary of the landfill which is in agreement with the groundwater flow in the study area.

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Summary and Conclusions

In the present study, we were able to successfully determine the geometry of a landfill located to the north-west of Cologne, Germany by using the integration of magnetic and ERT geophysical techniques.

Both techniques show that the landfill has a length of more than 190 m and an average width of approximately 100 m. We also differentiated between places where magnetic and non-magnetic materials were dumped (Zones Z1-Z4: Fig. 4).

Lots of subsurface magnetic bodies were observed within the undisturbed geology outside the landfill site which can be interpreted as discarded iron materials or could resemble UXOs, explosive remnants of World War II which must be taken into account. Gas pipelines that run to the south of the area were perfectly imaged by the magnetic survey.

A significant consistency between the two methods in determining the horizontal edges of the waste site was observed.

The results show that the waste body has very low resistivities compared with the highly resistive hosting gravelly sand layer, which facilitates imaging the landfill.

Low resistivity signatures at depths deeper than those expected indicate an infiltration of contaminant leachates downwards through the base of the saturated landfill. These potential migration pathways of leachate plumes were delineated quite distinctly.