Radiomagnetotelluric Exploration of a Waste Deposit in Cologne

Till Vondenhoff[1], Pritam Yogeshwar[1], Bülent Tezkan[1], Shiva Fadavi[1]*

University of Cologne

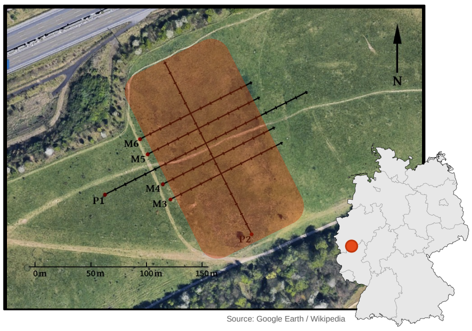
[1]Institute of Geophysics and Meteorology, University of Cologne
*Contact: tvondenh@smail.uni-koeln.de, www.geomet.uni-koeln.de

Introduction

It is well known that environmental problems can be caused by buried waste sites. A lot of waste sites in Germany date back to the time after World War II. Because they mostly have very little to no documentation about their contents, these have a potential to harm the environment and cause groundwater contamination.
An RMT survey was done to retrieve information about the extent of the main waste body. This survey was focused on two main profiles (P1, P2) and a mapping area (M3 - M6) covering the central waste body. Besides the electric transfer functions (Impedance), Tipper data was also recorded and evaluated.

Survey Area

The survey was conducted in June 2020 on a field in the north of Cologne, close to the Autobahn A1. Parts of this area have been used as a waste site from the 1950s until the 1980s.



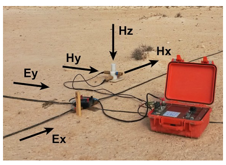
Source: Google Earth / Wikipedia

Fig 1: Map of Germany as well as a satellite image of the Survey Area. The waste body (red area) and the locations of the 6 measured profiles (P1, P2, M3, M4, M5, M6) are marked.

Data Acquisition

The RMT-data was acquired using an RMT-C device which measures a total of 5 different components (H_x, H_y, H_z, E_x, E_y) using 2 different frequency bands:

- 1st band → 10 kHz – 100 kHz
- 2nd band → 100 kHz – 1 MHz



Source: csrmt.info

Fig 2: RMT-C device with its 5 components

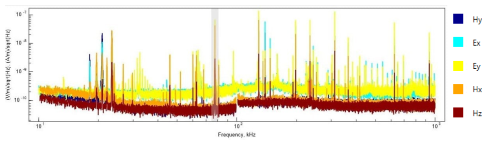


Fig 3: Frequency spectrum of the measured RMT-data. The different colors correspond to the different components measured by the device.

Data Processing

To process the RMT-data the software *EMProcessor* by Arseny Shlykov was used. This software was used to:

- Transform data into frequency domain.
- Select frequencies via coherency (level of 0.8) and azimuth (±30° parallel to strike as well as perpendicular to strike)
- Calculate the electric transfer function (Impedance) and the magnetic transfer function (Tipper) at each station.
- Derive apparent resistivity and phase angle

For further processing and graphic preparation, Matlab scripts were used.

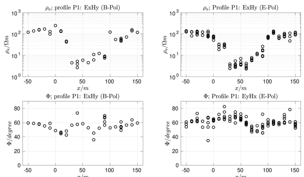


Fig 4: Aparent resistivity and phase angle for the frequency of 44 kHz of profile P1.

2D Inversion Results

To invert the RMT-data the algorithm RUND2INV_NLCG2_FAST (Rodi & Mackie, 2001) was used. For all 6 profiles, a starting model of 100 Ωm was chosen. The optimal regularization parameter λ (trade off between smoothness of the model and data fit) was found to be λ=40. The combined inversions (TE- & TM-mode) yield the most consistent results across all profiles.

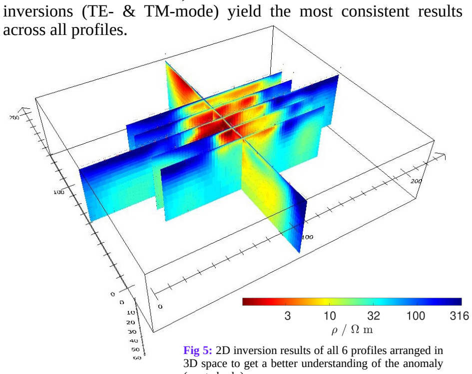


Fig 5: 2D inversion results of all 6 profiles arranged in 3D space to get a better understanding of the anomaly (waste body).

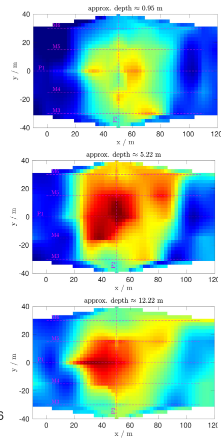
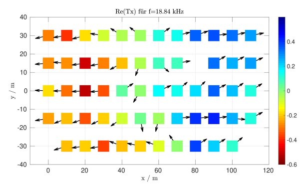


Fig 6: Interpolated map of all profiles combined. Shown are slices of the inversion results at different depths.



The recorded tipper data (magnetic transfer function) was also evaluated for specific frequencies. Shown in Fig 7 is tipper data of one frequency (18 kHz) for the whole mapping area.

Fig 7: Real part of the tipper data for one epecific frequency across the whole mapping area. The directions of the arrows are derived by the relation between tipper components Tx and Ty.

Data Fit

The fit of profile P1 shows a high level of correspondence between measured and calculated data. The highest deviations can be found in the region of the waste body.

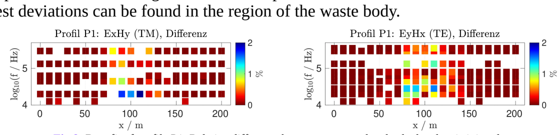


Fig 8: Data fit of profile P1: Relative difference between measured and calculated resistivity vlues.

Comparison

A goal of the survey was also to see how well applicable RMT-measurements are for such type of waste sites. For this, a comparison with other methods can give an overview:

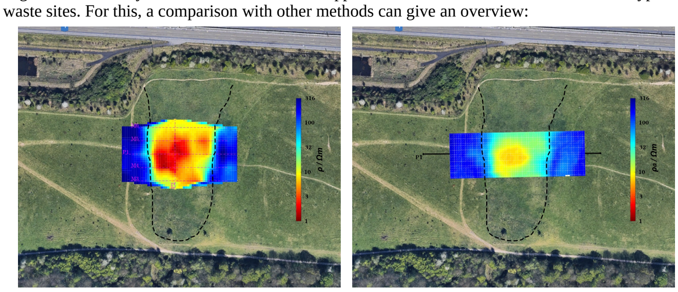


Fig 9: Map of the RMT inversion results (left) and the result of a CMD measurement (right). Both figures show the same section with the rough position of the waste body outlined with a dashed line. The results of both methods are shown for roughly the same depth (~ 2.2 m).

Conclusion

From the 2D inversion results, the waste body can be seen as a conductive anomaly. This anomaly is visible across all profiles and modes. Its upper boundary starts at a depth of 1 m. The lower edge of the anomaly, although not being very well resolved, seems to reach depths of up to 15 m. The combination of all profiles gives a good overview of the lateral extent. In width (east-west) the waste body spreads over 60 m to 65 m. In north-south direction, the waste body spreads even further than the investigated area. The comparison with the CMD-measurement (Fig 9) shows a high level of correspondence in lateral extent as well as in the occurring resistivities.