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Characterization of an urban landfill with the transient electromagnetic and spectral induced polarization methods to quantify raw materials and map leakages

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Circular economy requires reliable information about the content of old landfills regarding raw materials worth exploiting. Geophysical electrical methods are standard tools for such investigations; however, they require a galvanic contact between electrodes and the ground. Many landfills are covered by a shallow isolating layer consisting of an electrically resistive material (e.g., a PVC layer), which hinders current flow and significantly decreases the resolution and the signal-to-noise ratio (SNR). Low-induction electromagnetic methods have also been suggested for such investigations; yet these methods have a limited depth of investigation. To overcome these limitations, we investigate the applicability of the transient electromagnetic method to characterize an industrial landfill. The investigation is based on a TEM survey to define the positions of two deep boreholes The combination of borehole and geophysical data aims at identifying the composition and distribution of waste, a prerequisite to evaluate its potential content of raw materials. We conducted TEM measurements in a large industrial landfill (ca. 500 m long, 200 m wide and 20 m deep) sealed by an impermeable PVC layer. The objectives of the TEM survey are: 1) the delineation of the landfill geometry 2) locating possible changes in waste composition and 3) identifying damages in the isolating PVC layer which might result in leachate migration below the landfill. We obtain TEM data with the TEM-FAST 48 instrument in a 12.5 m square single-loop configuration at 81 sounding locations to cover the entire plateau of the landfill. We demonstrate that the TEM signatures are affected by induced polarization effects, which is likely related to the presence of molybdenum and other relevant raw materials. To evaluate this observation, we conducted complementary measurements with the spectral induced polarization method using a large electrode spacing to enhance the SNR. We validated the TEM results using two 40 m deep boreholes that reach from the top of the landfill into the confining clay-rich layer.