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Landfill characterization by multi-method geophysical investigation: the case study of Leppe (Germany)

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Whether environmental or economic interests are at stake, characterization of landfills is becoming a key operation. Characterization not only concerns old landfills, but also modern engineered landfills where the assessment and monitoring of internal processes such as leachate and biogas generation is of a primary importance. Nowadays, characterization is mostly carried out by conventional invasive methods based on drilling/trenching, sampling and laboratory analyses. Although they provide direct and analytical information, their spatial coverage, or representability, remains a major drawback. In addition, they can be expensive and increase the risk of damaging contamination barriers. Therefore, non- to minimally- invasive characterization geophysical techniques emerge as a complementary option. They allow to better capture the spatial heterogeneity across a site and are more cost-effective than punctual measurements alone. Furthermore, when compared with limited ground truth data, they may provide insights into waste composition, water content or temperature. The present study highlights the added value of a multiple geophysical approach to characterize a landfill located in Engelskirchen in Germany. Leppe landfill was used as a municipal solid waste (MSW) deposit site from 1982 until the end of 2004. Since then, only ash coming from the MSW incineration is discarded, mostly on top of the previous MSW deposit. The combination of geophysical methods used in this study included electrical resistivity tomography (ERT), induced polarization (IP), multichannel analysis of surface waves (MASW) and horizontal to vertical noise spectral ratio (HVSNR). The 3D ERT and IP model allowed to identify dry zones within the waste (which may have a direct impact on biogas production) and to roughly discriminate the layer of ash from the MSW layer. Seismic velocity model provided by MASW permitted to significantly improve the delineation between the two layers. HVNSR results combined with the information provided by MASW were used to estimate the thickness of the top layer on a larger area using a bilayer hypothesis. These geophysical characterization results were validated with available ground truth data. Overall, in the present case seismic methods showed to be more suited than geoelectrical techniques for the distinction between the ash and MSW layers.