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## Landfill investigation using geophysical methods for an improved characterization of the landfill geometry and for assessing microbiological activity

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The release of landfill gas is responsible for approximately 3 % of the global greenhouse gas emissions. Especially a high content of organic matter in municipal solid waste (MSW) in wet areas may enhance the microbial activity and the production of landfill gas and leachate as metabolic products. Accordingly, the delineation of saturated zones and biogeochemically active and inactive areas is critical for designing adequate stabilization systems to limit the environmental impact of landfills on greenhouse gas production. Therefore, landfill investigations with high spatial resolution are critical for environmental protection. Geophysical methods are a cost-efficient possibility to obtain almost continuous information about subsurface properties at various spatial scales, which can help to identify biogeochemical active zones. Within this case study we investigate the applicability of three geophysical methods, namely (i) the electrical resistivity tomography (ERT), (ii) the induced polarization (IP) method and (iii) the transient electromagnetic (TEM) method to characterize the landfill geometry and to discriminate between biogeochemically active and inactive areas. The investigated landfill is located close to Vienna (Austria) and consists of a mixture of MSW, construction and demolition waste (CDW) and excavated soil. We conducted ERT and IP measurements along 17 profiles distributed over the area of the landfill to provide high resolution images of the subsurface down to 8 m depth. Additionally, we used transient electromagnetic measurements along selected profiles to provide information on deeper structures of the landfill as well as to evaluate the electrical conductivity obtained with ERT. Our results show that the electrical conductivity obtained by both ERT and TEM is mainly sensitive to the increase in the fluid conductivity associated to leachate production and migration. Additionally, a decrease in electrical conductivity is associated to CDW and dry MSW and can help to distinguish between different waste types. However, images of the polarization effect obtained with the IP method, expressed in terms of the phase of the complex conductivity, revealed an improved contrast to characterize variations in the architecture and biogeochemical activity of the landfill. Hence, our study demonstrates that the geophysical methods we applied are well-suited for landfill investigations permitting an improved characterization of landfill geometry and variation in waste composition. In particular, the IP method can delineate between biogeochemically active and inactive zones.

