Resolving capabilities of 3D electrode configurations for spectral induced polarization surveys

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The induced polarization (IP) method is an extension of the electrical resistivity method that allows the measurement of both the electrical conductive and capacitive properties of the subsurface; it is one of the main methods applied in landfills to characterize the geometry and composition of waste as well as the migration of leachate. Commonly, landfill IP investigations are based on measurements along several 2D lines. Considering the complexity of landfills, we investigate here the resolving capabilities of 2D parallel electrode lines with inline measurements, and 3D electrode configurations (grid array with electrodes set in a quadratic mesh and circular array with electrodes set in four concentric circles) through a numerical study and field measurements. The field surveys were conducted on two landfills with different waste composition, with measurements in the frequency range between 1 and 240 Hz to solve the frequency-dependence of the electrical properties. The results of both the numerical study and the field data show a lack of sensitivity in the case of the 2D configuration leading to the creation of artefacts in the conductivity magnitude and phase imaging result. An underestimation of IP values is also seen for these arrays; such effects are particularly critical in the case of heterogeneously distributed IP anomalies, which are typical in landfills. In contrast, the tested 3D configurations are able to resolve the geometry of the electrical units correctly and anomalies are more sharply defined compared to the results obtained by 2D configurations. Furthermore, our results show that the grid array with crossline measurements and multiple dipole orientations provides better results than the circular array, which lacks in the resolution in the central area. Additional investigations of the frequency-dependence of the field data demonstrate that for the different study areas only 3D configurations provide smooth spectra of the conductivity magnitude and phase, which is essential for an accurate estimation of relaxation (e.g., Cole Cole) parameters.