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Characterization and monitoring of contaminated sites by multi-geophysical approach (IP, ERT and GPR).

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The contamination of soils and groundwater by hydrocarbons, due to blow out, leakage from tank or pipe and oil spill, is a heavy environmental problem because infiltrated oil can persist in the ground for a long time leading to important changes on soils and physical and biogeochemical properties, which impact on ecosystems and shallow aquifers. The existing methods used for the characterization of hydrocarbon contaminated sites are invasive, time consuming and expensive. Therefore, in the last years, there was a growing interest in the use of geophysical methods for environmental monitoring (Börner et al., 1993; Vanhala, 1997; Atekwana et al., 2000; Chambers et al., 2004; Song et al., 2005; French et al., 2009).
The goal of this work is to characterize underground contaminant distributions and monitoring a remediation activity using a multi-geophysical approach (cross-hole IP and ERT, GPR). The experiments consist in geophysical measurements both in surface and boreholes, to monitor a simulated hydrocarbon leachate into a $\sim$1 m3 box. The tank is filled with quartz-rich sand (k = 1.16 x 10-12 m2) and it is equipped with six boreholes and 72 stainless steel ring electrodes, at 5 cm spacing, for cross-hole electrical resistivity and time-domain IP measurements. 25 additional stainless steel electrodes were installed at the surface of the tank. Two measurement phases were realized: first, we monitored electrical resistivity, IP, and dielectric conductivity of the uncontaminated soil; the second experimental phase consists in the geophysical monitoring of a crude oil controlled spill.
Results showed significant changes in the responses of geoelectrical measurements in presence of a crude oil contamination. Instead IP results give a phase angle distribution related to the presence of hydrocarbon in the system but not so clear in the location of plume. Therefore, to clearly delineate the areas interested by contamination, we estimate the imaginary component of electrical resistivity.
Finally, the electrical behaviour of the medium from GPR data, compared to geoelectrical measurements, was investigated by the analysis of the strength of EM-reflections and absorption of EM signal. In particular, the most contaminated areas are characterized by a variation of soil permittivity dielectric value. Furthermore, the frequency analysis show a significant downshift of the frequency in correspondence of contaminated areas.
In conclusion, the experiment was able to obtain information about contaminant distribution in the subsurface. Besides combining measurements from multiple geophysical measurements allow us to obtain more accurate characterization of contamination spatial variability. Finally, the estimation of geophysical parameters in frequency domain gave a supplementary information to increase quality of acquired data.