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Combining ground penetrating radar and electromagnetic induction for industrial site characterization

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Industrial sites pose specific challenges to the conventional way of characterizing soil and groundwater properties through borehole drilling and well monitoring. The subsurface of old industrial sites typically exhibits a large heterogeneity resulting from various anthropogenic interventions, such as the dumping of construction and demolition debris and industrial waste. Also larger buried structures such as foundations, utility infrastructure and underground storage tanks are frequently present. Spills and leaks from industrial activities and leaching of buried waste may have caused additional soil and groundwater contamination. Trying to characterize such a spatially heterogeneous medium with a limited number of localized observations is often problematic. The deployment of mobile proximal soil sensors may be a useful tool to fill up the gaps in between the conventional observations, as these enable measuring soil properties in a non-destructive way. However, because the output of most soil sensors is affected by more than one soil property, the application of only one sensor is generally insufficient to discriminate between all contributing factors. To test a multi-sensor approach, we selected a study area which was part of a former manufactured gas plant site located in one of the seaport areas of Belgium. It has a surface area of 3400 m^2 and was the location of a phosphate production unit that was demolished at the end of the 1980s. Considering the long and complex history of the site we expected to find a typical "industrial" soil. Furthermore, the studied area was located between buildings of the present industry, entailing additional practical challenges such as the presence of active utilities and aboveground obstacles. The area was surveyed using two proximal soil sensors based on two different geophysical methods: ground penetrating radar (GPR), to image contrasts in dielectric permittivity, and electromagnetic induction (EMI), to measure the apparent soil electrical conductivity (ECa) and magnetic susceptibility (MSa). For both methods one of the latest-generation instruments was used. GPR data were collected using a 3d-Radar stepped-frequency system with multi-channel antenna design. For EMI, this was the multi-receiver DUALEM-21S sensor. This sensor contains four different transmitter-receiver coil pair configurations, which allows to record the ECa and MSa for four different soil volumes at the same time, thereby providing information about the vertical variation of these soil properties. Both the EMI and GPR survey were performed in a mobile set-up with real-time georeferencing to obtain a high-resolution coverage of the area. The results of both surveys were validated with conventional site characterization that was conducted for a soil contamination investigation, and ancillary information such as aerial photographs and utility maps. Both methods were compared on their performance in detecting different types of anomalies. We report on the successes and failures with this multi-sensor approach.

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