Detailed Geological Modelling of a Contaminated Urban Area Based on Geophysical Mapping: A Case Study from Horsens, Denmark

Theis Raaschou Andersen (Thra@via.dk) and Søren Erbs Poulsen
(VIA University College, Horsens, Denmark)

Background/Objectives. In 2050, two-thirds of the world's population will live in urban areas. As cities expand, former industrial urban areas (brownfields) are being urbanized due to the social and economic opportunities for land redevelopment. However, there is also an increased focus on remediation as contamination from the brownfields threatens groundwater, surface water and public health. Insufficient knowledge about the geological and hydrological setting hampers remediation efforts and introduces significant uncertainties in projections on the fate of contaminants. The aim of this study is to evaluate the use of borehole data in conjunction with multiple high-density geophysical mapping techniques and GIS information about anthropogenic structures in constructing a high-resolution geological voxel model. The geological model will serve as basis for simulating the contamination transport. Based on the work, we were able to pinpoint the best strategies and solutions for future remediation efforts at the Gaswork site in Horsens.

Approach/Activities. In order to carry out a detailed geological characterization at the brownfield, high-density geophysical profiling was conducted. This includes 10 profiles of direct current (DC) resistivity and time domain induced polarization (TDIP), 5500 m of multi-configuration ground conductivity meter (DualEM-421), two ground penetrating radar profiles and 56 boreholes comprising lithological information and water samples. Based on the borehole information, the high-density geophysical data and GIS data (sewer systems, water pipes, electricity and telephone cable trenches as well as houses with basements) a detailed 3-D geological model of the site was constructed.

Results/Lessons Learned. The project results show that combining different geophysical methods is advantageous when characterizing a shallow contaminant plume in an urban complex geological setting. DualEM-421 and DC/TDIP profiling are suitable for the geological mapping when the interpretation is constrained by borehole information. However, the DualEM-421 and DC methods are not capable of distinguishing between the electrical properties of the matrix and the porewater, respectively, as resistivity variations can be explained by changes in both lithology and contamination levels. When combined with borehole information, water sampling and GPR profiling, it is possible to separate the resistivity effects from the lithology and contamination, respectively. It is possible to estimate the spatial extent of the contaminant plume by the mapping strategy outlined in this study. The detailed subsurface characterization serves as an improved basis for parameterizing solute transport models of the contaminant plume. Moreover, the estimated spatial extent of the contaminant plume constrains the concentrations calculated with such models. The study outlines how detailed geological knowledge, derived from a joint interpretation of various geophysical methods, boreholes, water samples and GIS data can increase the likelihood for a successful redevelopment in contaminated urban areas.