A geophysical approach for mapping and quantifying near-surface freshwater-saltwater transitions

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ABSTRACT

Geophysical prospecting of the freshwater-saltwater transition has been carried out successfully since the 1950s by mapping the spatial distribution of the specific electrical resistivity of the underground. Zones of saline or brackish groundwater could be reliably detected onshore by geoelectric depth sounding because the bulk electric resistivity of sediments is essentially determined by the electric resistivity of the pore fluid, which depends on ion concentration or salt content.

Geoelectric sounding and electrical resistivity tomography (ERT) are reliable tools for identifying zones of saltwater intrusion or groundwater discharge in a qualitative sense. In order to assess the layer resistivity in more quantitative way stratigraphic information on layer thicknesses have to be considered as additional constraints in the tomographic computations. These stratigraphic constraints can be determined by both drilling and geophysical measurements with other than geoelectrical methods. We are presenting a number of examples where additional seismic and ground-penetrating radar (GPR) measurements and stratigraphy derived from drillholes contributed to significantly improving the ERT results. Also, resistivity mapping by the electromagnetic induction (EMI) method was integrated for better areal coverage. The methodical improvement concerned basically the reliability of the determination of layer resistivity that could be converted into an estimate of pore water salinity. The results were validated by values of electric resistivity of pore water probes obtained from shallow drillholes.

Field examples from three different sites are shown demonstrating how the combination of geophysical prospecting and drilling can improve the investigation of freshwater-saltwater transition in shore areas: (1) An example of freshwater discharge that has led to a freshwater lagoon near the village of Laboe (Germany) on the Baltic Sea; the site was investigated with drillings and an amphibic geoelectric survey covering both on- and offshore profiles; (2) an example of saltwater intrusion near the village of Araxos (NW Peloponnes, Greece) where ERT, seismic and GPR were applied in order to obtain reliable quantitative results on stratigraphy and pore water salinity; (3) the shore area of a freshwater lake near Stymphalia (NW Peloponnes, Greece) where a combination of ERT, EMI and drilling was applied in order to explore the underground pore water distribution.