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Assessing the potential for lake bank filtration: mapping shallow aquifers and groundwater flow in a lake with combined offshore geophysical and tracer methods

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Water extraction from bank-filtration wells bordering rivers and lakes is common practice in water management as surface water bodies provide a continuous supply of water, while the seepage of water through the sediment-water interface provides a physical, chemical and biological filtering of the extracted water. Hence, bank filtration offers a potential for also reducing contaminant concentrations.

Tissø is the fourth largest lake in Denmark with a surface area of 12.3 km^2 and a water volume of approx. 100 million m^3, which is continuously replenished by Halleby stream flowing to the lake in the north with an average annual discharge of 2.4 m^3/s. Due to the increasing demand for water resources, the local waterworks, Kalundborg Forsyning, aims to raise the present extraction of 5 million m^3/year surface water from Tissø by an additional 5-10 million m^3/year. To reduce water treatment costs, bank filtration could potentially be an additional optimal water extraction method around the lake provided that there are shallow aquifers in the area with good hydraulic connection to the lake. The aim of this study is therefore (i) to map the aquifer sediments under the lakebed and on land to locate shallow aquifers and their outcrops in the lake and (ii) to study whether groundwater discharges from these aquifers to the lake indicating good hydraulic connection.

A 5 km shoreline at the northern part of the lake was surveyed with offshore geophysical methods to locate shallow aquifers, which could be used for water extraction. Electrical Resistivity Tomography (ERT) with floating electrodes was used to map shallow underwater aquifer sediments along the shoreline, while offshore sediment properties in 200 m long transects perpendicular to the shoreline were surveyed both by ERT and a Ground Penetrating Radar (GPR). Groundwater seepage was studied with thermal and chemical tracers in an area selected based on the geophysical surveys. Samples for water stable isotopes and electrical conductivity were taken from several boreholes on land and offshore, while groundwater discharge fluxes to the lake were quantified by using temperature as a tracer.

The ERT survey along the lake shoreline located several potential disconnected aquifers extending up to 15 m depth. At the selected field site, both the ERT and GPR surveys detected a potential aquifer outcrop approximately 100 m offshore. The chemical tracers reveal a substantial concentration difference between the groundwater and surface water indicating that they are potential tracers for monitoring the water extraction. Groundwater fluxes estimated using vertical sediment temperature profiles show groundwater discharge to the lake with fluxes up to 0.06 m/d.