



## **Thermal utilization of shallow groundwater in Japan – current status and future tasks**

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In the past, extensive use of groundwater resources caused land subsidence in Japan and the heat utilization of groundwater in large, energy-hungry cities was virtually impossible. Further, fast groundwater velocities as well as clogging during water injection rendered the application of open-loop systems difficult over the last 40 years. Nevertheless, in a recent project in the city of Osaka, Japan, an open-loop heating and cooling system for a 10-story building was tested successfully over a period of two years. An analytical tool was developed in order to predict the subsidence of the weak, alluvial ground for a groundwater pumping rate of about 1.5m<sup>3</sup>/min, and the settlement of the clay layer was monitored. It was found that subsidence hardly occurred when close to 100% of the pumped-out groundwater was re-injected.

This approach could also be used in other major cities with alluvial aquifers that restrict groundwater pumping to avoid land subsidence, e.g.: Tokyo and Nagoya in Japan. However, the groundwater flow is not infinite. For heat utilization on a regional scale it is therefore also necessary to assess the appropriate groundwater usage on a catchment scale. The compilation of the required groundwater data started in 2018 in Japan. In addition, the development of new investigation and utilization technologies is important: from methods for in-situ aquifer permeability characterization, over borehole stabilization and sealing with high viscosity fluids and bentonite pellets, to three-dimensional numerical analysis for the prediction of land subsidence as well as for the heat transport.