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Temperature impact of open-loop systems on groundwater in an urban area: A case study of Murska Sobota, NE Slovenia

Simona Adrinek[1], Mitja Janža[1], and Mihael Brenčič[1,2]
[1]Geological survey of Slovenia, Department for Groundwater - Hydrogeology, Ljubljana, Slovenia (simona.adrinek@geo-zs.si)
[2]University of Ljubljana, Faculty of Natural Science and Engineering, Ljubljana, Slovenia

To achieve sustainable and efficient use of shallow geothermal resources, it is important to understand the heat transfer in the subsurface of the planned geothermal system. In the City Municipality of Murska Sobota, NE Slovenia, the use of geothermal open-loop systems has increased in recent years. Their high spatial density raises the question of potential mutual interference between the systems. By compiling geological, hydrogeological, and thermal data, obtained from the monitoring network, fieldwork, and knowledge of regional hydrogeological conditions, we have developed a transient groundwater flow and heat transfer model to evaluate the impact of the open-loop systems on the subsurface and surrounding systems. Time series data cover time span ranging from December 2019 to the end of December 2021. The sensitivity analysis showed the highest composite sensitivity values for hydraulic conductivity, porosity and dispersivity parameters, which were further calibrated with FePEST to minimize the error between groundwater level and temperature. The results of the groundwater flow model correspond well with the measured average groundwater levels. On the other hand, the thermal model shows higher deviations from the measured data, especially in the summer months when the simulated groundwater temperatures do not exceed 14.3 °C, while the measured temperatures reached even 15.4 °C. These deviations could be related to the effects of local thermal sources on the surface (e.g., sewage pipes, plumbing, buildings with more than one basement and roads), which were not considered in our model. The transient simulation showed that the thermal state in the observed area is restored over the summer, when the systems are not in operation. Also, the systems do not have significant mutual interference that would affect their efficiency. However, as interest in installing new systems in the area increases, simulations of the thermal plumes of new geothermal systems are needed to ensure sustainable and efficient use of shallow geothermal energy in the future.