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An open-loop ground-water heat pump system: transient numerical modeling and site experimental results

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The increasing diffusion of low-enthalpy geothermal open-loop Groundwater Heat Pumps (GWHP) providing buildings air conditioning requires a careful assessment of the overall effects on groundwater system, especially in the urban areas where several plants can be close together and interfere.
One of the fundamental aspects in the realization of an open loop low-enthalpy geothermal system is therefore the capacity to forecast the effects of thermal alteration produced in the ground, induced by the geothermal system itself. The impact on the groundwater temperature in the surrounding area of the re-injection well (Thermal Affected Zone - TAZ) is directly linked to the aquifer properties. The transient dynamic of groundwater discharge and temperature variations should be also considered to assess the subsurface environmental effects of the plant.
The experimental groundwater heat pump system used in this study is installed at the "Politecnico di Torino" (NW Italy, Piedmont Region). This plant provides summer cooling needs for the university buildings.
This system is composed by a pumping well, a downgradient injection well and a control piezometer. The system is constantly monitored by multiparameter probes measuring the dynamic of groundwater temperature.
A finite element subsurface flow and transport simulator (FEFLOW) was used to investigate the thermal aquifer alteration. Simulations were continuously performed during May-October 2010 (cooling period). The numerical simulation of the heat transport in the aquifer was solved with transient conditions. The simulation was performed by considering only the heat transfer within the saturated aquifer, without any heat dispersion above or below the saturated zone due to the lack of detailed information regarding the unsaturated zone.
Model results were compared with experimental temperature data derived from groundwater monitoring in the surrounding area of the injection well. Such analysis showed that the measured values differ slightly from the simulated values. That small difference is probably due to the simplification assumptions in the modelling. This hypothesis is still under investigation.