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High Temperature Aquifer Storage

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Combined heat and power generation (CHP) is highly efficient because excess heat is used for heating and/or process energy. However, the demand of heat energy varies considerably throughout the year while the demand for electrical energy is rather constant. It seems economically and ecologically highly beneficial for municipalities and large power consumers such as manufacturing plants to store excess heat in groundwater aquifers and to recuperate this energy at times of higher demand. Within the project High Temperature Aquifer Storage, scientists investigate storage and recuperation of excess heat energy into the bavarian Malm aquifer. Apart from high transmissivity and favorable pressure gradients, the hydrochemical conditions are crucial for long-term operation. An enormous technical challenge is the disruption of the carbonate equilibrium - modeling results indicated a carbonate precipitation of 10 - 50 kg/d in the heat exchangers. The test included five injection pulses of hot water (60 °C up to 110 °C) and four tracer pulses, each consisting of a reactive and a conservative fluorescent dye, into a depth of about 300 m b.s.l. resp. 470 m b.s.l. Injection and production rates were 15 L/s. To achieve the desired water temperatures, about 4 TJ of heat energy were necessary. Electrical conductivity, pH and temperature were recorded at a bypass where also samples were taken. A laboratory container at the drilling site was equipped for analysing the concentration of the dyes and the major cations at sampling intervals of down to 15 minutes. Additional water samples were taken and analysed in the laboratory. The disassembled heat exchanger prooved that precipitation was successfully prevented by adding CO_2 to the water before heating. Nevertheless, hydrochemical data proved both, dissolution and precipitation processes in the aquifer. This was also suggested by the hydrochemical modelling with PhreeqC and is traced back to mixture dissolution and changing temperatures. Optimising the addition of CO_2 might help to reduce hydrochemical processes in the aquifer. As a side effect of the extremely good hydraulic conditions, the research well was flowing freely with up to 19.4 L/s which resulted in a significant mixing of the injected water with formation waters during production. Due to the hydrochemical contrast of the sodium concentration, quantification of inflowing reservoir water was possible. Therefore, prognosis of the temperature development during the operation with flow rates of up to 60 L/s can be stated. Energy recovery consituted at the end of the heat storage test almost 50 % - without considering the influx of the cold reservoir water. Recovery rates of the fluorescent dyes are linked to their different sorption behaviour and variied between 23 % up to 79 %. The tracers are an additional tool for interpreting the groundwater flows and matrix interaction in the aquifer.