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Effects of temperature changes on groundwater ecosystems

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The use of groundwater as a carrier of thermal energy is becoming more and more important as a sustainable source of heating and cooling. At the same time, the present understanding of the effects of aquifer thermal usage on geochemical and biological aquifer ecosystem functions is extremely limited. Recently we started to assess the effects of temperature changes in groundwater on the ecological integrity of aquifers. In a field study, we have monitored hydrogeochemical, microbial, and faunal parameters in groundwater of an oligotrophic aquifer in the vicinity of an active thermal discharge facility. The observed seasonal variability of abiotic and biotic parameters between wells was considerable. Yet, due to the energy-limited conditions no significant temperature impacts on bacterial or faunal abundances and on bacterial productivity were observed. In contrast, the diversity of aquifer bacterial communities and invertebrate fauna was either positively or negatively affected by temperature, respectively. In follow-up laboratory experiments temperature effects were systematically evaluated with respect to energy limitation (e.g. establishment of unlimited growth conditions), geochemistry (e.g. dynamics of DOC and nutrients), microbiology (e.g. survival of pathogens), and fauna (temperature preference and tolerance). First, with increased nutrient and organic carbon concentrations even small temperature changes revealed microbiological dynamics. Second, considerable amounts of adsorbed DOC were mobilized from sediments of different origin with an increase in temperatures. No evidence was obtained for growth of pathogenic bacteria and extended survival of viruses at elevated temperatures. Invertebrates clearly preferred natural thermal conditions (10-12°C), where their highest frequency of appearance was measured in a temperature gradient. Short-term incubations (48h) of invertebrates in temperature dose-response tests resulted in LT50 (lethal temperature) values between 17 and 23°C for selected groundwater amphipodes and 18°C for the isopode Proasellus cavaticus. Extended incubation times dramatically reduced the respective LT50 values way below 20°C for amphipodes and 16°C for the isopode, respectively. Our findings clearly point at an urgent need for further ecological studies with respect to the ecological consequences of geothermal energy use. To avoid the deterioration of groundwater quality and important ecosystem services we propose the development of integrative management concepts for subterranean energy use in the future.