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Does shallow geothermal energy use threaten groundwater ecosystem functions?

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Today, the use of geothermal energy is strongly promoted as an alternative and sustainable source of energy. However, regarding the authorization, regulation and monitoring of such facilities with respect to possible environmental impacts, a severe lack of knowledge has been identified. Aquifers are not only abiotic reservoirs of water and sediment, but they are complex ecosystems harbouring an almost untapped diversity of microorganisms and fauna. Intrinsic groundwater organisms are highly adapted to extremely oligotrophic, but stable conditions including temperature. At the same time, groundwater biota are the key drivers of important ecosystem services, especially functions connected to water quality.

So what happens if groundwater biota need to cope with sudden temperature dynamics caused by GSHP use? Potential effects of thermal use on pristine aquifers, and on groundwater systems already facing enhanced loads of nutrients or contamination require urgent scientific attention.

Within this project, we have assessed - both in the field and in the laboratory – the impacts of temperature discharge and withdrawal on biotic parameters and functional characteristics of exemplary shallow groundwater systems. In the field, aquifer microbes did not show significant impacts under increased temperatures in terms of total cell numbers, selected enzyme activities and carbon production. However, bacterial diversity clearly increased with temperature, accompanied by the appearance of new bacterial lineages and the disappearance of others. On the contrary, faunal diversity decreased with temperature, highlighting the temperature sensitivity of groundwater invertebrates. These results demonstrate that aquifer thermal energy discharge can affect intrinsic aquifer biotic populations, while at the same time being only one of several drivers contributing to total variability connected to seasonal dynamics and spatial heterogeneity.

In laboratory column experiments covering a larger temperature range from 4°C to 45°C, sediment microbial community composition and activities clearly reacted to temperatures exhibiting shifts in microbial diversity and decreases in activities at both ends of the temperature ladder.

Moreover, temperature impacts can be expected to be much more pronounced in aquifers receiving additional inputs of organic carbon and nutrients, which is typical for urban and agricultural areas. We present the results of an extensive column experiment evaluating the temperature impact on aquifer sediments facing background contamination with hydrocarbons, pathogens or additional loads of organic carbon and nutrients.