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Multiple-tool approach of combining microbial markers with artificial and natural tracers to specify the origin of fecal contamination in a karst groundwater catchment

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Diverse tools do exist to study the pathway from the source of a contamination to groundwater and related springs. The backward approach, i.e. sampling spring water to determine the origin of contamination, is more complex and requires multiple information. Microbial source tracking using host-specific markers is one of the tools, which however has shown to be insufficient as a stand-alone method, particularly in karst groundwater catchments.

A karst spring in the Swiss Jura Mountains was studied with respect to the occurrence and correlation of a set of fecal indicators, including classical parameters as well as a number of bacteroidale markers. Sporadic monitoring proved the impact on spring water quality, mainly during high water stages. Additional event-focused sampling over varying recharge intensities evidenced a more detailed and divergent pattern of individual indicators. In particular, the results arose the question how to interpret peaks of human fecal markers in the rural-dominated catchment.

A multiple-tool approach, complementing fecal indicator monitoring with artificial tracer experiments and natural tracers measurements, assessed the input, storage and transfer of potential contaminants in order to specify the origin of both ruminant and human fecal contaminations. Natural tracers allowed for distinguishing between water components from the saturated zone, from the soil/epikarst storage, or from freshly infiltrated rainwater. Furthermore, the breakthrough of injected dye tracers, and their remobilization during subsequent recharge events, respectively, were correlated to the occurrence of fecal markers. System's residence time distribution over discharge, deduced from numerous former dye tracing tests, also allowed for attributing maximum travel distances to their arrival.

The findings of the approach hypothesize the origin of human fecal contamination at the spring being in relationship with septic tanks undergoing concentrated overflow already at moderate rainfall intensities. Those intensities are, however, not sufficient to transport diffuse ruminant contamination through the vadose zone. Linkage with vulnerability assessment and land-use information can finally better locate the potential source points. Such toolbox provides not only useful basics for groundwater protection and catchment management, but also insight into general processes governing fate and transport of fecal contaminants in a karst groundwater

environment.