Model-based assessment of dynamic volume estimates for karst aquifers

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Objective and approach

- Adequate management of karst water resources requires information about the drainable water volume (dynamic volume).
- The mathematical integration of the recession curve yields an estimate of the dynamic volume.
- This approach assumes that the observed recession can be extrapolated to longer times and lower discharge values.
- The numerical flow model MODFLOW-CFP is used to examine the adequacy of the approach using simplified settings.
- By comparing the actual dynamic volume to the volume estimate, we identify factors affecting the volume estimate.
- For more details see: Abirifard et al., J. Hydrol., 2022, https://doi.org/10.1016/j.jhydrol.2022.128286

Warm-up phase with cyclic recharge preceding the recession period.

Basic scenario with a highly conductive zone, respresenting a karst conduit draining the aquifer.

Underestimation of the dynamic volume

Hydraulic conductivity decreases with depth

At the late stage of the recession, the extrapolated discharge is lower than actual discharge, causing underestimation of the dynamic volume.

Overestimation of the dynamic volume

Recharge has not ceased at the start of the recession period

At the late stage of the recession, the extrapolated discharge is higher than actual discharge, causing overestimation of the dynamic volume.

Groundwater abstraction by pumping wells

Field example: Gallusquelle (SW Germany)

The recession slows down when the water table falls below a certain threshold, presumbly because of the lower hydraulic conductivity of the less karstified rock at greater depth.

Overview of factors affecting the volume estimation

Parameter	Under-Estimation	Good Estimation	Over-Estimation
Point recharge		✓	
Geometry of the catchment area (L/W ratio)		✓	
High critical Reynolds number and hydraulic conductivity in the conduit	✓		
Highly conductive zone (conduit) only near the spring	✓		
Change in (increase and decrease) matrix hydraulic conductivity with depth of the aquifer	✓		
Increase in matrix hydraulic conductivity along the aquifer toward spring	✓		
Increase in catchment area or specific yield with depth of the aquifer	✓		
Ongoing recharge			✓
Decrease in catchment area or specific yield with depth of the aquifer			✓
Decrease of matrix hydraulic conductivity along the aquifer toward spring			✓
Groundwater abstraction			✓