Tracing water from river to aquifer

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The coarse gravel bed of the Emme River in Switzerland is a major control in how much and how fast river water enters the aquifer below. A new study in the watershed evaluated how water on the surface mixes and moves underground. Credit: Andrea L. Popp

A new technique using dissolved noble gas tracers sheds light on how water moves through an aquifer, with implications for water resources and their vulnerability to climate change.

The Food and Agriculture Organization, an agency of the United Nations, has referred to mountains as the "water towers of the world." Globally, mountainous regions supply freshwater to billions of people through snowmelt and glaciers. Yet the 21st century is poised to strain these water resources. Climate models project changes to the timing and amount of precipitation, altered snow cover dynamics, and melting glaciers. These changes, in addition to other strains including increasing population pressure and contamination from past and present industry and agriculture, will affect the flow of rivers, water quality, and groundwater storage.

These pressures will require careful water management and possibly even redesigns of drinking water systems. In a new paper, Popp et al. describe a novel framework that uses dissolved noble gases to trace how river water mixes with groundwater and how quickly groundwater moves through an aquifer.

The case study took place in the Emme River catchment in the Swiss Alps, a snowmelt-fed system with a coarse gravel and sand riverbed overlying an aquifer. The authors used helium-4 isotopes to determine how river water and regional groundwater mix underground. They used radon-222 isotopes to infer travel times of recently infiltrated river water through the aquifer. The results helped the authors to estimate very young groundwater travel times, which is crucial for assessing water safety.

The study found that nearly 70% of groundwater in the watershed originates from recently infiltrated river water. The river water takes around 2 weeks to move through the aquifer, and the riverbed primarily governs infiltration. The high fraction of infiltrated groundwater and its short travel time through the aquifer suggest that it is vulnerable to increasing contamination and drought.

The novel method provides results in near-real time and allows uncertainties to be quantified by using a statistical approach: a Bayesian mixing model. The case study in the Swiss Alps demonstrates the viability and added value of the proposed framework. The authors suggest that when applied to different watersheds, the approach can highlight risks and vulnerabilities facing mountain-fed water supplies and improve water security worldwide.

More information: Andrea L. Popp et al. A Framework for Untangling Transient Groundwater Mixing and Travel Times, *Water Resources Research* (2021). DOI: 10.1029/2020WR028362

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