Geophysical Research Abstracts
Vol. 19, EGU2017-13730, 2017
EGU General Assembly 2017

Quantifying shallow and deep groundwater inputs to rivers with groundwater dating in hydrological observatories.

Luc Aquilina (1), Jean Marçais (1), Alexandre Gauvain (1), Tamara Kolbe (1), Jean-Raynald de Dreuzy (1), Thierry Labasque (1), Benjamin W. Abbott (2), Virginie Vergnaud (1), Eliot Chatton (1), Zahra Thomas (3), Laurent Ruiz (3), Olivier Bour (1), and Gilles Pinay (2)

(1) University Rennes1 - CNRS, OSUR-Géosciences Rennes, Rennes, France (luc.aquilina@univ-rennes1.fr), (2) University Rennes1 - CNRS, OSUR-Ecobio, Rennes France, (3) S.A.S., AGROCAMPUS OUEST - INRA, Rennes France

River water derives in part from groundwater—water that has spent some time in the subsurface (e.g. soil, unsaturated zone, saturated zone). However, because groundwater residence times vary from months to millennia, determining the proportion of shallow and deep groundwater contribution can be challenging. Groundwater dating with anthropogenic gases and natural geochemical tracers can decipher the origin of groundwater contribution to rivers, particularly when repeat samplings are carried out in different hydrological conditions. Here, we present two different applications of this approach from three hydrological observatories (H+ hydrogeological network; Aghrys and Armorique observatories) in western France, all these observatories belonging to the OZCAR national network.

We carried out a regional investigation of mean groundwater ages in hard rock aquifers in Brittany, using long-term chronicles from hydrological observatories and regional monitoring sites. We determined the mean residence-time (RT) and annual renewal rate (RR) of four compartments of these aquifers: the direct contribution of a very young water component (i.e. RT less than 1-2 yr), the upper variably saturated zone (RR 27-33%), the weathered layer (RR 1.8-2.1%) and the fractured zone (RR 0.1%). From these values and a nitrate chronicle, we were able to determine the respective contributions of each compartment to the largest river in Brittany, the Vilaine, which drains 30% of the region. We found that the deep fractured compartment with very slow renewal times contributed to 25-45% of river water in winter and 30-60% in summer. The very young water which includes direct precipitation and soil fluxes constituted 40-65% of the winter river water (Aquilina et al., 2012).

To complement these estimates, we investigated the relationship between dissolved silica and groundwater age in the Armorique hydrological observatory in northern Brittany. We computed the silica concentration expected along the river from the groundwater age deduced from a deterministic model of the aquifer (Kolbe et al., 2016). The relationship between silica concentration determined with anthropogenic gases and observed silica concentration was strong ($R2= 0.54-0.92$), indicating that silica was a reliable geochemical chronometer, though it systematically underestimated anthropogenic gas age estimates. The difference could be accounted for by the very young water contribution : approximately 20 - 40% of overall discharge.

Both approaches indicated that very young water is particularly important during winter and that deep groundwater contributes at least a third of the river discharge throughout the year. This last result has implications for river nitrate dynamics and understanding the potential limits of catchment management interventions which only reduce nitrate dynamics in shallow groundwater on decadal timescales.

Aquilina L. et al., 2012 - Nitrate dynamics in agricultural catchments deduced from groundwater dating and long-term nitrate monitoring in surface- and groundwaters. Sci of the total Environment 435, 167-178.

Kolbe et al., 2016 - Coupling 3D groundwater modeling with CFC-based age dating to classify local groundwater circulation in an unconfined crystalline aquifer. J. of Hydrology DOI: 10.1016/j.jhydrol.2016.05.020