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Groundwater inputs towards surface water: quantification and impact on the river water quality using chemical and isotope fingerprints ($^{87}\text{Sr}/^{86}\text{Sr}$), example of the Loire River (France)

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Within the Critical Zone, the river water quality plays a key role for the related ecosystems. The impact of contaminants delivered to surface water from groundwater inputs are often neglected, while they can constitute the major loads of nutrients or pesticides in some specific river sections. In this study, we focus on a limited section of the Loire River in France, downstream Orleans city, where the increase of the river discharge cannot be attributed to the confluence of the small tributaries. Indeed, previous studies have pointed out the role of the groundwater discharge from the large Beauce aquifer located to the north of the river, mainly focusing on the quantitative aspects.

Based here on geochemical and isotopic tracers, we first confirm groundwater inputs to the Loire River and we clearly attributed those inputs to the Beauce carbonate aquifer using the relationship between $^{87}\text{Sr}/^{86}\text{Sr}$ and the Cl/Sr ratios. Secondly, the conservative tracers (Sr isotopes and Cl concentrations) allow assessing the groundwater contribution to the river to around 20% of the total discharge during low flow periods. This proportion is in full agreement with the previous studies based on heat budget method, where the river temperature is estimated with satellite thermal infrared images. Lalot et al. (2015) showed that the main groundwater discharge is concentrated along a 9 km transect just downstream of Orléans city with a discharge of 5.3 and 13.5 $\text{m}^3 \cdot \text{s}^{-1}$ during summer and winter times, respectively. This is roughly in agreement with the calculations based on groundwater modelling (calculated groundwater discharge: 0.6 to 0.9 $\text{m}^3 \cdot \text{s}^{-1} \cdot \text{km}^{-1}$). Finally, we pointed out the quality impact of these groundwaters especially regarding nitrates. Groundwater impacts on surface water quality have recently been considered as a potential vector of surface water contamination but they are still weakly studied and quantified. Here, we show pics of nitrates concentrations that rapidly decrease in the Loire River (especially in low flow period) after the groundwaters inputs enriched in NO_3 coming from the highly anthropized Beauce aquifer because of intensive agriculture practices. The nitrate decrease in the river is probably due to a nitrate removal processes (plant/microbial uptake?). The impact of these inputs into the Loire but also into the small tributaries of the Loire River should be further investigated, especially regarding pesticides loads and fates, and their potential impact on the related ecosystems.

Lalot, E., Curie, F., Wawrzyniak, V., Baratelli, F., Schomburgk, S., Flipo, N., Piegay, H., Moatar, F., 2015. Quantification of the contribution of the Beauce groundwater aquifer to the discharge of the Loire River using thermal infrared satellite imaging. *Hydrol. Earth Syst. Sci.* 19, 4479–4492.