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Surface water – groundwater interactions in alluvial contexts: constraints using single and multi-isotope tracers

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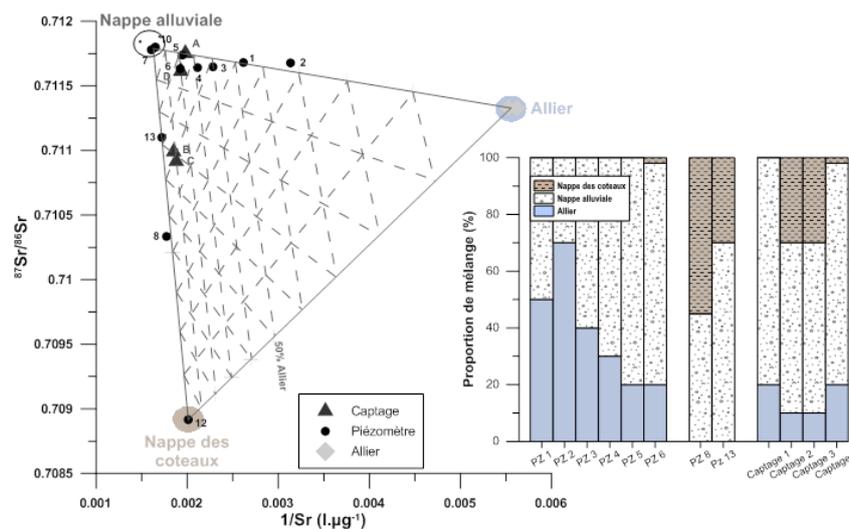
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Surface water and groundwater have been considered as separate water bodies for a long time by hydrologists and also decision makers, so that the relevance of interconnections between groundwater and surface water has frequently been underestimated. Since the last decades, rivers and aquifers are no more considered as physically independent entities, and are now approached as integral components of an aquifer-river-continuum with strong mutual influences between river, aquifer and the interconnecting hyporheic zone. Numerous research approaches were developed to identify and quantify the river-aquifer exchanges that can be in both directions depending on the river profile and the seasonal water levels and hydraulic gradients. The understanding of the links between hydrological, biogeochemical, and ecological process dynamics in hyporheic zones and their implications for river water quality and ecology are also of major concern for water management and decision makers.



Among the existing investing methods of surface water and groundwater relations, isotope techniques constitute a powerful approach; stable isotopes $\delta^{18}\text{O}$ and $\delta^2\text{H}$ being the most commonly used intrinsic “ideal” tracers of the water molecule.

Figure 1: Strontium isotopes to evidence and quantify mixings from various origins (Allier, France)

Furthermore, isotopes of dissolved elements (Sr, B, S, ...) also constitute valuable tracers to identify and, in optimal conditions, to quantify the exchanges between surface- and ground-water bodies. Through various examples we present the contribution of isotopic tracers to our understanding of groundwater recharge in alluvial valley-fillings, riverbank aquifers counting worldwide among the most important water resources for drinking water supply, irrigation and industrial activities. Sr isotopes are excellent tracers of water-rock interactions as $^{87}\text{Sr}/^{86}\text{Sr}$ reflect the signature of the minerals that constitute the drained aquifer lithologies. Boron isotopes also differ according to the drained lithologies, but, contrarily to strontium, signatures can be affected by secondary processes like adsorption/desorption onto clays; in an urban context, they are good tracers of wastewaters whose signature are characteristic of the boron origin used in detergents. Sulphur and oxygen isotopes of sulphates are also potential tracers of drained lithologies (solid sulphates in evaporites, sulphides in igneous and sedimentary rocks) in cases where fertilizers do not provide the majority of dissolved SO_4 . The understanding of surface- and ground-water relations, gained through a multi-tracer approach, can thus explain groundwater quality but also the spatial variability of surface water quality along a river section, information of primary importance for water managers.