



The use of O, H and Sr isotopes and carbamazepine to identify the origin of water bodies supplying a shallow alluvial aquifer

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Alluvial aquifers are of great socio-economic importance in France since they supply 82% of drinking water production, though they reveal to be very vulnerable to pesticides and emerging organic contaminants. The aim of this work is to identify the origin of water bodies which contribute to the recharge of an alluvial aquifer for a better understanding of its hydrochemistry and transfer of contaminants therein. The study is based on an isotopic and geochemical tracers approach, including major elements, trace elements (Br, Sr), and isotopes ($\delta^{18}\text{O}$, $\delta^2\text{H}$, $^{87}\text{Sr}/^{86}\text{Sr}$), as well as organic molecules. Indeed, organic molecules such as pharmaceutical compounds, more precisely carbamazepine and caffeine, have shown their use as indicators of surface water in groundwater.

The study area is a partially-confined shallow alluvial aquifer, the so-called Vistrenque aquifer, located at 15 km from the Mediterranean Sea, in the Quaternary alluviums deposited by an ancient arm of the Rhône River, in Southern France. This aquifer constitutes a shallow alluvial layer in a NE-SW graben structure. It is situated between a karst aquifer in lower Cretaceous limestones, on the NW border, and the Costières Plateau, on the SE border, having a similar geology as the Vistrenque. The alluvial plain is crossed by a surface water network with the Vistre as the main stream, and a canal used for irrigation essentially, the BRL canal, which is fed by the Rhône River.

$\delta^{18}\text{O}$ and $\delta^2\text{H}$ allowed to differentiate the BRL canal water, depleted in heavy isotopes ($\delta^2\text{H} = -71.5\text{‰}$ vs V-SMOW), and the more enriched local rainwater ($\delta^2\text{H} = -35.5\text{‰}$ vs V-SMOW). In the Vistre surface water a binary mixing were evidenced with the BRL canal water and the rainwater, as end members. Then, in the Vistrenque groundwater both the BRL and the Vistre contributions could be identified, as they still show contrasting signature with local recharge. This allows to highlight the surface water contribution to a heavily exploited alluvial aquifer. These mixing processes are confirmed by comparing O and H isotopes to major elements composition. Furthermore, organic compound concentrations such as carbamazepine which show relatively high concentrations in surface waters, was also detected in groundwater especially in those influenced by the BRL canal water, and hence may be used as a tracer of surface water contribution.

On the other hand, $^{87}\text{Sr}/^{86}\text{Sr}$ allowed highlighting this time a mixing process between groundwater bodies contributing to the recharge of the alluvial aquifer. The $^{87}\text{Sr}/^{86}\text{Sr}$ vs $1/\text{Sr}$ plot showed a locale influence on the Vistrenque groundwater by the karst limestone aquifer ($^{87}\text{Sr}/^{86}\text{Sr} \approx 0.7076$; $[\text{Sr}] = 1540 \mu\text{g/L}$), and the Costières Plateau water ($^{87}\text{Sr}/^{86}\text{Sr} \approx 0.7090$; $[\text{Sr}] = 320 \mu\text{g/L}$).

In conclusion, ^{18}O and ^2H isotopes allowed to highlight the influence of surface waters on the quality of a shallow vulnerable alluvial aquifer, by determining the relationship between the two water bodies. While $^{87}\text{Sr}/^{86}\text{Sr}$ were useful to identify mixing processes between groundwater bodies from aquifers of different geology, the limestone karst and alluvial sediments. A multi-isotope approach proved useful to understand the origin of water bodies and contaminants.