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Nitrate transfer in the Critical zone view through N & O isotopes of NO3 and CFC-SF6 groundwater residence time assessment

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Drinking water quality in agricultural rural areas remains locally a challenge even all the effort made by local authorities to restore the groundwater resources quality, especially regarding nitrates. In Plourhan, a ~2000 inhabitants, about 10 km from the sea, NW France, the drinking water is pumped in a natural spring emerging from the Brioverian basement. The nitrate concentrations exceed the 50 mg/L standard for drinking water supply, and thus needs to be diluted to be delivered to the population. Over the last 15 years, a large programme of measures was undertaken in order to reduce the NO_3 concentration, including the purchase of agricultural parcels around the spring, moving progressively from mixed farming and livestock to fallows and meadows, and thus drastically change the local land use. Despite all these efforts, nitrate concentrations only decrease very slowly and remain above the 50 mg/L standard.

In this context, the objective of this study is to better understand the transfer of nitrates at the basin scale, by studying flow paths, geochemical reactions, transit times that are key parameters to estimate the vulnerability and the recovery-time of the critical zone. In that way, a geochemical and isotopic approach is applied at the basin scale. Major elements analysis of the groundwater reflect the drained contrasted lithologies as metasediments (pelites & sandstones) and amphibolite, with a large spatial heterogeneity of the NO_3 concentrations, ranging from a few mg/L to more than 50 mg/L. Nitrogen and oxygen isotopes of nitrates (δ^{15}N-NO_3 and δ^{18}O-NO_3) suggest that denitrification can occur locally in some wells presenting low or intermediate NO_3 contents, whereas other wells present high or low NO_3 concentrations without any evidence of denitrification processes. The mean residence time of groundwater is assessed through CFCs and SF6 dissolved gas measurements. Some wells preferentially in amphibolite, present water with low recharge temperature (around 6°C while the mean recharge temperature in Britany is 11-12°C) correlated with low CFCs/SF6 values indicating that some very old groundwater (last glaciation : -19/17 k yrs) exists in the reservoir. Other ones in metasediments have modern water or a mixing between an old and a present day recharge. These results, together with structural and lithological detailed geological field mapping, help to draw up the conceptual model of the aquifer functioning regarding nitrates transfer in the critical zone.

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