Nitrate sources and dynamics in alluvial aquifer assessed through multi-isotope fingerprinting and groundwater dating

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In spite of significant efforts over the last few decades in terms of source control of nitrogen input from French agriculture to ground- and surface water bodies, increasing tendencies of nitrate concentrations are still observed for numerous drinking water wells. This can be partly attributed to the inertia of the soil-groundwater system, with a slow nitrogen dynamics in the soil zone and groundwater residence times in the order of magnitude of years to tens of years even in superficial alluvial aquifer. This delay of effects of groundwater remediation measures is a serious drawback for attempts to reach the goals of the European Water Framework Directive, aiming to return to a good qualitative and quantitative status for European groundwater bodies till 2015.

Here we present results of a regional study of nitrogen contamination of alluvial aquifers in the south-western Rhine Valley, France using a combination of stable isotopes of N and O, O and H of water, isotopes of dissolved B and Sr, with groundwater dating methods (CFCs, SF6). Potential nitrogen sources (mineral fertilisers, manure, and domestic waste water) were analysed together with the target wells and surrounding ground- and surface waters.

The results reveal mean groundwater residence times around 8 to 10 years for the wells in the ancient alluvial sediments and isotope fingerprints compatible with oxidation of organic nitrogen or ammonia but not with mixing with domestic wastewater. Groundwaters in the young alluvial deposits of the Rhine River are mostly contaminated by local CFC input so that groundwater dating was possible only for one point. Here again, nitrates seem mostly derived from organic nitrogen or ammonium, but waste-water is a possible source as revealed by boron isotopes. These conclusions on nitrogen sources need to be considered in the context of the evolution of source terms at least over the last decade. Indeed, supplementary delay of nitrate transfer to the impacted drinking water wells could be due to the residence time of nitrate in the soil zone, not taken into account by the groundwater residence time estimation. Any new measure of source control will show its effects only at the horizon of 2020 given the reaction time of the groundwater system in the ancient alluvial sediments.