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Future nitrate concentration in streams and aquifers predicted using an age-based groundwater flow model

Camille Vautier (1), Tristan Babey (1), Tamara Kolbe (1,2), Jean Marçais (1), Alexandre Gauvain (1), Ben Abbott (1,3), Thierry Labasque (1), Luc Aquilina (1), Gilles Pinay (4), and Jean-Raynald de Dreuzy (1)

(1) Géosciences Rennes, Université de Rennes 1, Rennes, France, (2) Swedish University of Agricultural Science, Uppsala, Sweden, (3) Department of Plant and Wildlife Sciences, Brigham Young University, Provo, Utah, USA, (4) IRSTEA Lyon, Lyon, France

In agricultural areas, the matter of nitrate legacy is of major concern, yet there is a lack of quantitative estimations of future nitrate budgets in streams and aquifers. Here we propose a prospective approach to predict the evolution of water quality in space and time. Our study is based on a distributed three-dimensional groundwater flow model of a 35 km2 catchment located in Brittany, western France [1]. The flow model was calibrated with age tracer data (CFC) collected in wells, and denitrification activity was inferred using reactive tracer data (NO_3-, O_2, N2 excess). We simulate several scenarios of future nitrate inputs, and evaluate the resulting output concentrations in the aquifer and in the streams over the next decades. This approach allows us to characterize the aquifer resilience by quantifying its recovery time after a decrease in nitrogen inputs. More generally, it enables to assess the time lag between a change in agricultural practices and the return to low nitrate concentrations in the watershed.

We additionally perform a sensitivity analysis to characterize the key parameters controlling the water vulnerability to nitrate pollution. The relative effects of natural characteristics (groundwater residence time, biological reactivity) and anthropic factors (space, time and magnitude of nitrogen inputs) on future nitrate concentration are tested. We aim to end up with a simple method of assessing vulnerability to nitrate pollution in areas where little information is available.

[1] Kolbe, Tamara & Marçais, J & Thomas, Zahra & Abbott, Benjamin & de Dreuzy, Jean-Raynald & Rousseau-Gueutin, Pauline & Aquilina, Luc & Labasque, T & Pinay, Gilles. (2016). Coupling 3D groundwater modeling with CFC-based age dating to classify local groundwater circulation in an unconfined crystalline aquifer. Journal of Hydrology.