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Interannual climate variability and spatially heterogeneous improvement of agricultural management impede detection of a decreasing trend in nitrate pollution in an agricultural catchment

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Despite widespread implementation of the nitrate directive in the European Union since the 1990s, the impact on nitrate concentration in rivers is limited (Bouraoui and Grizzetti, 2011). To assess whether this lack of response is due to the long time lags of nitrate transfer or to inadequate programs of measure, long term river and groundwater monitoring data are necessary.

This study analyses 15 years of daily nitrate concentration data at the outlet of an intensively farmed catchment in Western France (Kervidy-Naizin, 5 km^2) and quarterly nitrate concentration data in the groundwater of two hillslopes equipped with piezometers (Kerroland and Gueriniec) within the same catchment. In this catchment groundwater contribution to annual stream flow is dominant. The objectives of this study were to i) disentangle the influence of interannual climate variability and improvement of agricultural practices (i.e. reduction in N surplus) in the stream chemistry and ii) discuss the reasons for slow catchment recovery from nitrate pollution by comparing trends in groundwater and stream concentrations.

Analysis of stream data showed that flow-weighted mean annual concentration at the outlet of the Kervidy-Naizin catchment has decreased by 1.2 mg NO_3- l-1 yr-1 from 1999 to 2015. This decrease was slow but significant (p value < 0.01) even though interannual climate variability (i.e. annual cumulated runoff) added noise to the signal: i) deviation in the linear model of nitrate decrease with time was negatively correlated with annual runoff ($r = -0.54$, $p < 0.01$) and ii) local minimums in the nitrate time series were coincident with local maximums in the annual runoff. Thus high runoff during wet years led to dilution of the nitrate originating from groundwater, which added variability to the signal of linear decrease in stream concentration.

Analysis of groundwater data showed a significant and sharp decrease in nitrate concentration in the Kerroland piezometer transect (4.0 mg NO_3- l-1 yr-1) and no significant evolution in the Gueriniec piezometer transect, from 1999 to 2015. This contrasting evolution of groundwater nitrate concentration between the two transects was consistent with data on soil surface nitrogen surplus, with a balanced fertilisation in the Kerroland transect (N surplus close to 0 kg N ha-1 yr-1) and excessive fertilisation in the Gueriniec transect (N surplus > 100 kg N ha-1 yr-1).

We conclude that, despite the lags due to pluri annual nitrate transfer through the unsaturated and satured zones in catchments of Western France, significant decrease in nitrate concentration in groundwater and streams should be visible within less than 10 years after implementation of an efficient program of measures. Spatial heterogeneity in the implementation of programs of measures (i.e. reduction of N surplus) is a likely cause of slow, sometimes undetectable, reduction in nitrate concentration.

Bouraoui, F., and Grizzetti, B.: Long term change of nutrient concentrations of rivers discharging in European seas, The Science of the total environment, 409, 4899-4916, 10.1016/j.scitotenv.2011.08.015, 2011.