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Nitrate retention in a sub-surface artificially drained watershed

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Denitrification has been shown to be very active in reducing nitrate concentrations and load coming from agricultural areas. Artificial subsurface drainage modifies nitrogen dynamics by reducing water residence time in cultivated soils and in riparian zones. This study focuses on nitrogen retention at different spatial scales in an artificially drained watershed.

To address this question, 4 nested watersheds, were monitored in the Brie region (France). The smaller one is an agricultural sub-catchment of 1.3 km^2. The 3 larger watersheds (9.6 km^2, 45.7 km^2 and 104 km^2) are a mix of agricultural and forested areas and correspond respectively to the 1^{st}, 2^{nd} and 3^{rd} stream order of Strahler. Discharge rates were measured hourly at the outlet of these watersheds and nitrate concentrations were analysed daily, in drainage waters, in surface waters and in groundwater. At all scales, nitrate concentrations are generally higher during the winter drainage season compared to the low flow periods (late spring to early fall). Drainage signature characterized by high nitrate concentrations particularly at the beginning of the drainage season in the fall, is visible at the 1^{st}, 2^{nd} and 3^{rd} stream order but becomes "diluted" by surface runoff from forested zones and buffered by groundwater contributions. Nitrate budgets established show significant nitrogen retention at all spatial scales, varying between 3 and 53 % during winter drainage season and between 56 and 71 % during low flow period.

Analysis of the isotopic composition of nitrate-nitrogen was used to assess the role of

denitrification in the observed nitrogen retention. Indeed, denitrification is known to induce a relative enrichment in ^{15}N of the residual nitrate pool. At the outlet of the 4 nested watersheds, as nitrate concentration decreases, nitrate stable isotopic composition increases, as expected for denitrification. These results show that denitrification occurs at all scales in the watershed, even upstream in the agricultural sub-catchment, in drained or riparian areas.

In order to investigate the possible role of agricultural soils in denitrification, organic nitrogen isotopic composition was analysed in artificially drained zones and in riparian zones. The idea is that if denitrification occurs in these soils, a part of enriched residual nitrate would be assimilated into organic matter which would result in a progressive enrichment in ^{15}N of the latter. δ^{15}N-N_{org} of drained and riparian agricultural soils ranges between 5.5 and 9.5 $\%_{\circ}$, corresponding to the highest values of δ^{15}N-NO_3^- in drainage in surface waters, and contrasting with forest soils which ranges between 1.7 and 4.4 $\%_{\circ}$.

Thus, in this small artificially drained watershed, even if subsurface drainage decreases water residence time in soils and riparian zones, “underground” processes are still active in eliminating nitrogen.