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Nitrate dynamics in a sub-surface artificially drained watershed

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In most agricultural areas, a progressive degradation of the quality of ground- and surface waters has been observed during the latter part of the past century. This deterioration has been attributed, in part, to the implementation of subsurface drainage combined with the increased use of manufactured Nitrogen fertilizers in France.

Paradoxically, research conducted in the mean time has shown that the majority of the net input of nitrogen to soils seems to be lost before it reaches coastal waters, at least in large watersheds of several thousands of square kilometers.

Denitrification is thought to be the principal process responsible for nitrate disappearance from agricultural soils to the estuary. Understanding the magnitude and the location of denitrification that may take place in the hydrological compartments during downstream transfer is of major interest. This is particularly true in upstream watersheds where most of the land is subsurface drained. Indeed, some of the compartments (e.g. riparian zones, streams, . . .) may not play their role as water residence time in these compartments may be greatly reduced or even suppressed.

The objective of this work is to characterize and quantify the hydrological and biogeochemical processes, which are involved in the transfer and retention of nitrogen in a watershed of 104 km^2 in size integrating drained cultivated fields and forested zones. In this study, a comparison between outlets of sub-catchments has been carried out in terms of concentrations (NO_3^-, NH_4^+ and NO_2^-), fluxes and stable isotopic composition ($\delta^{15}N\text{-}NO_3^-$; $\delta^{18}O\text{-}NO_3^-$) to detect the processes that are likely involved in the transfer and possible retention of nitrogen. These sub-catchments are from order 1 to order 3 (Strahler, 1957).

Highest values of nitrate concentrations were found at the outlet of drained plots (1.3 km^2; up to 70 mg NO_3^--N.l$_{,}^{-1}$) but were found to quickly decrease further downstream (drainage area of 9.6 km^2) and rarely reach values above 10 mg NO_3^--N.l^{-1}. Further analysis has revealed that part of this decrease was probably due to the addition of groundwater of lesser concentration, hiding the actual magnitude of retention processes occurring in the mean time. The general scheme of concentration decrease as water flows downstream is also contradicted in our watershed as water income from nitrate rich aquifers is probably the most plausible cause of concentration increase as the streams incise the limestone plateau (drainage area of 45.7 km^2).

Nonetheless, at large scales (2nd and 3rd orders, 45.7 and 104 km^2, respectively) in the watershed, preliminary isotopic measurements give information about processes involved. An increase of the isotopic composition can be observed with the decrease of nitrate concentrations, suggesting that denitrification in this artificially drained watershed may actually take place. The actual location of the isotopic enrichment remains to be determined at this point.