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Propagation and alteration of headwater hydro-chemical signals through river networks in a meso-scale agricultural catchment

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Eutrophication, defined as nitrogen and phosphorus enrichment of inland and coastal water, affects both human health and biodiversity.
River networks can contribute to reduce eutrophication through permanent and temporary nutrient retention processes such as uptake, denitrification and sedimentation. However, in-stream retention generally does not have the potential to decrease significantly annual nutrient loads in contexts of intensive agriculture (Mineau et al., 2015). In this study, we tested the hypothesis that in-stream processes can nevertheless significantly affect intra-annual dynamics of carbon and nutrient exports (Wollheim et al., 2018).

The study site is the Yvel catchment (300 km2), located in western France, an agricultural intensive area. We sampled and analyzed water for 11 chemical compounds including carbon and nutrients species in 20 headwater catchments and at the main outlet of the Yvel catchment every two weeks for one year. The composition of the landscape, the properties of the soils and general geomorphology of the 20 headwater catchments were representative of the whole catchment.

We estimated the apparent retention and production by a mass-balance approach. For the headwater catchments, we computed the area weighted concentration for each solute at each date, obtaining the “source” hydro-chemical signals. We compared these “source” signals with the outlet concentration. A “source” signal higher than the outlet signal for a given solute indicates a net apparent retention in the river network; reciprocally a “source” signal lower than the outlet signal shows a net apparent production.

Nitrate (NO_3-), nitrite (NO_2-), dissolved organic (DOC) and inorganic carbon (DIC) were conservatively transported from March to mid-June, during the high flow / moderate temperature period. From mid-July to mid-November, we observed an apparent retention of NO_3, and at very low flows, nearly 100% NO_3- retention in the river network. During the same period, we observed a net production of NO_2-, DIC and DOC in the river network.

In-stream processes and point source discharge both influenced phosphorus dynamics. For dissolved phosphorus (DP), we observed that the concentration at the outlet always exceeded the “source” signal, due to point source inputs into the main river. For particular phosphorus (PP), a slight retention (sedimentation) was observed at low flows whereas an important remobilization occurred (resuspension of sediments and/or erosion of the stream channel) during a storm event in June. Another remobilization of PP in the river network was observed during the rewetting period, corresponding to a reconnection of the river network.

Overall, the results presented here indicate that in-stream processes are more important during low flow periods, contributing to reduce loads during eutrophication sensitive periods (i.e. summer low flow) although they have a limited influence on annual load.

References

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