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Release of dissolved phosphorus from riparian vegetated buffer strips: a field assessment of mechanisms and risks

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Riparian vegetated buffer strips (RVBS) have been promoted worldwide as a tool to reduce diffused phosphorus (P) emission from agriculture lands, mainly through their ability to retain particulate P. However, RVBSs are zones of periodic water table fluctuations, which may stimulate the transformation and release of particulate P into mobile dissolved P species. In this study, we evaluated how soil characteristics (P content and P speciation), groundwater dynamics and biogeochemical processes interact together to trigger these transformations and releases, by monitoring over three years molybdate reactive dissolved P (MRDP) and total dissolved P (TDP) concentrations in soil solutions from two RVBSs set in a small agricultural catchment located in Western France, as well as in the stream immediately close of these two RVBSs and at the catchment outlet.

Two main mechanisms were evidenced that released dissolved P in the studied RVBSs, each under the control of groundwater dynamics, namely soil rewetting during water table rise after dry periods, and reductive dissolution of soil Fe-(hydr)oxides during prolonged soil water saturation. However, both mechanisms were shown to be strongly temporarily and spatially variable, being dependent on the local topographic slope and the amount and frequency of rainfall. In fact, the third monitored year which was characterized by numerous dry episodes during the winter season resulted in the almost total inhibition of the reductive dissolution release process in the steeper of the two monitored RVBSs. Comparison of sites also revealed strong differences in the size of the mobile P pools as well as in the speciation of the released P, which correlated with differences in the status and speciation of P in soils. Finally, P concentration fluctuations and P speciation variations similar to those observed in RVBS soils were observed in the stream both immediately close to the RVBSs and at the outlet of the catchment, demonstrating the effective transfer of the released P to surface waters.

Overall, results from this study show that RVBSs are effective risk zones with regards to P transfer in agricultural landscapes, due to their ability to biogeochemically transform soil retained particular P into more mobile and more bioavailable dissolved P, but that this risk is likely to strongly vary both in space and time, due to the complex interplay of soil characteristics, groundwater dynamics and biogeochemical processes. The hydroclimate is clearly an important driver through its control on inter-annual and seasonal groundwater dynamics, which in turn determine the type and intensity of the activated release processes. However, the first order controlling factor seems to be topography. Topography indeed ultimately controls the spatio-temporal variability of both wet/dry cycle and subsequent redox oscillation frequency, which are the triggers of the release processes. It influences also the input of particle P from cultivated fields through its control on soil erosion. Finally, it could also regulate the mineralization rate of organic P and thus the size of the most bioavailable inorganic P pool in RVBS soils.