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Flow and biochemical zonation in the intra-meander hyporheic zone

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The microbial processes in the hyporheic zone play an important role in the transformation of nutrients in fluvial ecosystems. Heterotrophic microorganisms are abundant where there is a supply of organic matter to support their metabolic activity. The oxidation of organic carbon performed by these microorganisms is coupled with the sequential reduction of oxygen, nitrates, and other chemicals. Thus, the ability to predict which are the prevailing pathways of carbon degradation represents an important step to understand the role of the hyporheic zones in nutrient cycling. Unfortunately, this prediction is often hindered by the complex structure of the hyporheic flow, which controls the contact times between the microbial biofilms and the water-borne nutrients.

The aim of this contribution is to analyze how the surface-subsurface exchange of water in meandering rivers controls the degree of removal of organic carbon as well as the corresponding degradation pathways. In meandering rivers, the horizontal flow of water from the upstream to the downstream branch of the stream results in a very wide range of residence times in the hyporheic zone. Numerical simulations are performed in order to show how the distribution of residence times leads to different types of carbon removal pathways across the intra-meander region and to the well-known sequence of zones where aerobic and anaerobic reactions prevails. This zonation is controlled by the interplay between the characteristic timescales of the biochemical reactions and the water residence times in the hyporheic zone, which are obtained from hydraulic principles. It is also shown that an estimate of the importance of the different pathways can be obtained with a simple comparison of the hydrological and biochemical timescales.