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Influence of flow velocity and experimental setup on denitrification processes at the laboratory scale

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In fractured media, physical heterogeneities lead to a large distribution of flow velocities that can partly control chemical reactions involving microbial activity. The aim of this project is to assess influence of fluid flow velocity on chemical reactivity at the laboratory scale. The experimental setup tries to reproduce autotrophic denitrification observed in a cristaline aquifer (Ploemeur; France) where denitrification seems to be enhanced by the exploitation of the aquifer. The experimental setup is based on a column filled with crushed granite from the Ploemeur site. Nitrate-rich water (C=40mg/l) is injected through the column under controlled flow conditions. Nitrate degradation is measured at the outlet and at different sampling plots along the column. These experiments use natural field water without treatment in order to use total available communities instead of one known bacterial community. Typically, the experiments are made during ten days at fluid flow velocities ranging from 0.5 to 5 cm/h.

The first point is that the use of uncontrolled bacterial communities in experimental setup can lead to important evolution of the bacterial activity and competition. Results show that this competition is not only related to the experimental conditions but also to the experimental apparatus equipment. Batch experiments show that commonly used polymers (PVC, Tygon, Teflon) can react with nitrates via heterotrophic denitrification within the same time scale as the rock reactivity. Such reactions can even overwhelm the studied reaction. To assess the role of the experimental conditions, we control materials reactivity compared to the relevant time scale of the experiments.

The first set of experiments exhibit autotrophic denitrification along the column with variations of the location of the reactive zone during the experiments. Reactivity arises all along the experiments in the first hours but becomes highly localized at the inlet of the column in the following hours. It implies a rapid and important denitrification process (up to 80% of initial mass) within the first centimeters of the column. Due to this high localisation of the reactivity, real kinetics can be more important than kinetics evaluated from the variations of concentrations over the distance separating the sampling plots. Thus, our experiments provide interesting insigths about the dynamic of denitrification processes at the laboratory scale depending on both experimental setup and flow conditions.