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# Soil structure and saturation effects on denitrification and oxygen distribution

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Soil denitrification occurs predominantly in microbial hotspots, in which denitrifiers use nitrate as an alternative electron acceptor. The soil water content exerts dominant control on denitrification in general, and product ratios in particular, as it governs the diffusions lengths of gaseous oxygen through air-filled pores and dissolved oxygen in water-filled pores as well as the diffusion of denitrification products from the source in soil to the atmosphere. However, this microscale processes are typically unaddressed with bulk measurements of soil respiration and soil diffusivity.

The aim of this study is to gain a better understanding of the microscopic drivers that control bulk denitrification in soil. We present results from an incubation experiment with repacked soils composed of different aggregates sizes (2-4mm vs. 4-8mm), adjusted to different water contents (70, 83, 95% WFPS) and amended with $^{15}$N-labelled nitrate. High resolution gas chromatography was combined with IRMS measurements at selected time points to monitor respiration as well as denitrification and its product ratios. The local oxygen distribution in soil is measured with needle-type optodes placed at various locations in soil. After the experiment X-ray tomography and image analysis are used to measure the internal structure of soil, the distribution of water and the micro-environmental conditions around each $O_2$-sensor.

We find that total denitrification increases non-linearly with saturation. $N_2O$ release increases with increasing saturation with small aggregates, but decreases or reaches at plateau at 95% WFPS with large aggregates, most probably due to a shift to $N_2$ as the final product, which should be reflected in the product ratio. The local oxygen concentration can only partially be explained by soil structure assessed via X-ray CT, as this method is only sensitive to the physical structure governing oxygen supply and not to the biochemical structure governing oxygen consumption.