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The anaerobic soil volume as a controlling factor of denitrification

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Denitrification is a major component of the nitrogen cycle in soil that returns reactive nitrogen to the atmosphere. Denitrification activity is often concentrated spatially in anoxic microsites and temporally in ephemeral events, which presents a challenge for modelling. The anaerobic fraction of soil volume can be a useful predictor of denitrification in soils. Here, we provide a review of this soil characteristic, its controlling factors and its estimation from basic soil properties.

The concept of the anaerobic soil volume and its link to denitrification activity has undergone several paradigm shifts that came along with the advent of new oxygen and microstructure mapping techniques. The current understanding is that hotspots of denitrification activity are partially decoupled from air distances in the wet soil matrix and are mainly associated with particulate organic matter (POM) in the form of fresh plant residues or manure. POM fragments harbor large amounts of labile carbon that fuels local oxygen consumption and, as a result, these microsites differ in their aeration status from the surrounding soil matrix.

Current denitrification models link the anaerobic soil volume fraction to bulk oxygen concentration in different ways but take almost no account of microstructure information, such as the distance between POM and air-filled pores. Based on meta-analyses, we derive new empirical relationships to estimate conditions for the formation of anoxia at the microscale from basic soil properties and we outline how these empirical relationships could be used in the future to improve prediction accuracy of denitrification models at the soil profile scale.