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Figuring out the process of denitrification by stable isotope approaches - Prospects and limitations -

CF Stange and O Spott
Helmholtz Centre for Environmental Research - UFZ, Department of Soil Physics

Improvement in the analysis of stable isotopes, higher measurement capacity and faster and more complex analysis methods allow a more detailed insight into the complexity of N cycling in soils or sediments, in particular in the formation and emission of N2 gas. The knowledge about the site-specific N2 to N2O ratio of denitrification and perhaps other processes is important to develop sustainable land use strategies for reduction of GHG emissions. Adapted stable isotope approaches are an irreplaceable tool for process identification, process quantification and processes separation. In the last years a few of new processes were found (e.g. anammox, codenitrification) and new stable isotope approaches for quantification and processes separation were published (Wrage et al.). Source partitioning of N gas production in soils is inherently challenging, but is vital to better understand controls on the different processes, with a view to develope appropriate management practices for mitigation of harmful N gases (e.g.N2O) (Baggs, 2008). Recently dual-isotope labelling approaches (Wrage et al., 2005) and triplet 15N tracer experiments (TTE) with 15N labelling of different pools (e.g. Müller et al., 2006, Russow et al 2009) have been developed to differentiate between more than two processes. The high number of simultaneously occurring processes during soil N cycling (Hayatsu et al. 2008) limits an easy applicability of isotope approaches (Spott and Stange 2007 ;Wrage et al. 2005; Phillips and Gregg, 2003), and therefore partitioning and process quantification is often afflicted with high uncertainties (Ambus et al., 2006). Especially the heterogeneity of environmental conditions in soils caused by the soil structure is difficult to handle (e.g. homogeneously labelling a soil). Hence, spatially separated processes in combination with high turnover rates (gross production and consumption) can produce different pools of one substrate in the soil (Russow et al. 2009) and limit the "state of the art" approaches (e.g. pool dilution/enrichment technique). The soil structure and the division of pools into process-related sub-pools should be considering in the future investigations.
Additionally analytical and numerical models have to be improved and adapted to the individual problems to excite a better understanding of the coupled processes. Uncertainty analysis and error propagation must be included in these approaches to derive confidence intervals, because the uncertainties for model parameter estimation increase with the number of involved processes and parameters (Müller et al. 2006, Müller et al, 2007).

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