Dual isotope tracing to determine the origin of nitrous oxide

Jan Willem van Groenigen & Dorien M. Kool
Dept. of Soil Quality, Wageningen University, P.O. Box 47, 6700 AA Wageningen, The Netherlands.
JanWillem.vanGroenigen@wur.nl

Nitrous oxide (N_2O) is the third most important greenhouse gas, and the main ozone depleting substance of the 21st century. For soil scientists, N_2O is especially important as the soils of the world are by far the main source for atmospheric N_2O. Limiting its emission is one of the major challenges soil science faces today, as emissions are projected to increase consistently over the coming decades. Surprisingly little is known about the biochemical pathways that produce N_2O. Traditionally, only autotrophic nitrification and heterotrophic denitrification have been considered as main sources. This allowed the use of ^{15}N labeling of nitrate resp. ammonium to distinguish between the two sources. However, it has been clear for some time that this is a simplified representation of reality. Of particular interest is a process called 'nitrifier denitrification', which is the stepwise reduction of nitrite to N_2O by ammonium oxidizing bacteria (AOBs). Although it has long been known that AOBs were capable of performing nitrifier denitrification, proof of its significance in actual soils has been hampered by methodological constraints. In this talk we present a novel isotope labeling method to quantify the contribution of nitrifier denitrification to N_2O emissions from the soil. The method is based on a combination of ^{15}N and ^{18}O labeling. Using $^{15}N\text{-}NH_4^+$ and $^{15}N\text{-}NO_3^-$ labeling, a distinction between nitrifier and denitrifier pathways can be made. Using $^{18}O\text{-}H_2O$ labeling, the nitrifier contribution can further be divided between nitrification and nitrifier denitrification. An $^{18}O\text{-}H_2O$ label allows to correct for O exchange between intermediates of the (de)nitrification pathways and water. Our results show that (i) the ^{18}O signature of N_2O is to a large extent determined by O exchange with water; and (ii) that nitrifier denitrification should routinely be considered as one of the major pathways of N_2O production. Our method will allow the future study of the factors controlling nitrifier denitrification, as well as the search for new ways to mitigate N_2O emissions.