

Nitrous oxide production from reactive nitrification intermediates: a concerted action of biological and chemical processes

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This contribution tries to open up a new perspective on biogeochemical N_2O production processes, taking the term bio–geo–chemistry literally. What if a major part of N_2O is produced from reactive intermediates of microbiological N turnover processes (“bio...”) leaking out of the involved microorganisms into the soil (“...geo...”) and then reacting chemically (“...chemistry”) with the surrounding matrix? There are at least two major reactive N intermediates that might play a significant role in these coupled biological–chemical reactions, i.e. hydroxylamine (NH_2OH) and nitrite (NO_2^-), both of which are produced during nitrification under oxic conditions, while NO_2^- is also produced during denitrification under anoxic conditions. Furthermore, NH_2OH is assumed to be also a potential intermediate of DNRA and/or anammox.

First, this contribution will summarize information about several chemical reactions involving NH_2OH and NO_2^- leading to the formation of N_2O . These abiotic reactions are: reactions of NO_2^- with reduced metal cations, nitrosation reactions of NO_2^- and soil organic matter (SOM), the reaction between NO_2^- and NH_2OH , and the oxidation of NH_2OH by oxidized metal ions. While these reactions can occur over a broad range of soil characteristics, they are ignored in most current N trace gas studies in favor of biological processes only. Disentangling microbiological from purely chemical N_2O production is further complicated by the fact that the chemically formed N_2O is either undiscernible from N_2O produced during nitrification, or shows an intermediate ^{15}N site preference between that of N_2O from nitrification and denitrification, respectively. Results from experiments with live and sterilized soil samples, with artificial soil mixtures and with phenolic lignin decomposition model compounds will be presented that demonstrate the potential contribution of these abiotic processes to soil N trace gas emissions, given a substantial leakage rate of these reactive intermediates into the soil matrix. It will be shown that the magnitude of these chemically produced N_2O fluxes is not only governed by soil nitrogen availability and soil water content, but also by organic matter content and composition, pH, redox conditions and redox-active metal ion content.

The presented data reveal that the interplay between biological and chemical processes is relevant for soil N_2O emissions. The integration of these processes and their additional controlling variables in soil N trace gas emission models would very likely have a great potential for reducing the uncertainty in emission model results and for facilitating the design of appropriate, site-specific N_2O mitigation strategies.