Paper sharing seminar, 11.10.2017,Tharangika Ranatunga

Soil nitrate reducing processes- drivers, mechanisms for spatial variation, and significance for nitrous oxide production, Giles et al (2012). Frontiers in Microbiology. 3, 407

Introduction

- Agricultural soils - 60% of global N_2O emissions primarily through microbial driven soil processes. eg. Denitrification, DNRA and even nitrification
- Denitrification reduce NO_3^- through various intermediate steps to N_2.
- DNRA reduce NO_3^- to NH_4^+
- In both processes, N_2O is a by-product.
- Why it is critical to understand the effects of complex soil environment on both nitrate reducing communities and soil's abiotic conditions? **Due to strong gradients in abiotic factors over short distances**
- Factors vary both spatially and temporally in soil.
- Great understanding of dynamics of denitrification and DNRA will allow the development of more effective mitigation startegies focused on areas of important N_2O sources.
- Denitrification is controlled by several factors: O_2 and water content, nitrate, carbon, pH, temperature and is catalyzed by enzymes: narG, nirS/nirK, norB,nosZ respectively.
- Studies focus on individual factors that can alter nitrate reduction in the rhizosphere are needed in order to fully understand the effects of roots on nitrate reducing communities and rates of this process.

Spatial variability in soil

- Abiotic conditions will play an important role in determining the spatial arrangement of denitrification.
- Especially true with rhizosphere root growth and inputs can change large changes in soil conditions over a small distance.
- Unless consideration is made for spatial variability when a sample strategy is designed, there is an implicit assumption : Any system is homogeneous in regard to microorganism and resource distribution/ any variation is averaged due to the relatively large sample size taken.
- These may not be useful assumptions. Why? **Soluble compounds move through soil by mass flow, hydrodynamic dispersion, diffusion.**
- In such a system with no flow, spread of a soluble resource, for eg. organic carbon from a point source, , would be equal in all directions, with the concentration of resource inversely propotional to the distance from the source.
- Concentartion gradients would spread by diffusion until evenly distributed throughout the system.
- In such equilibriums, denitrifying microorganisms expected to be randomly distributed with no regard to species and with activity dependant on a local, but evenly distributed resource.
- Drivers of soil abiotic heterogeneity - water content and soil structure as they influence transport and location of chemical comounds.
- Differences in soil particle shape, size – no two flow paths are identical
- In unsaturated bulk soil, water is held as afilm around soil particles by capillary action leaving air spaces in many pores.
- Pore retain water will also deped on soil particle size, geometry and connectivity.

- Dynamic nature of soil nitrate reduction – at any point, any time, locally dependant on the relevant factor that is limiting, either directly or through long-term control of nitrate reducer abundance in that microhabitat.
- Roots introduce an extra level of spatial complexity.
- Within rhizosphere, resources originate from the plant roots, but the flow of waters is also driven toward the root by plant uptake.nitrate reduction is likely to be high in the rhizosphere, where C source is high and O_2 is lower because of root respiration (related studies are with and without plants, shown that denitrification is higher with planted systems). Studies have found root exudates to stimulate denitrification.
- Studies of individual factors that can alter nitrate reduction in the rhizosphere needed to fully undertand the effects of roots on nitrate reducing communities and rates of this process.

Functional gene studies

- Due to limitations of sampling size, averaging the contribution of community members on a large range of habitats.
- To link community structure and function, samplings need at relevant spatial scale.
- Studies need to focus spatial and temporal scale relevant to organisms concerned.

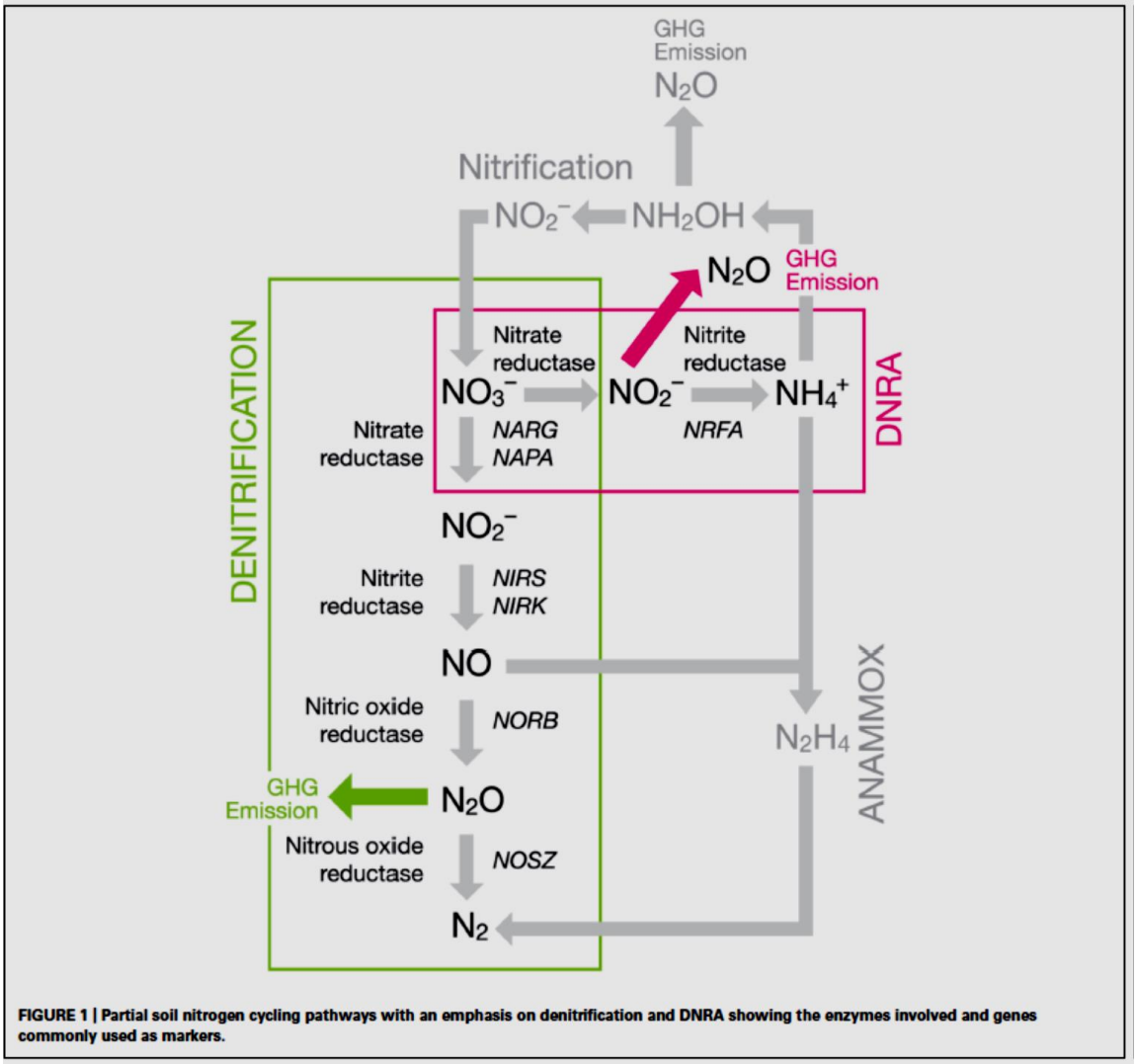

FIGURE 1 | Partial soil nitrogen cycling pathways with an emphasis on denitrification and DNRA showing the enzymes involved and genes commonly used as markers.