Alternative pathways of nitrogen loss from paddy soils

With the financial support by the National Natural Science Foundation of China and the Strategic Priority Research Program of Chinese Academy of Sciences, Prof. Zhu Yongguan's group at the Institute of Urban Environment and the Research Center for Eco-Environmental Sciences, Chinese Academy of Sciences, elucidated the alternative pathways of nitrogen (N) loss from paddy soils, which has recently been published in *ISME J* and *Environ Sci & Technol* (2014, 48(18): 10641—10647).

China is one of the major rice producers and consumers of N fertilizers (usually as urea and ammonia) in the world, which results in large amounts of N loss through NH_3 volatilization, NO_3^- run off and leaching and N_2O emissions. However, >10% of the total N fertilizers applied in arable soils remain uncharacterized. Recently, the discoveries of anaerobic ammonium oxidation coupled to nitrite reduction (termed anammox) and anaerobic ammonium oxidation coupled to iron(III) reduction (termed Feammox) in natural ecosystems provide new insights into the mechanisms responsible for N loss, yet their roles in paddy soils, which are rich in iron(III) oxides and are intensively fertilized, remain unclear. By combining ^{13}C-acetate-based rRNA-stable istope probing (SIP) and high-throughput pyrosequencing techniques, Zhu's group demonstrates that long-term urea fertilization promotes iron(III) reduction and modulates iron(III)-reducing bacterial community, especially stimulates *Geobacter* spp. in a typical paddy soil from Southern China. This suggests the microbial coupling between N cycle and iron(III) reduction in paddy soils (*ISME J*, 2015, 9: 721—34). They subsequently incubated slurries of a paddy soil chronosequence with a gradient of indigenous microbially reducible iron(III) levels using $^{15}NH_4Cl$-based isotopic tracing and acetylene inhibition techniques, in order to assess the potential for Feammox in these soils. They provide direct evidence for the occurrence of Feammox in paddy soils, and show that direct N_2 production via Feammox is the dominant pathway of gaseous N loss, suggesting that Feammox could potentially be an important pathway for N loss in paddy soils (*Environ Sci & Technol*, 2014, 48: 10641—7). In addition to Feammox, Zhu's group also investigated the anammox process in paddy soils using catalyzed reporter deposition-fluorescence *in situ* hybrization, ^{15}N-isotope tracing and molecular techniques. They show that the abundance and activity of anammox bacteria in the rhizosphere was much higher compared with the non-rhizosphere soil; up to 31%—41% of rhizosphere soil N_2 production was contributed by anammox, whereas about 2%—3% of N_2 was generated via anammox in bulk soil. These findings suggest the importance of rhizosphere-driven anammox process, which was previously largely overlooked (*ISME J*, 2015: 1—9). Taken together, Zhu's group proposes a conceptual model of N loss from paddy soil through different pathways along the redox gradient in paddy soils.

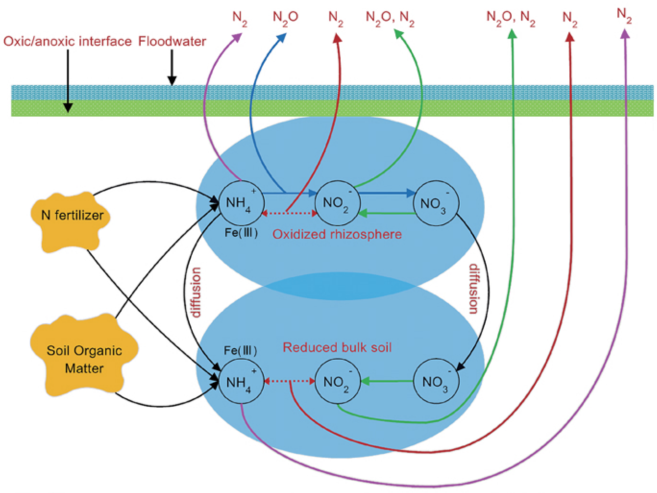

Figure Schematic representation of the N loss from paddy soil. The classical processes of nitrification (blue), denitrification (green) and recently discovered anammox (red) as well as Feammox (magenta) are shown both in oxidized rhizosphere and reduced bulk soil.