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Quantitative importance of denitrification and N2O emission in an N-saturated subtropical forest catchment, southwest China

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Anthropogenic emission of nitrogen in the environment has increased rapidly, due to fast economic growth. This has resulted in increased deposition rates of reactive nitrogen, primarily as NOx (from fossil fuel combustion) and NH3 (from fertilizer production and animal husbandry). In response, temperate and boreal forests may develop nitrogen saturation, characterized by increased leaching of nitrate. In addition, elevated emission of N2 and N2O, due to nitrification and denitrification, may occur. To date, few studies exist quantifying the nitrogen balance, including N2 and N2O production, in nitrogen-saturated, monsoonal, sub-tropical forest ecosystems in south-west China. Since nitrate contributes to the eutrophication of stream water, and N2O is a potent greenhouse gas, it is important to quantitatively understand the role of nitrification and denitrification in the nitrogen cycle.

Several subtropical forests in southwest China, receiving elevated nitrogen deposition (30-73 kg N ha-1 a-1; Zhang. et al., 2008), are characterized by high temperature and soil moisture content in much of the growing season. This may cause a much stronger intensity of denitrification compared with that in temperate and boreal forests. In turn this may lead to decreased nitrate leaching and a higher potential of N2O emission.

In my PhD project, I will investigate the nitrogen cycle in a forest catchment (TieShanPing; TSP), which is near one of the biggest cities, Chongqing, in southwest China. Previous research suggests high nitrogen deposition (3.52 gN m-2 a-1), but low nitrogen flux (0.57 gN m-2 a-1) in runoff (Chen & Mulder, 2007). Tree growth, and thus plant N uptake, is limited and nitrate fluxes below the root zone are relatively large, suggesting 'N-saturation'. Based on this, we hypothesize that significant amounts of nitrogen are emitted as gases, with denitrification playing an important role, and N2 and N2O (especially N2) being major components of the emitted gases. Denitrification is hydrologically controlled and depends on landscape position, with high intensity expected in the wetland and riparian zones in the wet and hot summers.

The project consists of three work packages including: (1) Selection for 'hot spots' and 'hot moments' for denitrification and N2O emission. Three methods will be applied: static chambers for N2O flux; dissolved N2O and N2/Ar as well as natural abundance of 15N and 18O isotopes in NO3- in soil water and groundwater for denitrification intensity comparison. (2) Intensive experiments on selected plots along one or more transects (hillslope to riparian zone), by introducing Isotope tracer 15N onto upper soil and into groundwater zone (push-pull method) for in situ quantitative determination of nitrification/denitrification and N2O sources. (3) Laboratory studies for a better process understanding of field experimental results. In detail, nitrification and denitrification potentials in intact soil samples from selected plots and depths will be determined; rates of nitrification and denitrification and production ratios (N2O/NO3- for nitrification and N2O/N2 for denitrification) will be explored in response to selected physico-chemical parameters reflecting field conditions. Next, laboratory results will be linked to field observations for deeper controlling mechanism understanding. The 3-year project starts in summer 2009.

Keywords: denitrification; nitrification, N2, nitrous oxide (N2O); 15N, 18O, natural abundance; subtropical forest; China

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