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The effect of soil pH on N2O/(N2O+N2) product ratio of denitrification depends on soil NO_3- concentration

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Globally, agricultural soils account for about 60% of the atmospheric N2O emissions and denitrification in soil is the major source of atmospheric N2O, which contributes to global warming and destruction of stratospheric ozone. Denitrification is the microbially mediated process of dissimilatory nitrate reduction that may produce not only N2O but also nitric oxide (NO), and molecular nitrogen (N2). The major controls on denitrification rates are soil NO_3, O_2, and labile C levels. Typically, when soils become more anoxic, larger proportions of N2O produced in denitrification are further reduced to N2 before leaving the soil. Microbial ecology may possibly find solutions to this major environmental problem of agricultural systems once mechanisms controlling the product ratio of denitrification (N2O/N2O+N2) are better understood. Recent investigations of these gaseous microbial products provided the evidence for a negative effect of soil acidity on the N2O/N2O+N2 product ratio. However, in an earlier study, we showed that, regardless of soil type, higher NO_3- concentrations in soil may also retard the reduction of N2O to N2. In this context, the positive effect of higher soil pH on the N2O/(N2O+N2) product ratio in soils with high NO_3- content is still poorly understood. Therefore, we set up a number of incubation experiments in order to test short-term and long-term effects of soil pH and NO_3- concentration on denitrification rates and the product stoichiometry of denitrification. We measured N2O, NO as well as elemental N2 in soils with pH levels ranging 4.1 to pH 6.9 collected from a long-term liming experiment. In a continuous flow incubation system we evacuated and flushed all vessels with He. Then, fresh He was directed through an inlet in the lid at a flow rate of 15-30 ml min-1. Gas samples were analyzed twice a day for N2O by ECD and for N2 by TCD detectors. Denitrification rates increased significantly with increasing soil pH, however, during the initial phase of the experiment, the N2O/(N2O+N2) product ratio was similar (0.85 $\pm$0.4) in all soils. But, the ratio decreased rapidly in high pH soil while in low pH soil it remained almost constant for nearly 100 hours and then decreased towards zero. The results showed that the length of the anoxic spell is a third factor influencing the N2O/(N2O+N2) product ratio. This means that short anoxic periods will result in high N2O/(N2O+N2) product ratios even in soils with high pH whereas in low-pH soil, the product ratio was high for longer periods of anoxia. All experiments clearly showed that the effect of pH on N2O/(N2O+N2) product ratio of denitrification was weaker with increasing soil nitrate concentrations.