

# Relevance of direct organic N-oxidation as source of nitrogen oxides (NO and N<sub>2</sub>O)

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## 1 INTRODUCTION

Forest soils exhibit a variety of complex biochemical nitrogen (N) reactions in which nitric oxide (NO) and nitrous oxide (N<sub>2</sub>O) can be produced by coexisting processes that respond differently to the same environmental conditions. In general, two biochemical processes, (i) the oxidation of ammonia (nitrification) and (ii) the reduction of nitrate (denitrification), are known as the major sources of nitrogen oxides. However, in addition to inorganic nitrogen substrates, soil organic N compounds (N<sub>org</sub>) have recently also been reported to be oxidised and transformed into N<sub>2</sub>O. Zhang et al. [1] calculated that organic N oxidation contributes between 27 and 42 % to the total N<sub>2</sub>O release from subtropical forest soils. During the last years triplet <sup>15</sup>N tracer experiments (TTE) have been developed to investigate the major N transformation pathways and N gas production in soils.

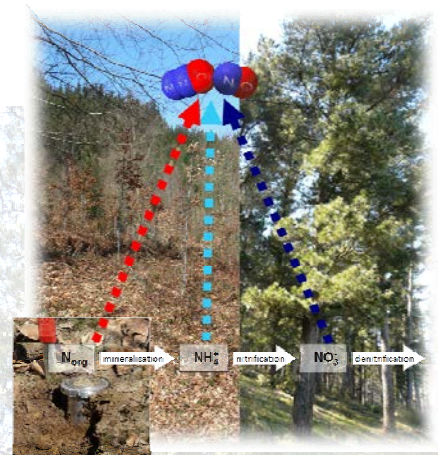


Fig. 1: View from the beech to the young beech stand (left side) and the pine stand (right side) as well as a sampling core (small picture).

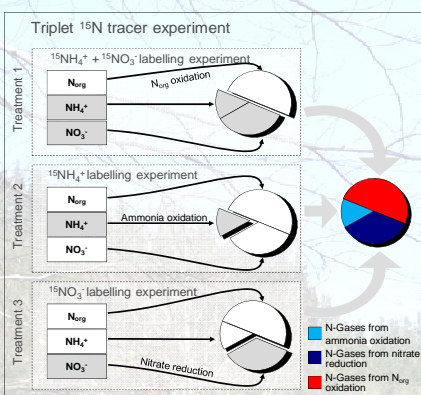


Fig. 2: TTE-Scheme with an indirect labelling of the N<sub>org</sub> pool to study soil N-release due to N<sub>org</sub> oxidation.

## 2 MATERIALS AND METHODS

The influence of two different oxygen levels (21 and 2 vol.% O<sub>2</sub>) on NO and N<sub>2</sub>O release of soil samples from 5 different Basque forest sites (Mature Pine, New Pine Plantation, Young pine, Young beech, Mature Beech) was investigated. From each stand 9 soil samples with <sup>15</sup>N tracer in different pools (3 treatments, see Fig. 2) were incubated and N-gas release (NO and N<sub>2</sub>O) was monitored. <sup>15</sup>N-abundance of released N-gases were determined 9 times (Points of measurements, Fig. 3). <sup>15</sup>N-abundance in the soil N-Pools (NH<sub>4</sub><sup>+</sup> and NO<sub>3</sub><sup>-</sup>/NO<sub>2</sub><sup>-</sup>) was measured at the beginning, the end (ca. 96h) and in the middle of the incubation (48h). The analytical solution of the inverse abundance approach (IAA) to calculate the fraction of nitrification (A), denitrification (B), and organic N oxidation (C) is found by applying the Gauss elimination approach [2].

## 3 RESULTS

Figure 3 shows the contribution of NH<sub>4</sub><sup>+</sup>, N<sub>org</sub>, and NO<sub>3</sub><sup>-</sup> to the total N<sub>2</sub>O and NO release from the sampled forest soils. It reveals that, under oxic conditions (21 % v/v O<sub>2</sub>), N<sub>2</sub>O production based on N<sub>org</sub> was the dominant pathway and contributed between 48 and 76 % to the total soil N<sub>2</sub>O release. Under hypoxic conditions, the relative contribution of N<sub>org</sub> to the total soil N<sub>2</sub>O release significantly decreased (down to 8% at the young beech stand), whereas its absolute contribution increased concomitantly. In accordance with other studies [3], denitrification was the dominant process of soil N<sub>2</sub>O release under hypoxic conditions (2 % v/v O<sub>2</sub>). Denitrification also always served as the major pathway of soil NO release, accounting for more than 40 and 60 % of the total soil NO release under oxic and hypoxic conditions, respectively. At the mature stands (pine and beech) also the ammonia oxidation (nitrification) contributed significantly to the NO release under oxic condition, accounting between 30 and 40%. Compared to the N<sub>2</sub>O release the contribution of organic N oxidation to NO release was small. From the sum of the three source (between 94 and 108 %), it can be supposed that the major sources of soil NO and N<sub>2</sub>O production in the studied forest soils have been adequately considered using the IAA.

## 4 CONCLUSIONS

- ▶ In addition to the well-known processes of nitrification and denitrification, other N gas-forming processes that are based on a direct utilisation of organic N occur in soils.
- ▶ Concerning homogenised soil samples the combined TTE/IAA approach represents a very useful tool to separate sources of nitrogen oxides.
- ▶ In the studied forest soils, N gas formation based on the organic N pool is of great significance with respect to the total soil N<sub>2</sub>O release.
- ▶ Although a reduced O<sub>2</sub> availability increased the soil N gas releases at all sites, the individual contribution of different soil N pools to the total N gas release and the impact of O<sub>2</sub> is related to the specific soil/stand.

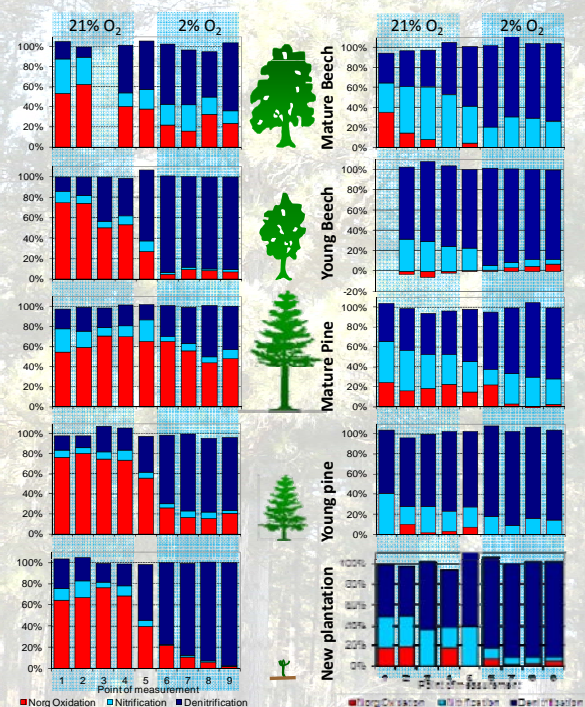


Fig. 3: Calculated proportions of the N<sub>2</sub>O sources (left site) and the NO sources (right site) from five forest soils under two different oxygen conditions (21 vol.% and 2 vol.% O<sub>2</sub>).

## 5 REFERENCES

- (1) Zhang J, Cai Z, Zhu T (2011) N<sub>2</sub>O production pathways in the subtropical acid forest soils in China. Environmental Research 111(5): 643-649
- (2) Stange CF, Spott O, Müller C (2009) An inverse abundance approach to separate soil nitrogen pools and gaseous nitrogen fluxes into fractions related to ammonium, nitrate and soil organic nitrogen. European Journal of Soil Science 60(6): 907-915.
- (3) Bollmann A, Conrad R (1998) Influence of O<sub>2</sub> availability on NO and N<sub>2</sub>O release by nitrification and denitrification in soils. Global Change Biology 4: 387-396.