Improving calculation of critical loads with N_2O-emission experiments

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What are Critical Loads?

Long-term exposure to high levels of N has shown impacts on forest growth and biodiversity. It leads to soil acidification and a decline in microbial biomass. To protect forest ecosystems from high atmospheric N-deposition, the concept of critical loads (CL) was developed. It defines long-term tresholds that would allow maintaining an ecosystem's resilience (Schlutow et al., 2018).

Methodology of the experiments

We collected undisturbed soil cores from 15 German Level-II-plots and one ICP-IM-plot (Fig. 1). N_2O fluxes were analyzed in a laboratory study with a cavity ring-down spectrometer. Measurements were performed with soil temperature levels of 5, 15 and 20°C. Soil moisture was varied between 70 and 90 % water-filled pore space (WFPS). Undisturbed soil cores were used to represent natural conditions and disturbed ones for the N_2O-emission potential, respectively. N_2O is mainly released by denitrification. However, with this method we are not able to distinguish between the different processes of N_2O formation.

Why is denitrification important for Criticial Loads?

CL's are calculated with a simple steady-state mass balance. One part of the calculation is represented by N fluxes from denitrification. These fluxes are highly variable and in case of N_2 a complicated measurement technique is needed. Research on quantifying denitrification from forest soils is still needed to improve the calculation of CL's for N.

Fig. 1: Sampling of soil cores (left), 250 cm³ soil core ready for analysis (middle) and vessels for soil cores inside the measuring unit for N_2O, CH_4 and CO_2

Results and discussion

Low N_2O emissions of <1 kg N ha^{-1} a^{-1} were measured on all 16 plots with undisturbed soil cores for the different soil temperature and moisture levels (Fig. 2).

N_2O emissions up to 77 kg N ha^{-1} a^{-1} were observed for disturbed soil samples at a soil temperature of 20°C and a WFPS of 90 % (Fig. 2). Sites with high clay content in combination with high N deposition showed the highest N_2O fluxes. Fluxes from disturbed soil samples have to be regarded as the maximum potential of N_2O soil emissions. Under field conditions such emissions could occur, e.g. when harvesters cause increased N mineralization of the N stocks in very wet forest soils. This hypothesis should be tested in future research projects

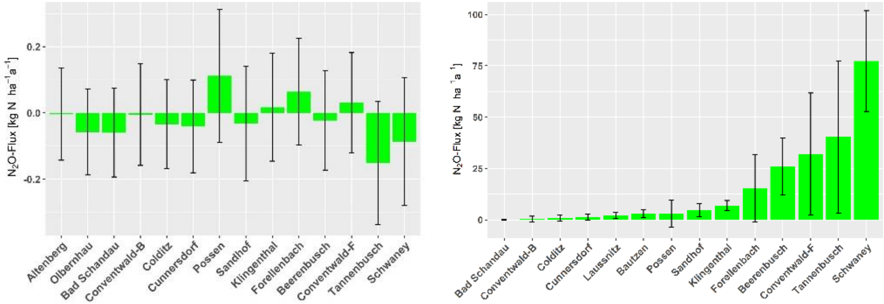

Fig. 2: Average N_2O fluxes and standard deviation for undisturbed soils (left) and disturbed soils (right). Soil temperature: 20°C, WFPS: 90 %.

Important drivers of denitrification

- **Soil moisture**
  - **Grain-size distribution, clay content**
  - **Precipitation / draughts**
  - **Land cover**
- **Soil temperature**
  - **Freeze-thaw cycles**
  - **Soil colour**
  - **Land cover**
- **Nutrients**
  - **C/N-ratios**
  - **Atmospheric deposition**
- **Soil pH-value**
- **Land-use-change**

Summarized from Oertel et al. 2016

Important References

Oertel C, Matschullat J, Zurba K, Zimmermann F and Erasmi S 2016 Greenhouse gas emissions from soils—A review Chem Erde Geochem **76** 327-352

Schlutow A, Nagel H-D and Bouwer Y 2018 Bereitstellung der Critical Load Daten für den Call for Data 2015-2017 des CCE im Rahmen der Berichtspflichten Deutschlands für die CLRTAP, ÖKO-DATA Strausberg p 154

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