Simultaneous determination of molecular nitrogen and nitrous oxide in biochar-treated soils

Kerstin Michel[a], Regine Maier[b], Michael Tatzber[a], Barbara Kitzler[a]

[a] Austrian Research Centre for Forests (BFW), Vienna, Austria (kerstin.michel@bfw.gv.at)
[b] ETH Zurich, Zurich, Switzerland

1. Background and Objectives

Nitrous oxide is a potent greenhouse gas. The production of N_2 but also N_2O removes reactive N from soils. In arable systems N losses are therefore of high ecological and economical significance. The use of biochar (BC), i.e. C rich material which is produced from biomass by pyrolysis at temperatures < 700 °C, is increasingly discussed as measure for soil amelioration. However, its (long-term) effects on denitrification activity in general and on N_2 losses in particular still remain unclear.

The objectives were therefore (1) to investigate the long-term impact of BC application on N gas fluxes, especially N_2 emissions, from two arable soils using the Helium-gas flow core technique and (2) to evaluate potential controlling factors.

2. Experimental Sites

Traismauer (Trm) (Lower Austria; soil sampling: 2015)	**Kaindorf (Kd)** (Styria; soil sampling: 2014)
Strongly continental climate (10 °C, 550 mm)	Temperate climate (8.8 °C, 800 mm)
Calcareous Chernozem (pH 7.4)	Cambisol (pH 6.6)
Single hardwood BC application in March 2011 (72 t ha^{-1})	BC (husk, fibre sludge) + compost in 2013 and 2014 (T1: 1%, T2: 0.5 % + 175 kg N ha^{-1})
Control: NPK (each year: 75-120 kg N ha^{-1})	Control: $(NH_4)_2SO_4$ (2013: 350 kg N ha^{-1})

3. Measurements

- N_2 and N_2O: He-gas flow core technique (Fig. 1)
  - Water content: **Trm**: 50 and 70 % water-filled pore space (WFPS), **Kd**: 23 and 50 % WFPS
  - Temperature: **Trm**: 5, 15, and 25 °C; **Kd**: 24 °C
- Organic C, total N, pH, extractable organic C, NH_4^+, NO_3^-
- Microbial biomass C and N

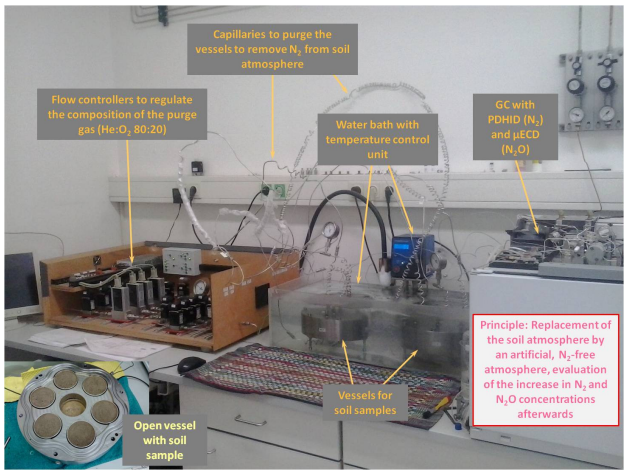

Fig. 1 Measuring device for the direct determination of N_2 and N_2O fluxes

4. Results

N gas fluxes

- **N_2 fluxes**
  - N_2 fluxes were significantly higher in the BC treated soil samples except for **Kd**, 50 % WFPS (Figs. 2 and 3)
  - Increasing water content significantly increased N_2 emissions ($p < 0.05$)
  - **Trm**: Temperature did not signifcantly affect N_2 fluxes. However, there was a clear trend to higher emissions at low temperatures (5 °C).

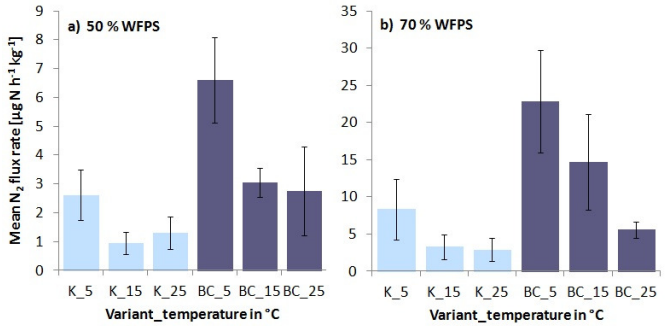

Fig. 2 Mean N_2 fluxes (± SD; n = 3) from **Trm** samples at different water contents and temperatures. The differences between BC-treated (BC) and control (K) samples and the water contents are significant (Kruskal-Wallis test; $p < 0.05$).

- **N_2O fluxes**
  - **Trm**: N_2O was only sporadically detected (not shown)
  - **Kd**:
    - Highest N_2O emissions were measured from N-enriched BC-compost samples (T2) at both water contents (Fig. 3)
    - N_2O emission were always lower than N_2 fluxes

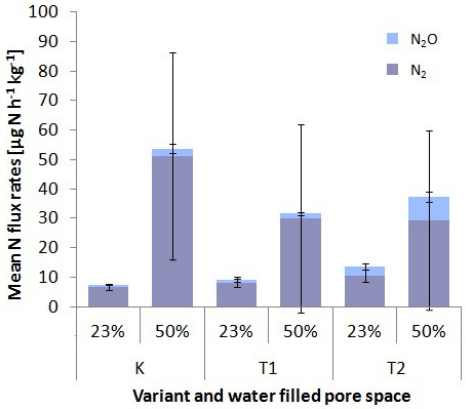

Fig. 3 Mean N gas fluxes (± SD; n = 3) from **Kd** samples at two different water contents and 24 °C. Fluxes of N_2O from T2 were significantly higher compared to K (control) and T1 (Student Newman-Keuls test, $p < 0.05$).

Controlling factors

- Only pH was significantly higher (0.2 units) in the BC-treated samples of **Trm** compared to the control
- The measured soil physico-chemical and microbial properties could thus not explain the differences in N gas fluxes between BC-treated and control samples

5. Conclusions

The effect of BC on N_2 fluxes depends on the water content of the soils. At lower water contents, N_2 emissions are higher in BC-treated soils compared to N-fertilized soils suggesting an increased denitrification activity. The changes in N_2 fluxes cannot be explained by altered physico-chemical conditions or changes in microbial biomass. Higher water contents increase N_2 emissions, but the extend is site- and treatment- dependent. Fluxes of N_2O also increase with increasing water content but are distinctly lower or even not detectable in the investigated soils.

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