Will aged Biochars continue to reduce N\textsubscript{2}O emissions?

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Exploration of long-term analogs in space and time for the continued safe use of biochar in soils

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Siegerländer Hauberg (wikipedia)
Gefährliche Schmelze am Nordpol: Arktiseis zur Hälfte verschwunden

http://www.n-tv.de/wissen/Arktiseis-zur-Haelfte-verschwunden-article7266116.html

…nur noch 3.37 Mio km²
Surplus N – a global problem

Figure 1 'Hole-in-the-pipe' model of the regulation of trace-gas production.

Nitrous Oxide (ppb)

Radiative Forcing (W m⁻²)

Time (before 2005)
GHG fluxes: „typical“ behavior of fresh biochar

Results:
PhD cand.
Ghulam Haider

Kammann et al. 2011 (Plant & Soil); Kammann et al. 2012 (JEQ); Augustenborg et al. 2012 (JEQ)
**N retention? – Plant growth after leaching**

![Barley biomass graph](image)

- **Barley biomass (g)**
- **soil control**
- **soil control + BC pure**
- **soil control + BC N-load.**
- **soil control + BC N-load. + BC pure**
- **soil control + BC N-load. + BC pure**
- **soil control + BC N-load. + BC pure**
- **soil control + BC N-load. + BC pure**

Comparison of N retention and plant growth after leaching:
- **no N addition**
- **+ Nitrate**
- **+ Ammonium**
- **+ Urea**
- **+ Amino Acids**

* denotes significant differences.

**MSc cand. Nicole Messerschmidt**
Biochar-composting: accelerated “ageing”

What does fresh biochar do? What exactly is biochar “ageing”?

BC-Composting experiment (@ Delinat Institute, CH, H.-P. Schmidt)

Temperature before and after daily compost turnover (= aeration)

* p < 0.05, t-test
Biochar-composting: accelerated “ageing”

BC-Composting experiment: GHG fluxes - CO\(_2\) and N\(_2\)O emissions

Work by MSc Matthias Schröder
Old charcoal kiln places: “biochar soil”

Charcoal kiln area: Siegerländer “Hauberg”; last use > 50 years ago

*Charcoal kiln soil (CC):* pH 4.8, lower bulk density

*Adjacent forest soil (Adj):* pH 4.4, N-min stocks identical

**M:**

- **Depths:** 0-5 cm and 5-20 cm, 5-mm sieved;
- **Incubation:** in jars, 60% WHC, 15 °C
- **Treatments:** +/- 100 ppm NH$_4$NO$_3$;
- **Measurements:** GHG fluxes daily; $N_{\text{min}}$ extractions

*73. ANS-Symposium,* 20. September 2012

Kammann et al.  

*MSc thesis Christoph Finke*
Charcoal-rich kiln soil fertility: not reduced

Tabelle 7: Mittelwerte der Gehalte und Vorräte von Ct, nonBC-C und BC

<table>
<thead>
<tr>
<th>Flächentyp</th>
<th>Ct</th>
<th>nonBC-C</th>
<th>BC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Referenz</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Meiler</td>
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</tbody>
</table>

Largely not an N effect

Adj. forest soil 1:1 mixture kiln-site soil

Diploma thesis D. Hegenberg, Uni Bonn, (W. Amelung)
Kiln soils: $N_2O$ emissions

**Top soil (0-5 cm)**

**Sub soil (5-20 cm)**

**N$_2$O emissions (µg N kg$^{-1}$ h$^{-1}$)**

- Days after start (N fertilization): 0, 7, 14, 21, 28

**N$_2$O emission sum (µg N kg$^{-1}$)**

- CC +F
- CC -F
- Adj +F
- Adj -F

**Factors**

- Depth: <0.001
- CC/Adj: 0.117
- Fertil.: <0.001
- Depth x CC/Adj: <0.001
- Depth x F: <0.001
- CC/Adj x F: 0.058
- Depth x CC/Adj x F: <0.001

**Grassland, F+**

**Eurosoil 2012, 5. July**

Kammann et al.  

MSc thesis Christoph Finke
Kiln soils: CH$_4$ oxidation and balance

GWP100-yr:

N$_2$O: 298

CH$_4$: 25
Oldest analog: Terra preta soils

- Incubation at 25°C, 70% rH, 80% WFPS
- Application of 50 ppm NH$_4$NO$_3$
- 4 sampling dates (day 0, 1, 3, and 7)
- n=6 per soil (96 jars), KCl extractions

Fig. 1. Map showing the location of the samples sites on the Caldeirão Research Station (Embrapa Amazônia Ocidental) in the municipality of Iranduba, Amazonas, Brazil. (a) TPI-SF: Terra Preta de Índio soil under secondary forest, (b) TPI-MP: Terra Preta de Índio soil under manioc plantation, (c) ADJ-SF: Adjacent soil under secondary forest, (d) ADJ-MP: Adjacent soil under manioc plantation.
**Terra preta soils: \( N_{\text{min}} \) dynamics**

**Results:**

- **N-min stocks:** TP >> Adj in both ecosystems (SF and agri.)
- **NH\(_4\)/NO\(_3\) ratio:** TP 1.4-1.5, Adj 2.0-2.3
**Terra preta soils: $N_2O$ emissions**

Results: $N_2O$ peak Adj forest only
$N_2O$ emissions very low
TP slightly larger background $N_2O$
Summary and Conclusions

1. BC-Composts: lower N$_2$O emission reduction
   no danger of increased N$_2$O emission

2. Kiln soils: no potential for strong N$_2$O emission
   net N$_2$O+CH$_4$: significantly improved

3. Terra preta: +/- same pattern as kiln soil
   high emissions from Adjacent forest only

There is room for careful optimism:
Biochar as a suitable management tool beyond
initial N$_2$O emission reductions
Thank you for your attention!

Cooperations and Acknowledgements:
Kiln soils: soil respiration

![Diagram showing CO₂ efflux sum (mg CO₂ kg⁻¹) for top soil and sub soil with different factors and depths. The diagram includes bars for CC F+, CC F−, Adj F+, and Adj F−.]

- **Top soil**
  - CC F+
  - CC F−
  - Adj F+
  - Adj F−

- **Sub soil**
  - CC + N-Fertil.
  - Adj unfertil.

- **Statistical analysis**
  - **Factor**
    - Depth: <0.001
    - CC/Adj: <0.001
    - Fertil.: <0.001
    - Depth x CC/Adj: 0.004
    - Depth x F: 0.19
    - CC/Adj x F: 0.111
    - Depth x CC/Adj x F: 0.696
**Kiln soils: N-min dynamics**

**NH$_4^+$ concentration (mg N kg$^{-1}$ soil)**

- **Top soil**
  - CC
  - Adj
  - N fertilization
  - no N fertil.

- **Sub soil**
  - CC
  - Adj

**NO$_3^-$ concentration (mg N kg$^{-1}$ soil)**

- **Top soil**
  - CC
  - Adj
  - N fertilization
  - no N fertil.

- **Sub soil**
  - CC
  - Adj

**Day after N-application**

0 5 10 15 20 25 30
Climate: 30-year averages

How "Skeptics" View Global Warming

Global Land Temperature Anomaly (°C)

Year


skepticalscience.com
Climate: 30-year averages

How Realists View Global Warming

Global Land Temperature Anomaly (°C)

Year


skepticalscience.com