Effects of biochar application on soil functions: results from lab incubations, greenhouse pot experiments and field trials

Ecological soil functions

How does biochar affect these functions?
The Austrian project “BIOCHAR”

“Biochar for carbon sequestration in soils: analysis of production, biological effects in the soil and economics”
The Austrian project “BIOCHAR”

- Pyrolysis
- Incubation experiments
- Pot experiments
- Field experiments

13C labeling
Basic soil (fertility) characteristics

Effects of woodchips BC in different soil types (after 7 months in the pot experiment; n=4)

(Kloss et al., J. Plant Nutr. Soil Sci., in revision)
Basic soil (fertility) characteristics

Effects of different BC types in an acidic soil (after 7 months in the pot experiment; n=4)

(Kloss et al., J. Plant Nutr. Soil Sci., in revision)

**CAL-extractable K**

**N supplying potential**
Soil bulk density

after two field seasons (n=4)

Biochar incorporation (90 t ha⁻¹)

after 2 field seasons (Cambisol)

(Karer et al., in prep.)
Soil-water characteristic curves after two field seasons (Chernozem) (Karer et al., in prep.)
Nitrate leaching

Effects of woodchips BC in different soil types (pot experiment; n=5)
Metal mobility

Effects of woodchips BC on NH$_4$NO$_3$-extractable metals in different soil types (pot experiment; n=4)

(Kloss et al., in prep.)
Metal sorption with biochar aging

Effects of woodchips BC on metal sorption in an acidic soil (taken from the pot experiment after 0 and 15 months)
Herbicide sorption

Effects of woodchips BC on herbicide sorption in two soil types (Cambisol and Chernozem taken from the field experiments after one growing season)

Chloridazone

Terbuthylazine

(Selim et al., in prep.)
Buffering, filtering, and transformation

Organic pollutants, heavy metals, acidity, nutrients, herbicides (Selim et al., in prep.)

Herbicide desorption

Effects of woodchips BC on herbicide desorption in two soil types (Cambisol and Chernozem taken from the field experiments after one growing season)
Soil microbial community

**Biological habitat and gene pool**

**Edaphon (0-30 cm depth):**

- ~25 t ha\(^{-1}\) (~80% micro-organisms)

(Watzinger et al., Eur. J. Soil Sci., in revision)

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**Soil microbial community**

- **Chernozem (pH 6.8)**
  - ΔpH: +0.8

- **Planosol (pH 5.4)**
  - ΔpH: +0.8
  - ΔpH: -0.1

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**(A)** Planosol (pH 5.4)

**(B)** ΔpH: +1.1

**(C)** Chernozem (pH 6.8)

**(D)** ΔpH: +0.4

**Duration of the incubation / days**

**Duration of the pot experiment / days**
Biochar degradation and incorporation into microbial PLFAs

Organic C

Actinomycetal PLFAs

- Biochar label in total microbial biomass: 0.6 to 3.5%
- Estimated mean residence time of biochar: in the range of millennia (mean: 3000 years)
Conclusions

- Biochar affects multiple soil functions through effects on physical, chemical and biological processes.

- Effects are soil-specific, dependent on biochar type, and change over time.

Future research needs

- Underlying mechanisms, e.g. N fate, aging effects, etc.
- Effects on bulk density and soil structure
- Distribution / incorporation of biochar in the field
- Purpose-designed biochars
- Biochar-compost mixtures
- Long-term (field) experiments