Nutrient dynamics following biochar application to soil

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Background

• Objective:
  understand how a) inherent biochar nutrient content and b) added nutrients (fertiliser) applied to different soil types affect nutrient retention dynamics

• Implications:
  If differences in response are a function of soil type rather than biochar type, the application of biochar may need to be limited to specific soil types
Background

- Soils:
  - Acidic sand (WA)
  - Fe- and Al-rich ferrosol (NSW)

- Biochars:
  - 450°C wheat straw
  - 450°C chicken manure

- Nutrients:
  - P (as phosphate)
  - S (as sulfate)
  - N (as nitrate)

- Approaches:
  Adsorption and desorption experiments of pure biochars and biochar-soil mixture and measurements of the proportion of nutrients in solution after 48 hours

Possible biochar functions in soil

### Biological functions
- Habitat for microbes
- Increased nutrient use efficiency
- Increases recalcitrant C pool (C sequestration)

### Physical functions
- Decreases bulk density
- Influences water retention
- Alters soil thermal properties

### Chemical functions
- Cation exchange capacity
- Increases pH
- Absorbs toxic elements
Some biochar characteristics

Some soil characteristics
Nutrient release in pure biochar materials

- water-extracts
- extracts averaged over 6 sampling times to max of 240 hours

Nutrient release in pure biochar materials:
S fertiliser equivalents
Nutrient release in pure biochar materials: P fertiliser equivalents

- 0 kg ha\(^{-1}\) fertilizer
- 1 t ha\(^{-1}\) biochar
- 5 t ha\(^{-1}\) biochar

Nutrient release in pure biochar materials: N fertiliser equivalents

CM only
(no significant NH\(_4\) and NO\(_3\) in WS)
Nutrient dynamics in soil-biochar mixtures: S

**Wheat straw biochar**

- Proportion of S remaining in solution after 48 hours
- Application of S (kg ha\(^{-1}\))
- Graphs show the remaining proportion of S for different biochar types and soil combinations.

**Chicken manure biochar**

- Proportion of S remaining in solution after 48 hours
- Application of S (kg ha\(^{-1}\))
- Graphs show the remaining proportion of S for different biochar types and soil combinations.

Nutrient dynamics in soil-biochar mixtures: S

**Wheat straw biochar**

- Proportion of P remaining in solution after 48 hours
- Application of P (kg ha\(^{-1}\))
- Graphs show the remaining proportion of P for different biochar types and soil combinations.

**Chicken manure biochar**

- Proportion of P remaining in solution after 48 hours
- Application of P (kg ha\(^{-1}\))
- Graphs show the remaining proportion of P for different biochar types and soil combinations.
Summary and conclusions

• **Biochars can provide significant nutrients to soil:**
  As a function of biochar type and temperature and nutrient
  \[ S = WS_{450} < WS_{550} < CM_{450} < CM_{550} \]
  \[ P = WS_{450} < WS_{550} < CM_{450} = CM_{550} \]
  \[ N = CM_{450} \]

• **Different sorption dynamics exist for different nutrients:**
  - \( S \) = indifferent to biochar and soil type
  - \( P \) = strongly influenced by soil type, moderated by biochar
  - \( N \) = strongly influenced by both soil and biochar type

**Nitrogen + soil:**
- WA soil: retains \( \geq 20\% \) of the supplied N
- NSW soil: does not retain any of supplied N

**Nitrogen + biochars:**
- CM biochar: retains \( \geq 20\% \) of the supplied N
- WS biochar: retains \( \geq 25\% \) of the supplied N

**BUT:**
**Biochar + soil without added N:**
- WS biochar: released up to 70\% in WA and 40\% in NSW soil
- CM biochar: released up to 40\% in WA and 46\% in NSW soil
Acknowledgments


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