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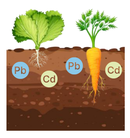
Long-Term Effects of Repeated Organic Amendment Applications on Cadmium Bioavailability: Insights from a Five-Year Pot Experiment

Comeliau S., Bergen J-C., Paquet C., Marit E., Biron P., Houtart A., Colinet G.

University of Liège - Gembloux Agro-Bio Tech (Water – Soil – Plant Exchanges, Gembloux, Belgium)

INTRODUCTION

Past industrial activities in central Belgium have led to significant atmospheric deposition of metallic **trace elements** (TE) in soils.



Vegetable production is regulated by European standards setting maximum allowable TE concentrations in food products.

Food safety is therefore a major public concern due to the transfer of metals, such as **Cd and Pb**, from soil to vegetables grown in market gardens.

Objective

To identify **remediation strategies** enabling safe vegetable production in soils impacted by low-level atmospheric contamination.

METHODS

Experimental setup

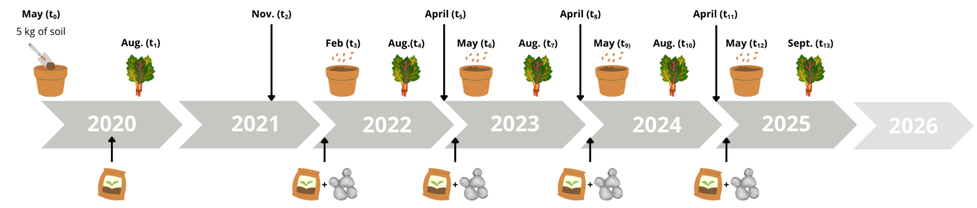
- Pot experiment (**5 kg soil per pot**) initiated in **2020** (long-term study)
- Contaminated market garden soil :
  pH (KCl) 5.0; Cd ≈ 1.5 mg·kg⁻¹ ; Pb ≈ 65 mg·kg⁻¹

Amendments

- Repeated application of :
  - **Biochar**
  - **Green waste compost**
    (150 g per 5 kg soil)
- Additional treatment since **Dec 2022** :
  - **Lime** (0, 1, 2 g per 5 kg soil)

Crop

- **Swiss chard (*Beta vulgaris*)** grown each season

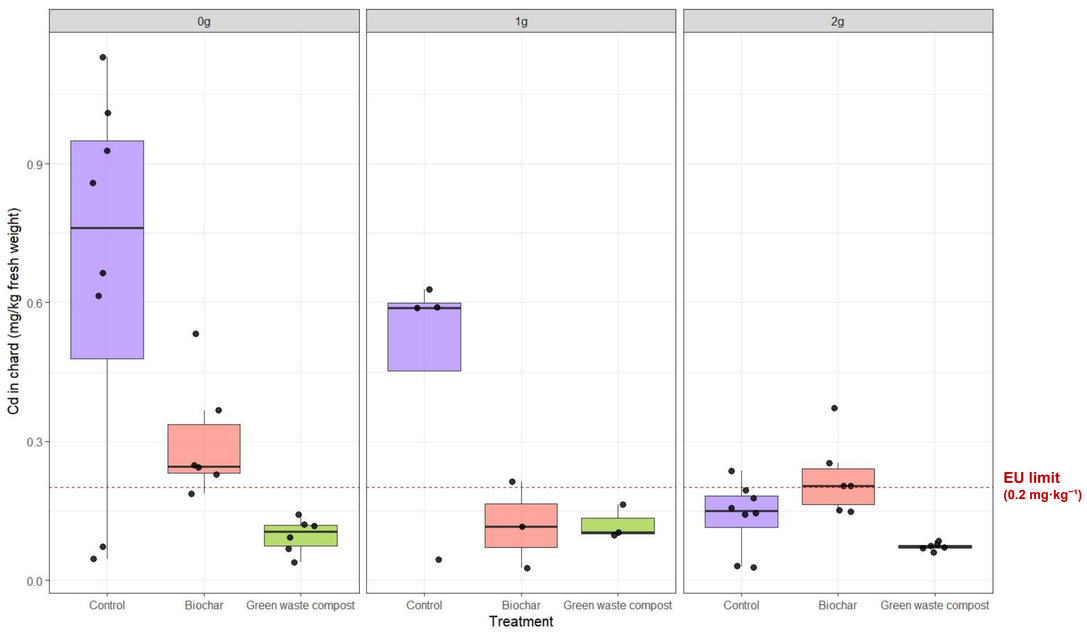


Timeline of amendment applications and cropping cycles

RESULTS

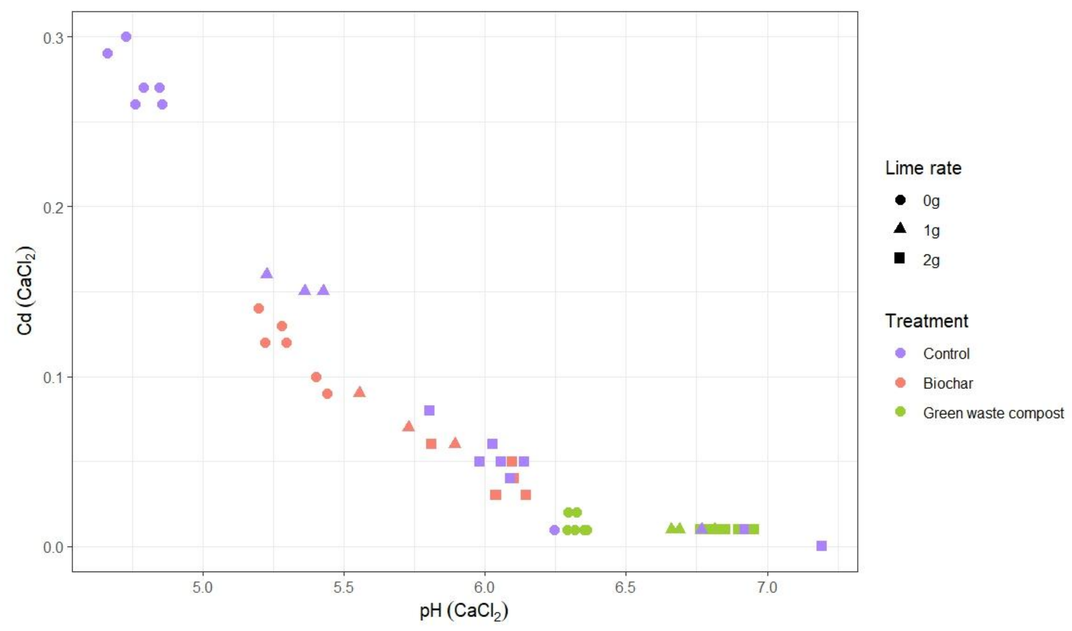
Cadmium uptake in Swiss chard (2025)

Lime application rates: 0, 1 and 2 g per 5 kg soil



- Cd concentrations in Swiss chard were strongly reduced by soil amendments
- Green waste compost resulted in Cd concentrations consistently below the EU limit
- Biochar showed moderate reductions
- High variability was observed in the control
- Increasing lime rate further decreased Cd concentrations in plants

Soil Cd availability and pH (2024)



- Extractable Cd ($CaCl_2$) strongly decreased with increasing soil pH
- All amendments contributed to reducing Cd availability
- Lime had a strong effect through soil pH increase

DISCUSSION

Interpretation

- The reduction of Cd uptake is mainly driven by soil pH increase
- Increasing pH reduces Cd solubility and mobility in soil
- Green waste compost showed the highest efficiency, likely due to pH increase and interactions with organic matter
- Biochar had a positive but more moderate effect
- The effect of amendments became apparent only after repeated applications, indicating a delayed response (data not shown)

Key messages

- Soil amendments effectively reduce Cd transfer to crops
- Cd availability is strongly controlled by soil pH
- Compost is the most effective strategy

PERSPECTIVES

- Confirm results with **2025 soil analyses (Cd availability)**
- Assess the **long-term stability** of Cd immobilization
- Investigate the respective roles of :
  - soil pH increase
  - organic matter interactions

See complementary poster: field-scale validation (3-year trial)