# What solutions to reduce uptake of trace elements by vegetables in market gardens? Lessons from multi-year field and pot experiments

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ICOBTE& ICHMET 2023 — 1st Joint International Conference in Wuppertal, Germany
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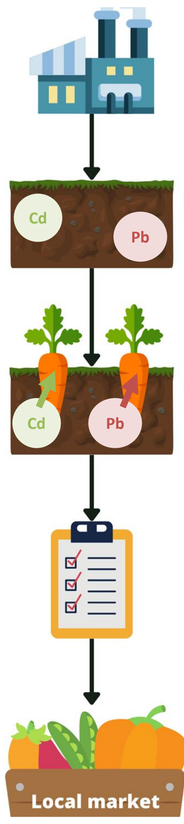
## Background




Past industrial activities in central Belgium have been responsible for large atmospheric deposition of metallic trace elements (TE) in the environment.

The commercialization of food products such as vegetables is subject to a European directive setting maximum levels for TE in foodstuffs.

Food safety has become a prominent public concern since transfers of metals such as Cd and Pb from soil to vegetables were observed in market gardens.

The research aims to identify remediation strategies allowing a safe production of vegetables in areas impacted by small atmospheric contaminations.

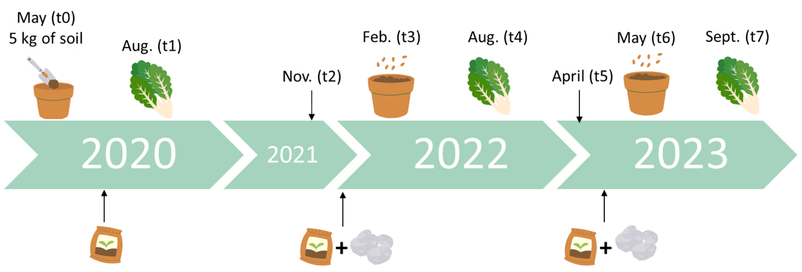
## Research questions

In order to answer the question of identifying solutions to reduce transfers of TE to vegetables, we studied the effects of incorporating conditioners (biochar, green waste compost and lime) to soil on both soil properties and plant content.

Trials were conducted in pots and field conditions to handle different levels of experimental control.

## Methods

### Multi-year pot experiment




Repeated applications of biochar (7,5 kg/m²) and green waste compost (7,5 kg/m²)

From Dec. 2022:
additional lime treatment (0 – 1 – 2 g/5 kg)

Cd – Pb uptake by Swiss chard
Soil $CaCl_2$ extractible TE and pH

### Field experiment

80 plots of 1 m²

Treatments – 10 replicates

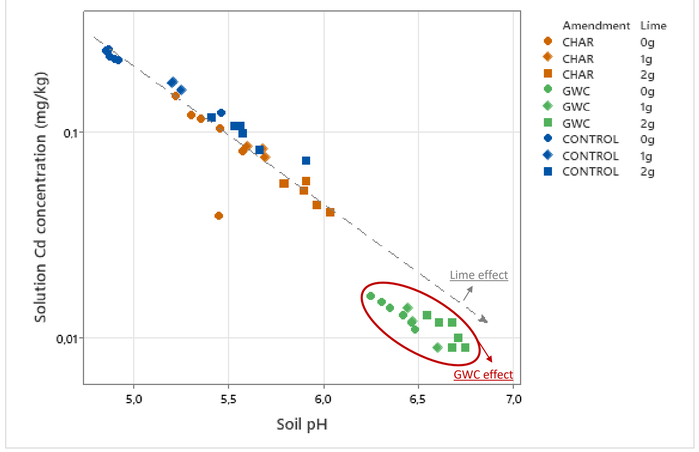
| | | | |
|---|---|---|---|
| Control | Lime 200 g/m² | GWC 5 kg/m² | Biochar 5 l/m² |
| + Additional lime treatment 200 g/m² | | | |
| Control | Lime | GWC | Biochar |
| | Lime double dose | GWC + lime | Biochar + lime |

*Lactuca sativa* L. + *Beta vulgaris* L. subsp. vulgaris

Cd uptake by Swiss chard and lettuce
Soil $CaCl_2$ extractible TE and pH

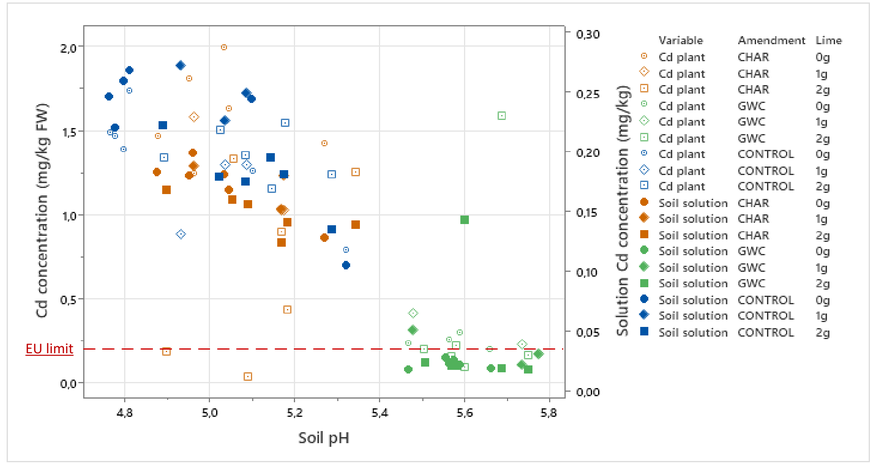
## Results

### Pot experiment



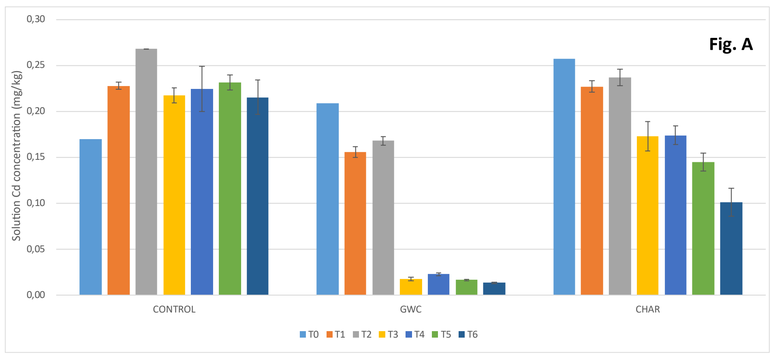

Relationship between $CaCl_2$ Cd concentration (mg/kg) and soil pH (t6) according to treatments

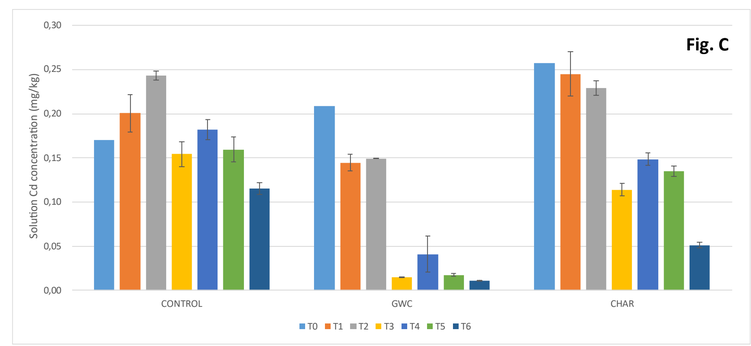
- Soil $CaCl_2$ extractible Cd depends on pH.
- Compost addition significantly increased the soil pH and hence decreased the Cd concentration. Compost however produces additional effect of Cd reduction, which is not explained by pH.
- Lime addition in respect of agricultural recommendations also contributed to pH increase but in a lesser extent than compost.
- No effects of treatments could be observed on Pb.



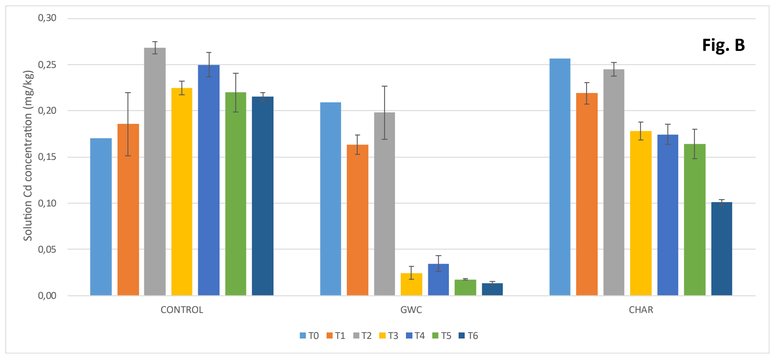

Relationship between Cd content in Swiss chard (mg/kg FW) and soil pH (t4) according to treatments

- Large variability of results was observed for plant Cd content.
- The highest Cd concentrations observed in Swiss chard are 10 times higher than the European standard (0,2 mg/kg FW).
- Green waste compost results in the lowest cadmium levels in Swiss chard. Some even comply with the maximum authorized level.
- Soil pH play a key role in controlling Cd in solution, which in turn influences cadmium levels in plants.



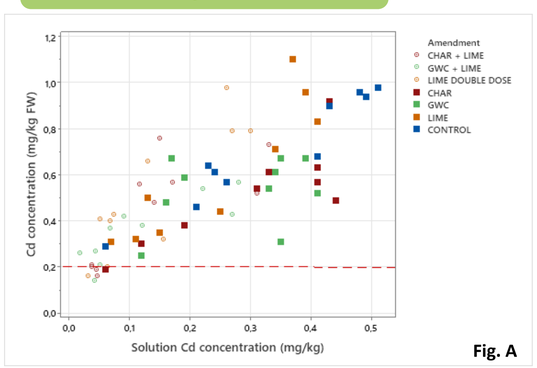




Evolution of solution Cd concentration (mg/kg) during the experimental period (t0 to t6) based on the applied lime dose. Figure A corresponds to the control, Figure B to the single dose and Figure C to the double dose of lime. The error bars represent the stand errors of the means (n = 6 for Figure A and C, n = 3 for Figure B).

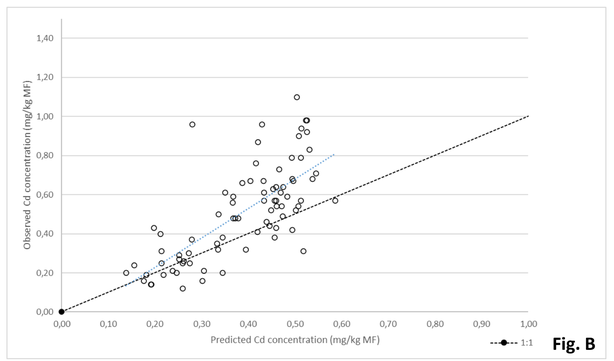



- The Cd concentration in soil $CaCl_2$ extract of the control group remains relatively stable over time (Fig. A).
- The highest reduction of Cd concentration was observed right after the second application of green waste compost. The reduction is so marked that no additional effect is observed after the third application.
- The addition of biochar reduces the Cd concentration after every application, but to a lesser extent than green waste compost.
- Liming also reduced the Cd concentration of the control group. The higher the dose, the more the soil $CaCl_2$ extractible Cd decreased. This effect is also observed in pots that received biochar. The lime effect can not be seen in pots that received compost, due to the strong effect of compost.

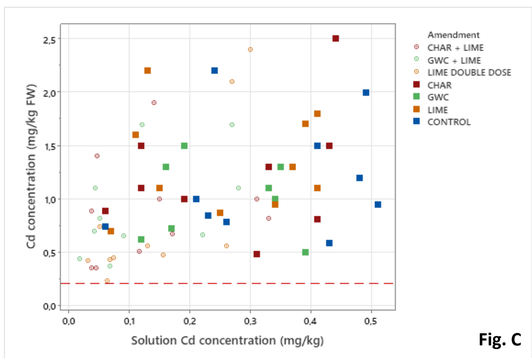
### Field experiment




Relationship between Cd content in lettuce (mg/kg FW) and $CaCl_2$ Cd concentration according to treatments




Cadmium concentrations in lettuce predicted with reference model compared to observed cadmium concentrations in field-grown lettuce.




Relationship between Cd content in Swiss chard (mg/kg FW) and $CaCl_2$ Cd concentration according to treatments

- Under field conditions, the relationship between $CaCl_2$ Cd and Cd concentration in plants is more linear for lettuce than for Swiss chard (Fig. A and C)
- Soil pH and soil cadmium content are the factors considered in the model used for risk assessment of metals transfer from soil to lettuce in the Walloon Region. As shown in Figure B, the model generally underestimates the concentrations measured in field-grown lettuce.
- For Swiss chard, the model results do not match the measured concentrations. To improve predictions, one possibility would be to incorporate the soil pH into the model equation.
- The results suggest that there must be other factors to consider for controlling the bioavailability of Cd in the field.
- These findings are mainly based on observations limited to one growing season. Repeating experiments over longer periods of time is necessary and under progress.

## Conclusions

- Soil pH seems to be one of the main levers to control Cd mobility in the context of market gardening.
- The results highlight the potential of compost to reduce Cd bioavailability and increase soil pH, especially in the pot experiment.
- Even with a low soluble Cd fraction and a soil pH close to neutral, vegetable content still exceeds the European standard.
- Pot and field experiments are performed under different conditions. Even if contaminated field soil is used in pot experiments, the experimental settings may significantly contribute to the obtained results.

## Next step

- Third harvest of Swiss chard in pots

## Perspectives

- Repeat field trials on the same plots to study the impact of organic amendments and lime additions in the long term (3 to 5 years).