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The activity has been implemented within the framework of national project
Information and providing advice on improving the quality of environment in Slovakia.
The project is cofinanced by Cohesion Fund of the EU under Operational programme Quality of Environment.

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Remediation and revitalization of trace metal contaminated garden soils using a sustainable EDTA washing technique

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Gardens with remediated soils: hazard mitigation + safe food

Garden soil project

- **Remediation**
  - EDTA soil washing [1, 2]
- **Revitalization**
  - Introducing soil amendments to revitalize washed soil [3]
- **Risk assessment and mitigation**
  - Plant selection/production and trace metal (TM) bioavailability monitoring

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FWF Der Wissenschaftsfonds.

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ENVIT environmental technologies and engineering

[1] Pociecha, M., Lestan, D., 2012. Novel EDTA and process water recycling method after soil washing of multi-metal contaminated soil. Journal of hazardous materials 201, 273–279.
[2] Voglar, D., Lestan, D., 2012. Pilot-scale washing of metal contaminated garden soil using EDTA. Journal of hazardous materials 215, 32–39.
[3] Jelusic, M., Vodnik, D., Lestan, D., 2014. Revitalization of EDTA-remediated soil by fertilization and soil amendments. Ecological engineering 73, 429–438.

Locations

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- **Arnoldstein**, mining and smelting until 1992
- 913 mg kg^{-1} Pb (Friesl-Hanl et al., 2009)
  5.6 mg kg^{-1} Cd
  545 mg kg^{-1} Zn
- Acidic soil
- Cambisols

Shot tower in Arnoldstein, a memorial for the environmental misconduct.
Pictures: www.wikipedia.org

Historic smelting activities in Prevalje (Meza Valley), captured in 1844.

- **Meza Valley**, metal smelting until 1994
- Pb 5040 mg kg^{-1} (Voglar and Lestan 2014)
  Cd 19.6 mg kg^{-1}
  Zn 3150 mg kg^{-1}
- Calcareous soil
- Fluvisols

[1] Friesl-Hanl, W., Platzer, K., Horak, O., Gerzabek, M.H., 2009. Immobilising of Cd, Pb, and Zn contaminated arable soils close to a former Pb/Zn smelter: a field study in Austria over 5 years. Environmental geochemistry and health 31, 581–594.
[2] Finzgar, N., Jez, E., Voglar, D., Lestan, D., 2014. Spatial distribution of metal contamination before and after remediation in the Meza Valley, Slovenia. Geoderma 217, 135–143.

EDTA soil washing

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- Soil washing will be done by Envit in Prevalje, Slovenia

1. Soil sieving
2. EDTA washing
3. Fe^0 addition
4. Filter pressing
5. Recycling of EDTA (95%)
6. Soil rinsing

Pictures: liferesoil.envit.si

- Efficiency for TM is 80% Pb, 40% Cd and 70 % Zn, but most of the bioavailable fraction [1]

[1] Voglar, D., Lestan, D., 2012. Pilot-scale washing of metal contaminated garden soil using EDTA. Journal of hazardous materials 215, 32–39.

Raised bed experiments

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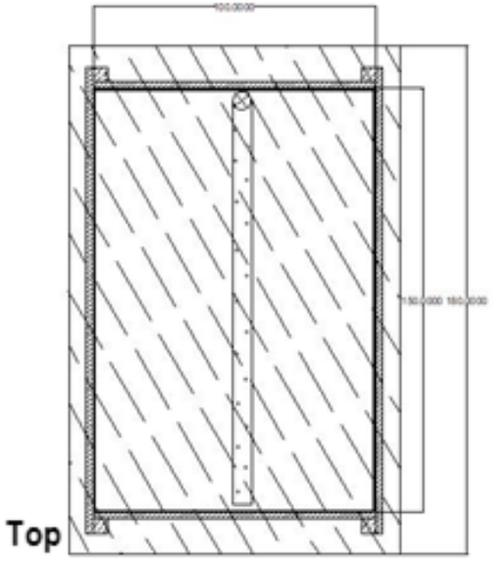
Set up

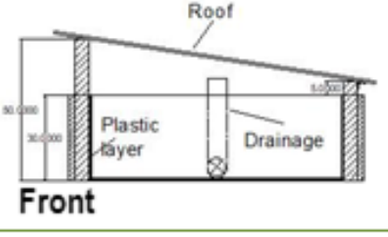
- 12 raised beds
- Similar experiments in Slovenia and Austria
- Use of different soil amendments (vermicompost, biochar, water treatment sludge)
- Cultivation of vegetables (Radish, Carrot, Spinach, Lettuce) on (un)washed soil substrate

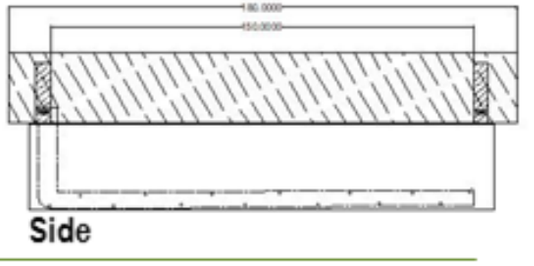
Analysis

- Plant parameters
- Trace metal (TM) bioavailability
- Collection of percolation water
- Investigating soil function ($^{13}C/^{15}N$ isotopes)

Raise bed

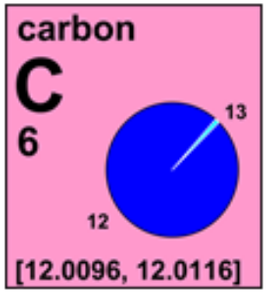




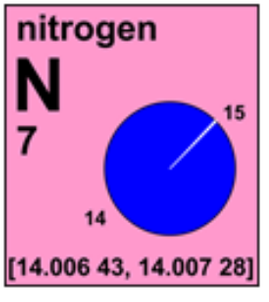


Labeling of plant material

- Pulse labeling of spinach under a high ^{13}C CO_2 atmosphere and application of ^{15}N NH_4NO_3 fertilizer



http://www.ciaaw.org/



- Applied on to the raised beds as green manure
- Investigating soil function (C, N cycle)
  - $\delta^{13}C/^{12}C$ and $\delta^{15}N/^{14}N$ in soil and plant
  - $\delta^{13}C/^{12}C$ in PLFA
  - Potentially carbon sequestration

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Present/past experiments

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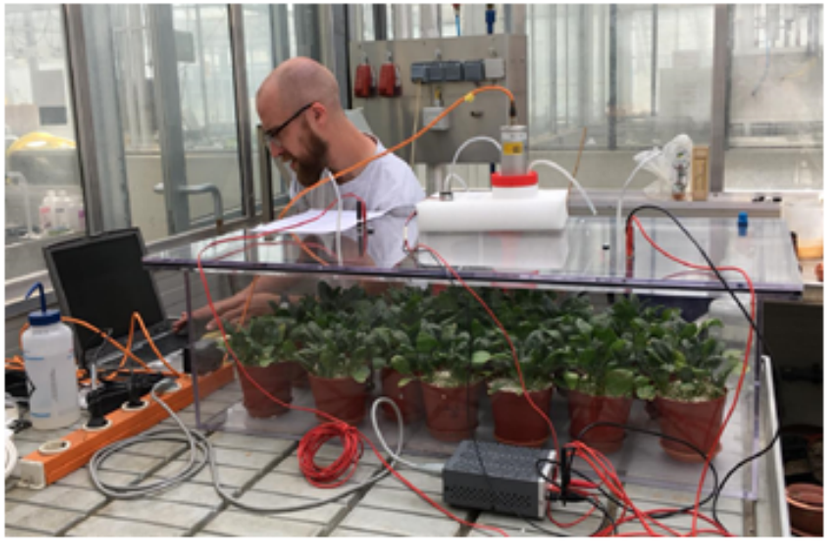
- Pulse labeling plant material (^{13}C, ^{15}N) for use in the outdoor trial



Pre trials:

- Cultivar selection
- Pot experiments investigating TM bioavailability using different soil amendments

Radish cultivar selection

- Cultivar ‘F. Breakfast’ → low uptake
- Cultivar ‘Topsi’ → high uptake
- > 50 % lower TM accumulation due to cultivar selection

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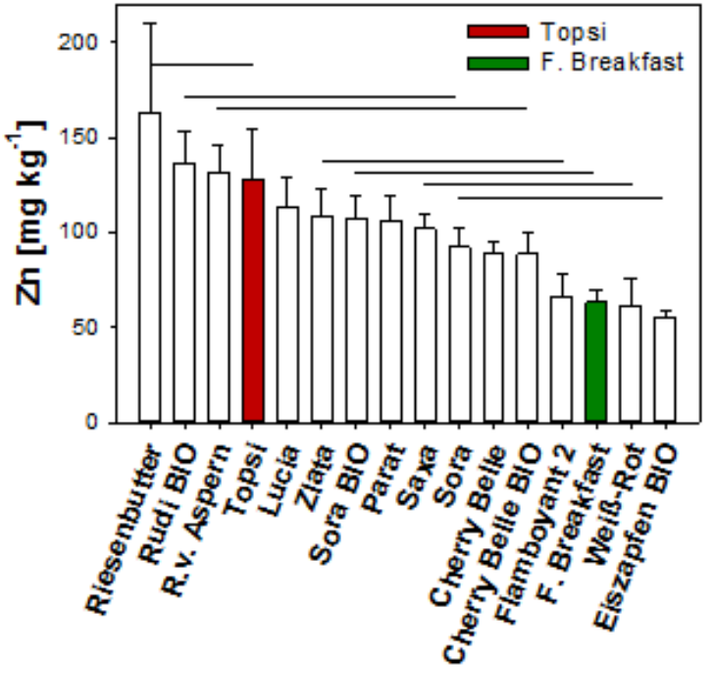

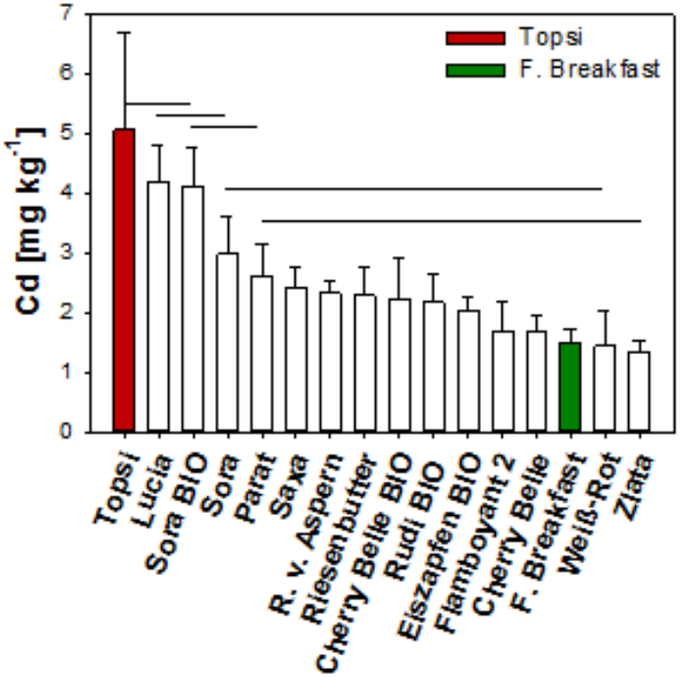

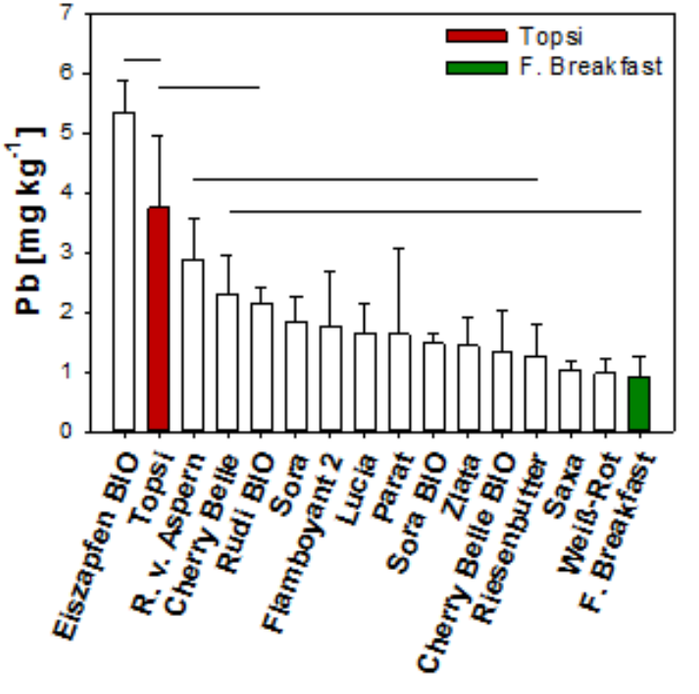

Bioavailability experiment

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Block1			
W-TSP	W-AC	W-M3	W-WTS
W-K	W-V	W-M2	U-Brkf
W-10	U-NPK	W-NPK	W-M1
U-WTS	W-Co	W-CS	U-Co
W-M4	W-C500	U-Mix	W-C800

Block2			
U-Mix	W-NPK	U-Co	W-Co
W-CS	W-WTS	U-NPK	W-M4
W-K	W-V	W-AC	W-C800
W-M1	W-10	U-Brkf	W-M3
W-TSP	W-C500	W-M2	U-WTS

Block3			
U-Brkf	W-10	W-M4	W-TSP
U-Mix	W-C800	U-NPK	W-K
W-V	W-NPK	U-Co	W-M2
U-WTS	W-M1	W-C500	W-AC
W-M3	W-WTS	W-Co	W-CS

Block4			
W-M4	W-C800	W-AC	U-NPK
W-M2	W-M3	U-WTS	U-Brkf
U-Co	W-10	W-CS	W-WTS
W-C500	W-M1	W-Co	W-NPK
W-V	W-TSP	W-K	U-Mix

Block4			
W-10	W-V	W-C500	U-Mix
U-Co	W-NPK	U-NPK	W-M3
W-Co	W-TSP	W-M4	W-CS
W-AC	W-WTS	W-M1	U-Brkf
W-C800	W-M2	W-K	U-WTS

5 wt% Compost
3 wt% Biochar
1 wt% WTS

- Radish (*Raphanus sativus L.*), Topsi cultivar
- 20 amendments, Randomized block designs (n = 5)
- Green house with drip irrigation system
- 6 weeks growth period

Results – Zn, Cd, Mn

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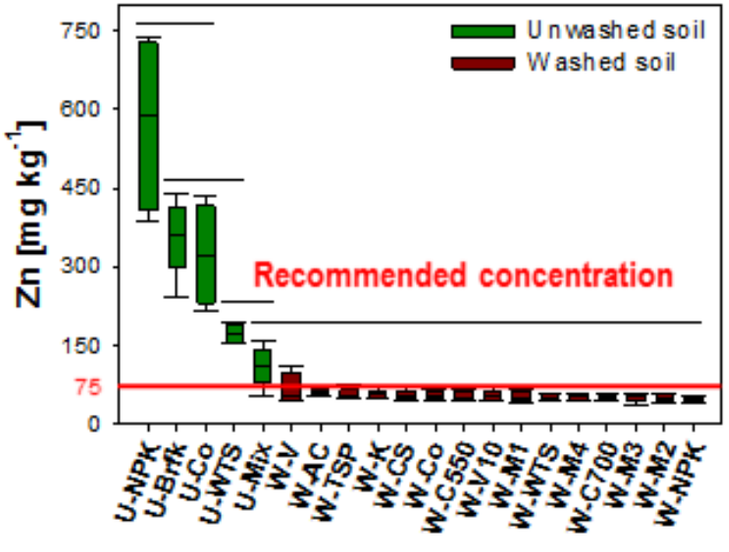
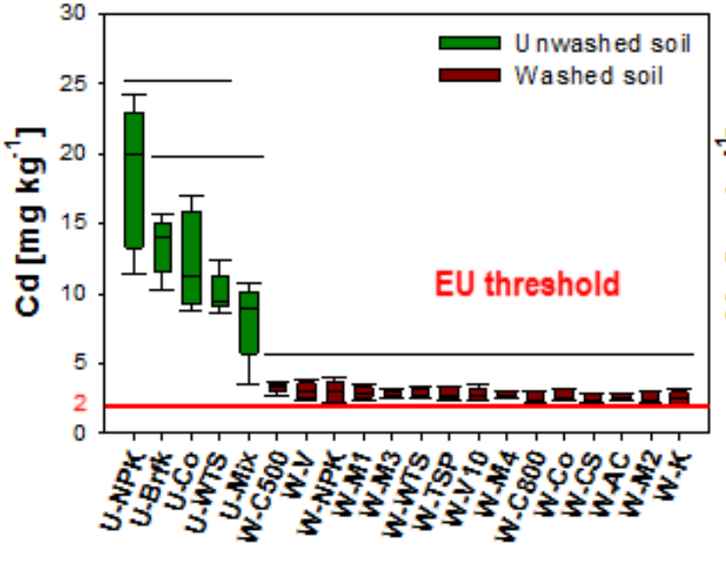
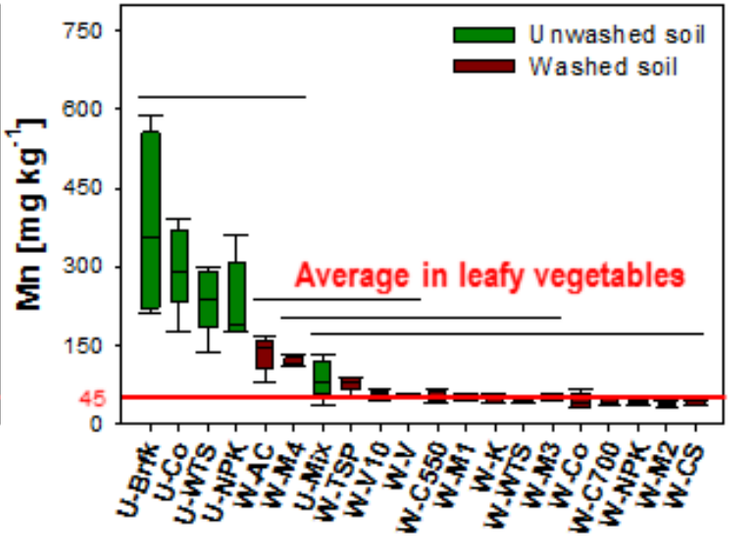
- Significant decrease in Zn, Cd and Mn uptake
- No effect of soil amendments on the TM availability in the washed soils
- NPK fertilizer enhanced TM uptake







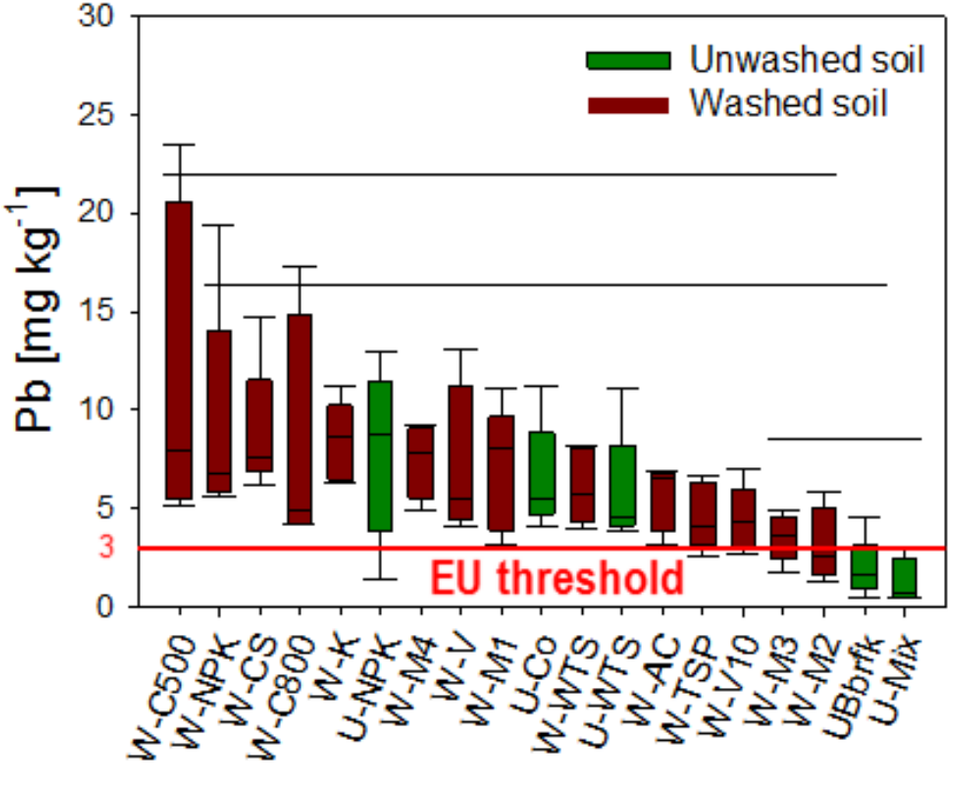
Results – Pb

- Enhanced uptake in the **washed** variants
- Lowest uptake was found in the unwashed variant, in combination with vermicompost and biochar

Variant	pH value ($CaCl_2$)	Pb [mg kg^{-1}]
Washed soil	5.65	250
Unwashed soil	5.19	969

- Possible mobile EDTA-Pb complexes need to be investigated

stability constant	Pd^{2+}	Cd^{2+}	Zn^{2+}	Mn^{2+}
log K_f	18.0	16.5	16.5	13.9



Harris, D.C., 2010. Quantitative chemical analysis. Macmillan.

Biomass production

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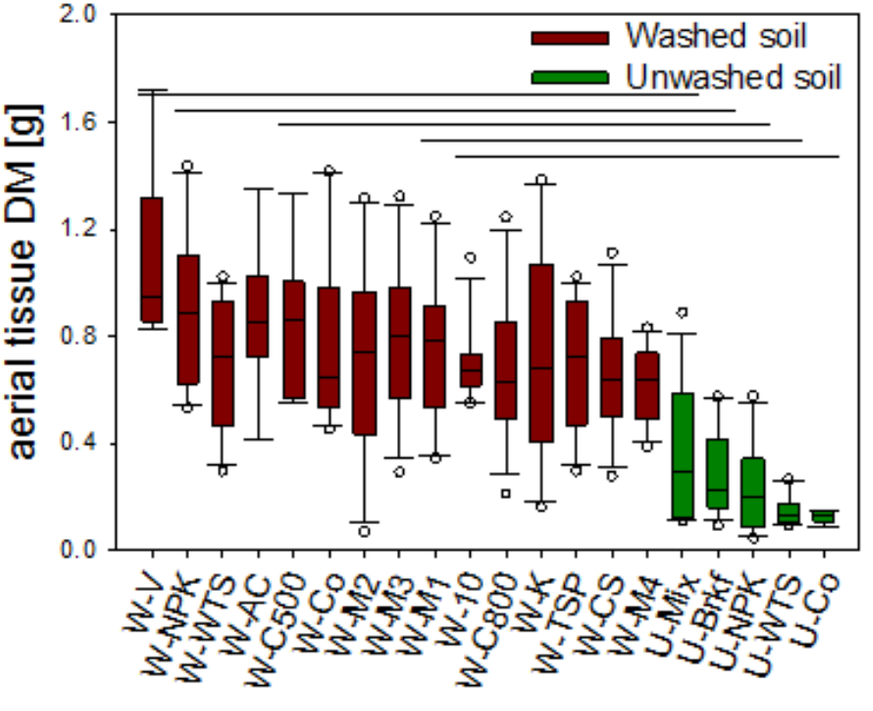
- Soil washing resulted in significantly higher plant biomass production ($p < 0.05$)



Promoting parameter

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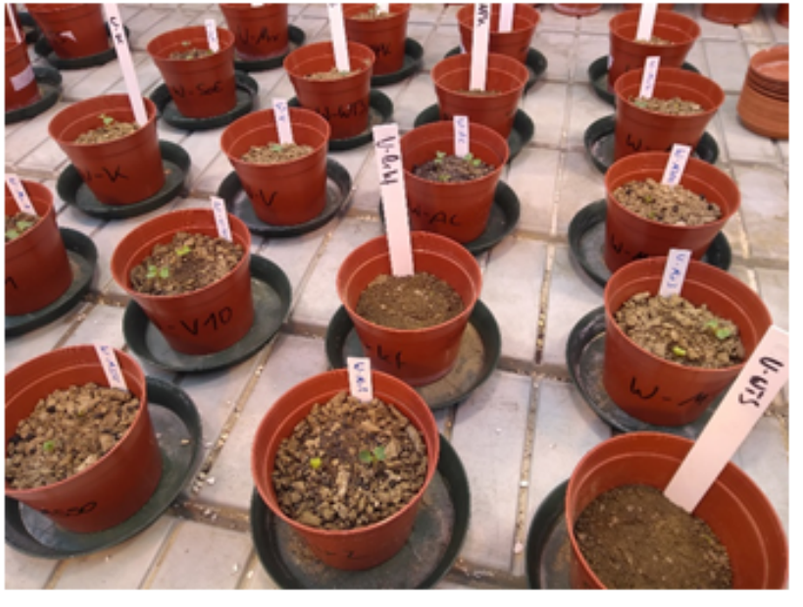
Decreased toxicity

Advanced soil structure (pellets)



Mostly macro aggregates (Dr. Vesna Zunpac, Univ. Ljubljana)

Conclusion

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- EDTA washing has the potential to decrease the concentration of TM under food security thresholds
- Soil amendments –especially vermicompost– enhance plant productivity
- Toxic effects have to be separated from the promoting increase in soil quality (nutrients, structure)

What is to come

- Nutrients contents in the washed soil
- Investigating soil structure
- Raised bed construction
- Labeling

Thank you for your attention!

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