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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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Influence of two amendments on phyto- and sanitary availability of metals in highly contaminated soils: a greenhouse study

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Introduction

Context

Essential
Non-renewable

Economic
source of raw materials

Social
living area

Environmental
Protection of humans and environment

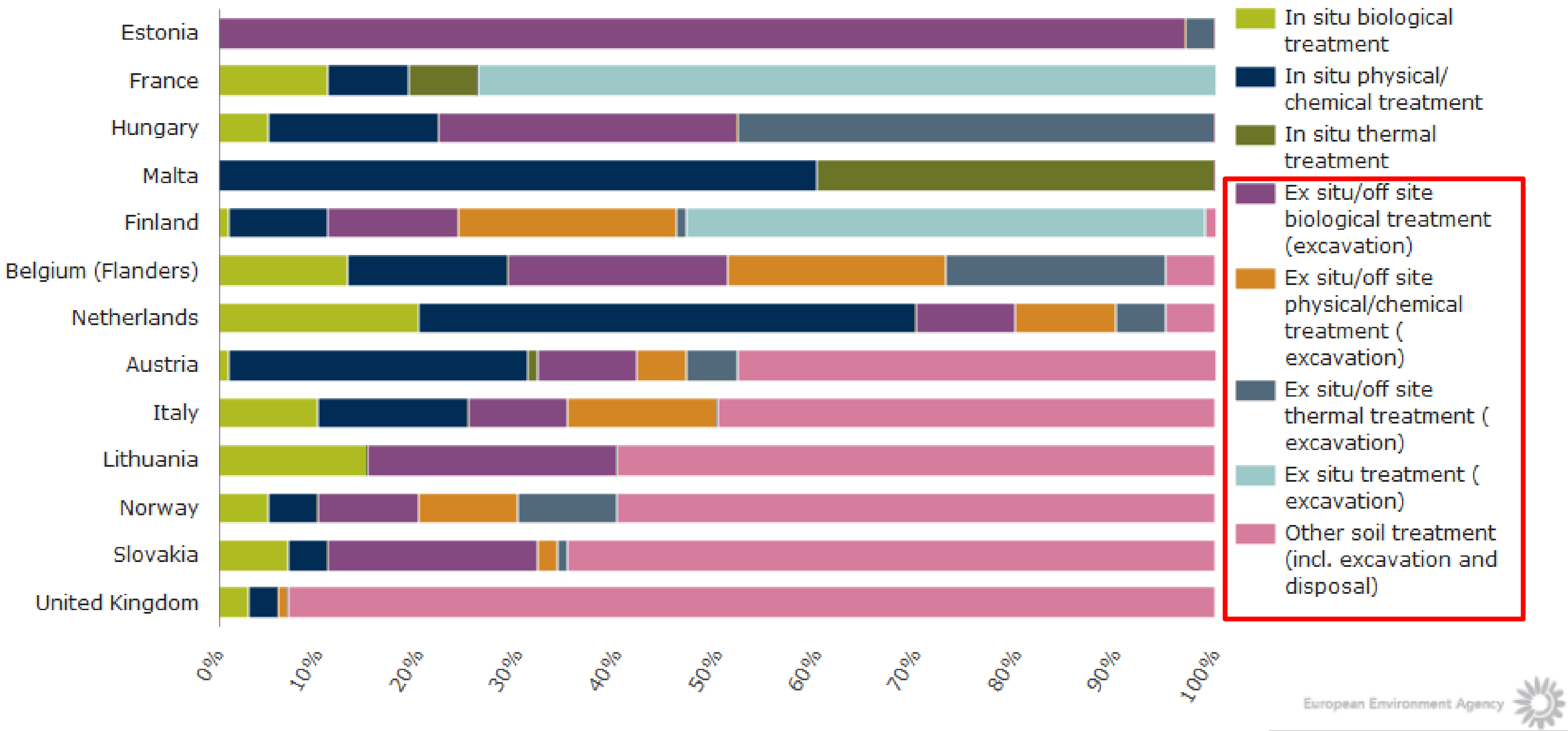
In 2006, 39 countries (Europe):

- 3 million of sites: pollutant activities
- 1.8 million of sites: potentially contaminated

Introduction

Context

Chart — Most frequently applied remediation techniques for contaminated soil



- **Inappropriate:**
  - ✓ Considerable disturbances
  - ✓ Expensive
  - ✓ Economically unfeasible on a large scale

Context

- **New technic: adding amendments to decrease the metal availability**
  phosphate compounds, liming materials, metal oxides, biochar …
  used alone or in combination

lime

iron grit

biochar

- **Objective of the work:**

Evaluate the ability of two amendments (biochar and iron grit)
to immobilize metals in contaminated soils under greenhouse conditions

Materials and methods

Soils and amendments

MAZ:
- Brownfield soil
- Old settling bassin (plastic industry)

ME:
- Agricultural soil
- Near a former lead smelter

	Cd	Pb	Zn	Cu	pH_{water}	Corg	Total $CaCO_3$
	mg kg^{-1} DW					g kg^{-1}	g kg^{-1} DW
MAZ	5	84	658	86	7.9	48	438
ME	15	812	1016	37	7.5	18	4
*Threshold**	*0.7*	*24*	*62*	*12*			

** Usual concentrations in agricultural soils*

Materials and methods

Soils and amendments

MAZ:
- Brownfield soil
- Old settling bassin (plastic industry)

ME:
- Agricultural soil
- Near a former lead smelter

Biochar (BC):
- Made from hardwood plants
- 400°C – 12 h
- < 4 mm

Iron grit (IG):
- 0.12 – 0.30 mm
- Fe: 98.3 %

	Cd	Pb	Zn	Cu	pH_{water}	CEC
	(mg kg^{-1} DW)					(cmol^{+} kg^{-1})
BC	1.0	24.2	12	12	8.4	0.9
IG	0.5	25.8	168	2490	10.4	-

Materials and methods

Experimental setup

4 treatments for each soil (2.1 kg pot^{-1}):

1) Untreated soil (T)
2) Soil + 2% (*w/w*) BC (BC)
3) Soil + 1% (*w/w*) IG (IG)
4) Soil + 2% (*w/w*) BC + 1% (*w/w*) IG (BC/IG)

Equilibrium in greenhouse during 5 weeks (75 % WHC)

→ 1.5 g of ryegrass (*lolium perenne*)

→ Harvest 6 weeks after sowing

Materials and methods

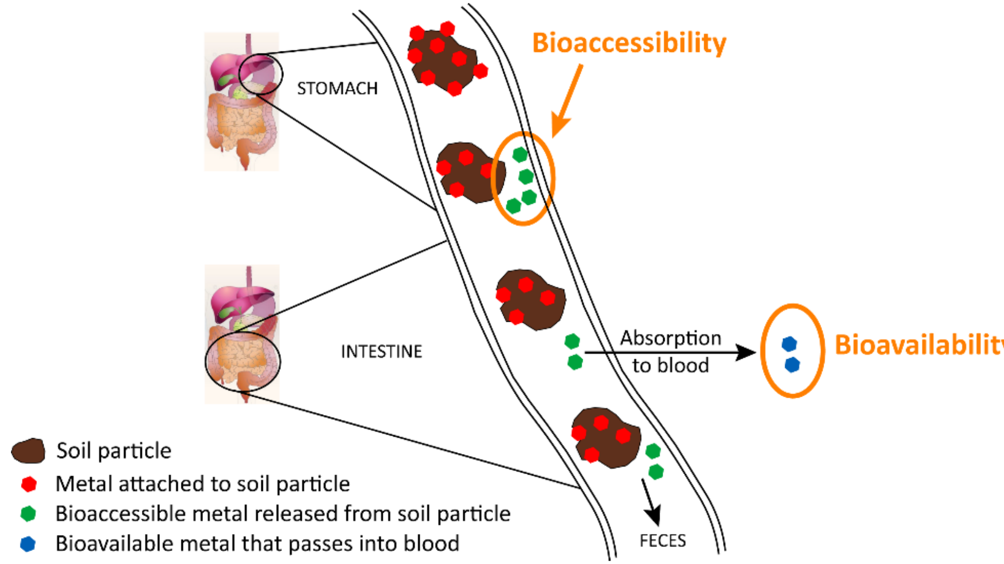
Analyses

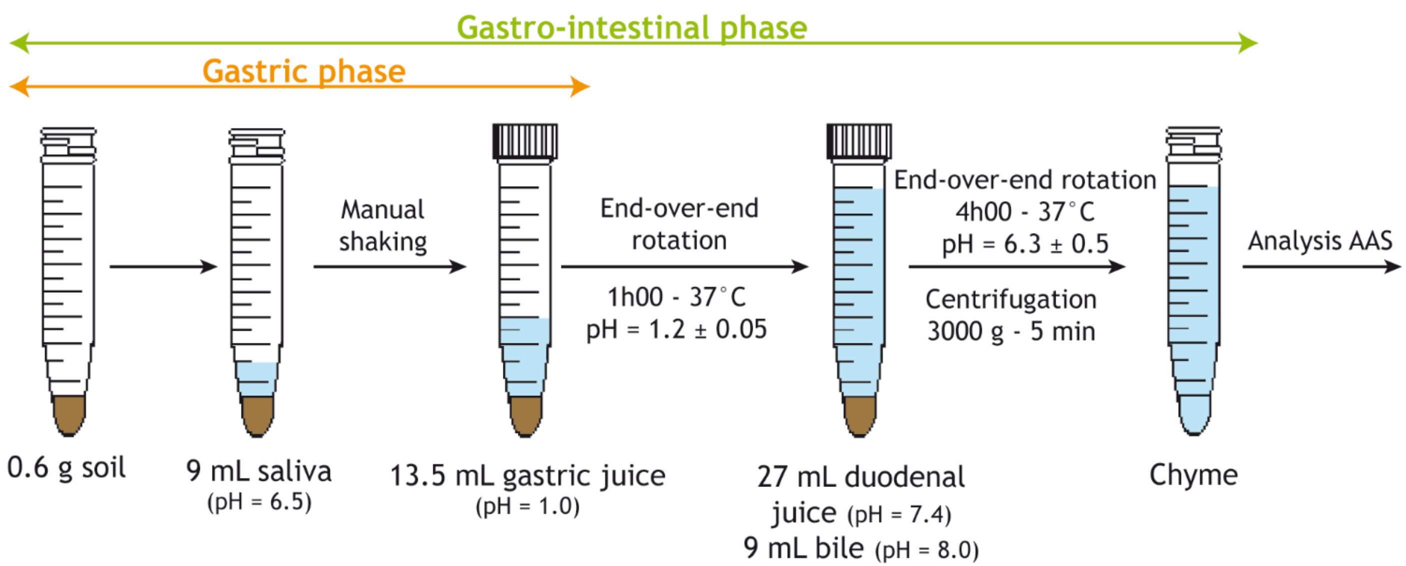
Soils:

1) Physico-chemical parameters
   (pH, CEC, total $CaCO_3$, Corg)

2) Metal pseudototal concentrations

3) Oral bioaccessibility (UBM test)





Materials and methods

Analyses

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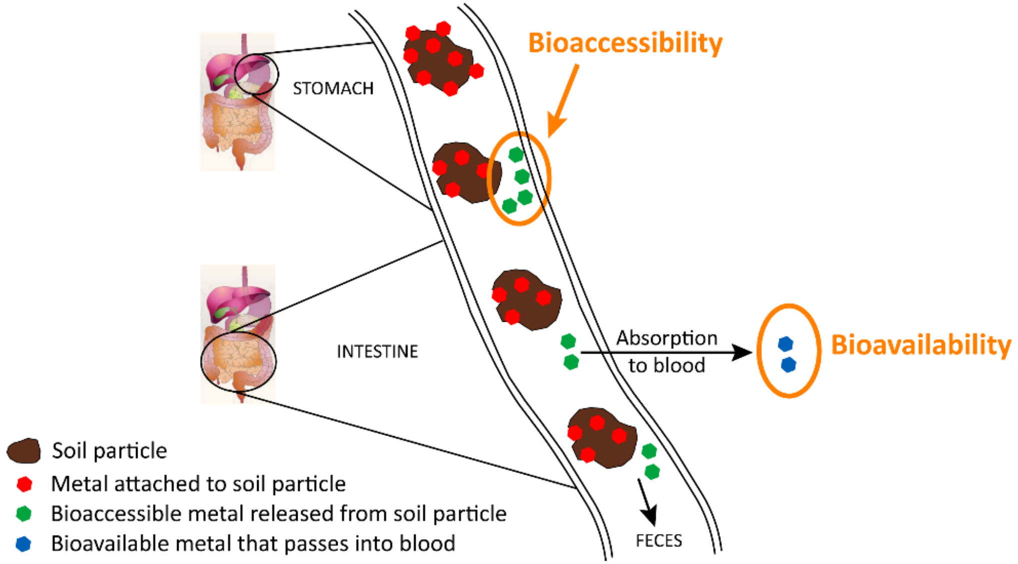


Plants:

1) Aerial biomass

2) Metal concentrations in shoots

Results

Soil physicochemical parameters

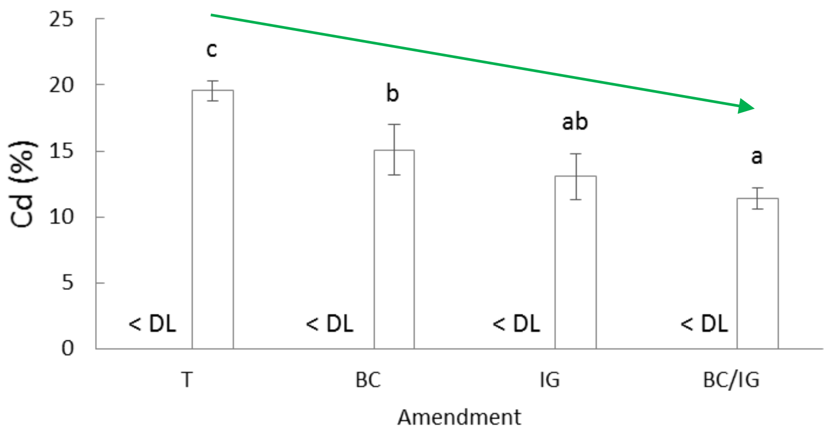
MAZ	Unamended	2 % Biochar	1 % Iron Grit	2 % Biochar + 1 % Iron Grit
pH_{water}	7.85 ± 0.05	7.93 ± 0.04	7.90 ± 0.02	7.94 ± 0.04
Total $CaCO_3$ (g kg^{-1})	457 ±19	441 ± 15	475 ± 7	380 ± 28
Corg (g kg^{-1})	44.5 ± 3.4	40.7 ± 5.9	47.4 ± 10.7	44.7 ± 2.2
CEC ($cmol^{+}$ kg^{-1})	7.9 ± 0.5	6.7 ± 0.6	7.5 ± 0.1	7.5 ± 0.2
Cd (mg kg^{-1} DW)	3.4 ± 0.8	4.2 ± 0.2	3.9 ± 0.4	3.7 ± 0.3
Pb (mg kg^{-1} DW)	62.4 ± 25.3	76.5 ± 9.5	87.2 ± 9.7	73.3 ± 5.3
Zn (mg kg^{-1} DW)	456 ± 99	531 ± 41	537 ± 67	503 ± 19
Cu (mg kg^{-1} DW)	52.4 ± 15.6	65.1 ± 5.7	98.4 ± 33.4	80.6 ± 5.5

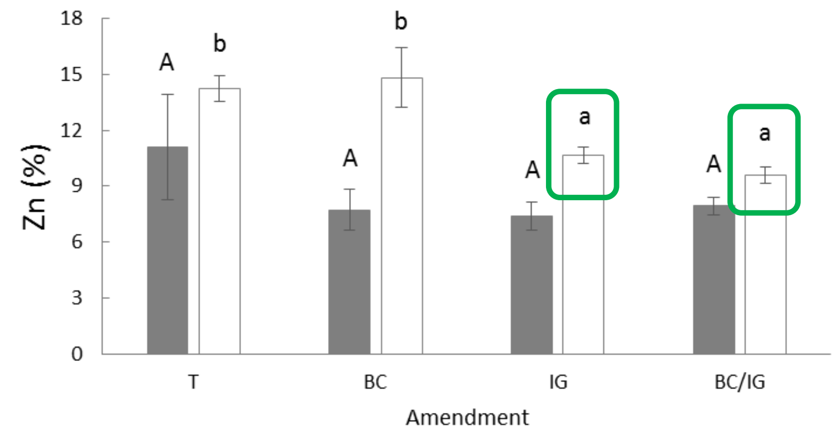
ME	Unamended	2 % Biochar	1 % Iron Grit	2 % Biochar + 1 % Iron Grit
pH_{water}	7.97 ± 0.13	7.90 ± 0.06	7.98 ± 0.04	8.02 ± 0.03
Total $CaCO_3$ (g kg^{-1})	2.96 ± 0.30	3.59 ± 0.79	2.43 ± 0.36	3.53 ± 0.38
Corg (g kg^{-1})	17.60 ± 1.26	17.02 ± 0.99	19.43 ± 0.64	20.36 ± 0.74
CEC ($cmol^{+}$ kg^{-1})	12.58 ± 0.76	12.00 ± 0.41	12.32 ± 0.65	11.80 ± 0.21
Cd (mg kg^{-1} DW)	13.8 ± 0.2	13.5 ± 0.2	12.9 ± 0.4	12.5 ± 1.0
Pb (mg kg^{-1} DW)	763 ± 12	755 ± 20	690 ± 32	671 ± 42
Zn (mg kg^{-1} DW)	971 ± 23	953 ± 31	893 ± 18	885 ± 18
Cu (mg kg^{-1} DW)	32.0 ± 0.6 a	30.8 ± 1.8 a	51.9 ± 10.1 b	51.4 ± 3.9 b

High [Cu] in IG

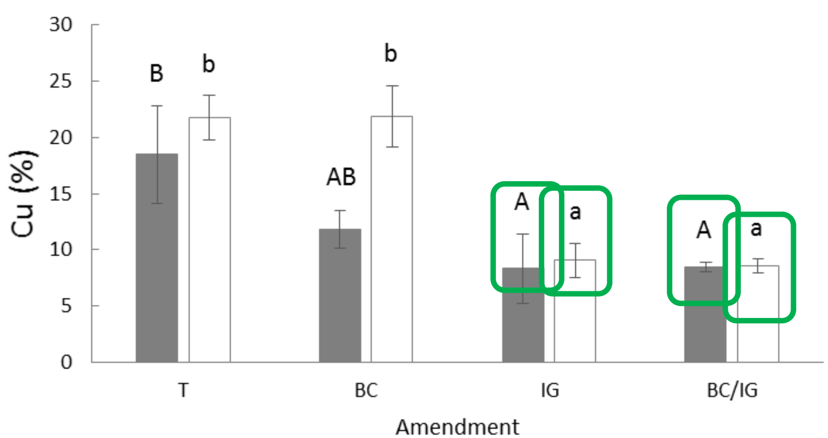
Results

Metal phytoavailability





■ MAZ □ ME



- MAZ:
  - ✓ ↘ with IG (alone or in combination) for Cu
- ME:
  - ✓ ↘ with the 3 amendments for Cd
  - ✓ ↘ with IG (alone or in combination) for Zn and Cu

Results

Plant biomass (g pot^{-1})

	MAZ	ME
T	8.43 ± 0.33	8.21 ± 0.49
BC	9.50 ± 0.66	8.02 ± 0.26
IG	9.83 ± 0.29	8.50 ± 0.23
BC/IG	9.60 ± 0.72	8.66 ± 0.66

Better conditions for ryegrass ?

↘ *$[Cu]_{ryegrass}$ in amended soils*

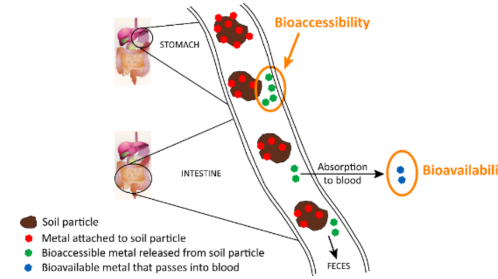
Nutrient supply with amendments?

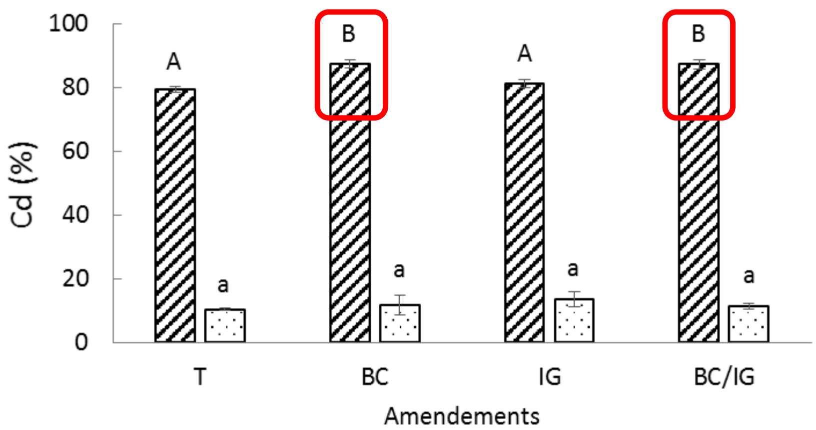
Despite lower
metal phytoavailability

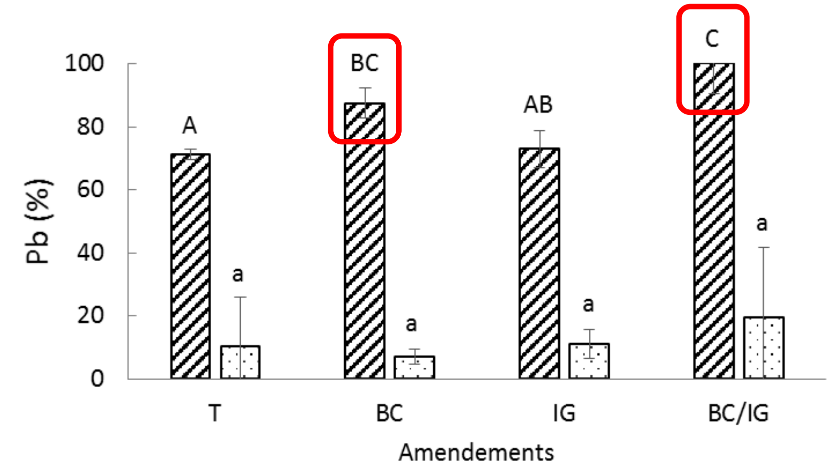
Maximum yield in this soil ?

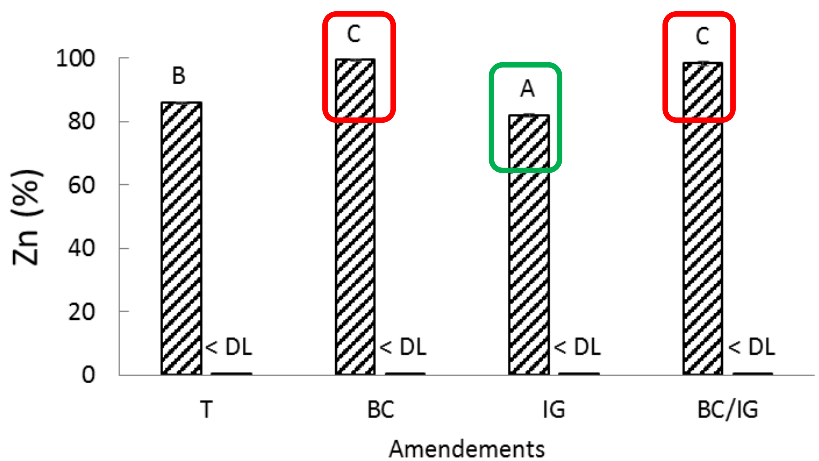
Results

Oral bioaccessibility – MAZ soil







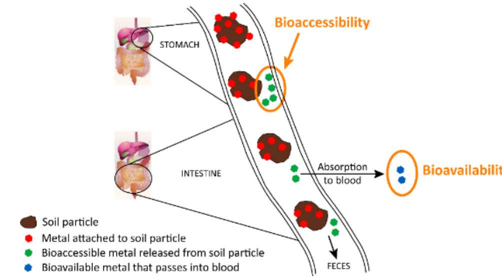


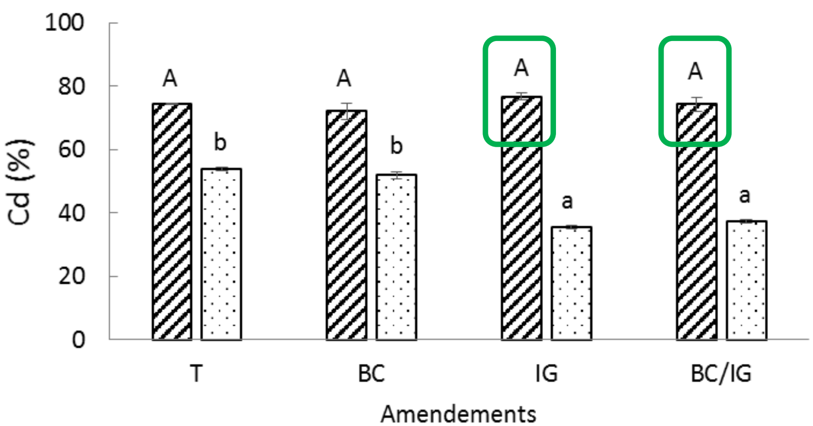
- Gastric phase:
  - ✓ ↗ with BC (alone or in combination) for Cd, Pb and Zn
  - ✓ ↘ with IG for Zn

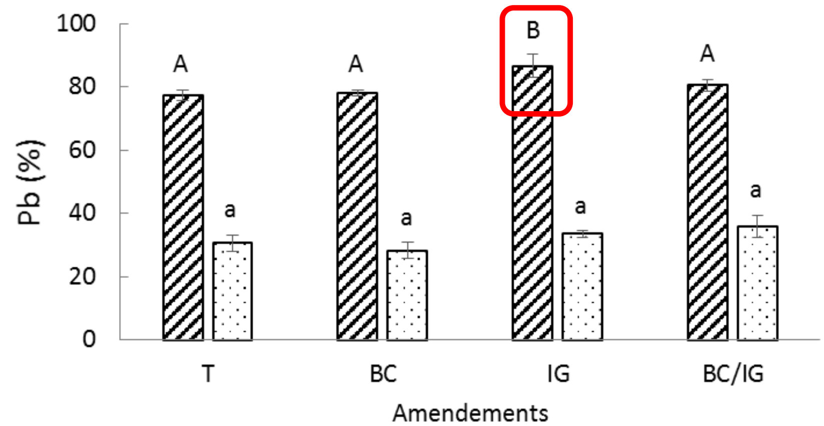
- Gastrointestinal phase:
  - ✓ No effect

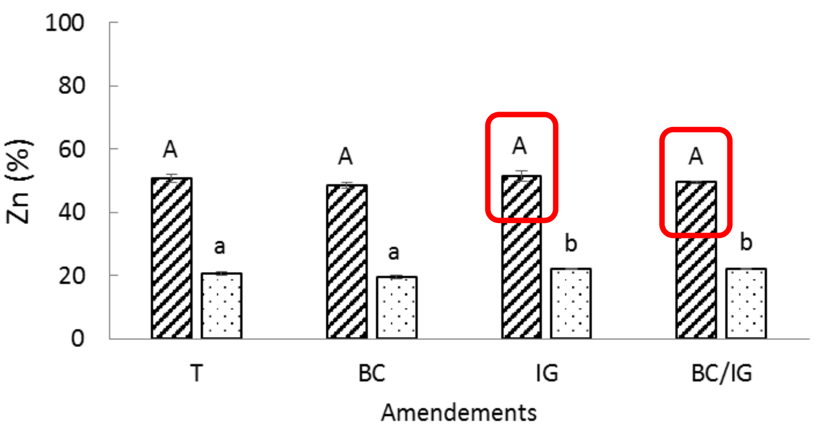
Results

Oral bioaccessibility – ME soil









- Gastric phase:
  - ✓ ↗ with IG for Pb
- Gastrointestinal phase:
  - ✓ ↘ with IG (alone or in combination) for Cd
  - ✓ ↗ with IG (alone or in combination) for Zn

Conclusion

MAZ	ME
Phytoavailability	
IG : ↘ Cu	BC/IG : ↘ Cd
	IG : ↘ Zn and Cu
Biomass	
IG : ↗	/
Oral bioaccessibility : gastric phase	
BC : ↗ Cd, Pb and Zn	IG : ↗ Pb
IG : ↘ Zn	
Oral bioaccessibility : gastrointestinal phase	
/	IG : ↘ Cd
	IG : ↗ Zn

Conclusion

1. Different efficiency according to the soil and the metal tested

phytoavailability ≠ sanitary availability

IG more efficient

Contradictory results

2. Tests should be choose according to the future use of the site

3. Importance of *ex situ* tests before applying amendments in the field

Thank you for your attention

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