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Immobilization of heavy metal in contaminated mine technosols using biochar: A phytomanagement strategy

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Biochar II: Production, Characterization and Applications
Cetraro (Calabria), Italy
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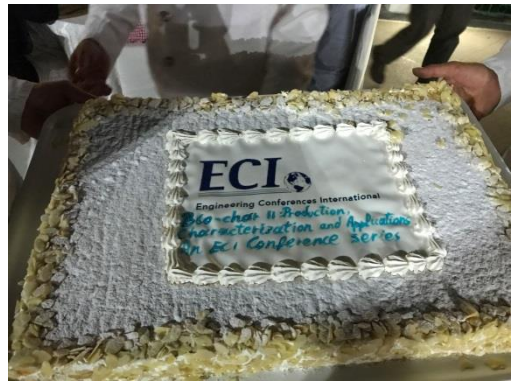
Immobilization of heavy metals in contaminated mine technosols using biochar: A Phytomanagement strategy



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IDDEA

What is soil pollution?

A soil, is considered contaminated when :

-Its chemical state deviates from the normal composition (Kabata-Pendias 2011)

-When it has lost its function (JRC Technical Reports, 2016)

- And lastly when abnormal levels of contaminants become **detrimental** to human health (Rodriguez-Eugenio et al. 2018).

Detrimental effects caused by metal(loid)s depend mainly on their biovalability?

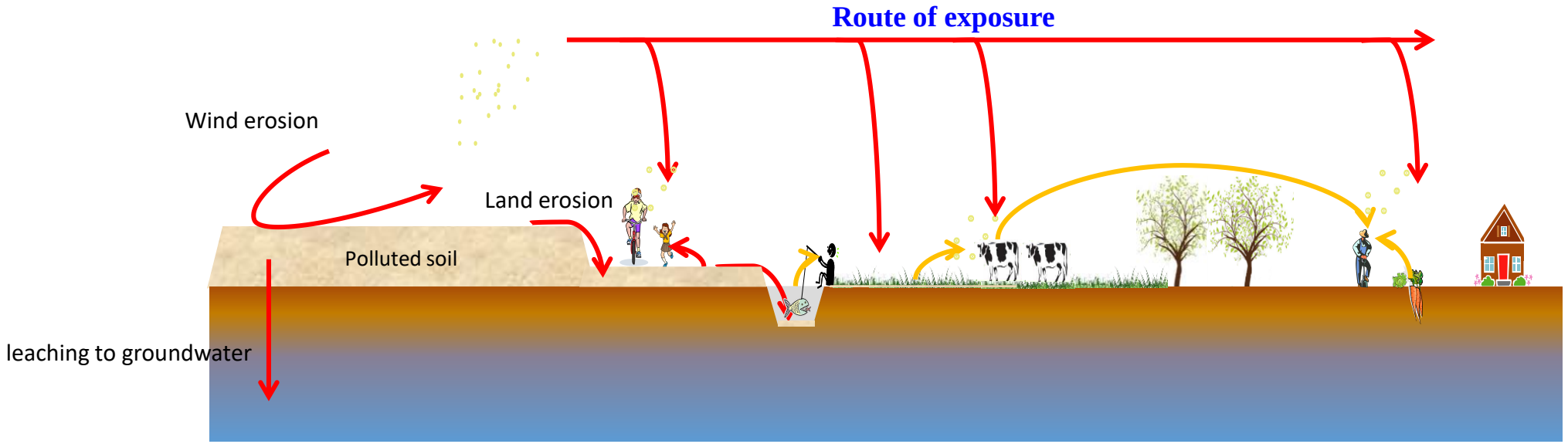
Bioavailability is defined as the fraction of pollutant that, within a given time span, is available or will be made available for its uptake by plants and other organisms (Peijnenburg and Jager 2003)

Bioavailability depends on the physical, chemical and biological properties of the soil (Rodriguez-Eugenio et al. 2018).

In conclusion

- a soil can present very high levels of pollution but this pollution can be poorly available (Because bound to the residual fraction of the soil) → low risk for the environment
- a soil having a low total metal(loid) concentrations with a high bioavailability will represent a high risk for the environment

What are the pathways of pollutant transfer to the environment?



Sources: concentration of metals and metalloids

Vectors: direct transfer of substances (aerosols, soils, plants)

Vectors: indirect transfer of substances (plants, meat, etc.)

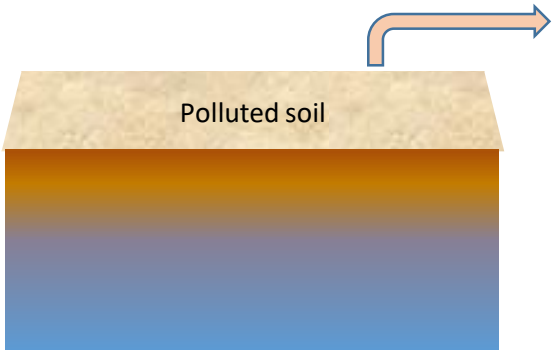
Target groups: biosphere

How to limit the transfer of pollutants (metals and metalloids) to the environment?

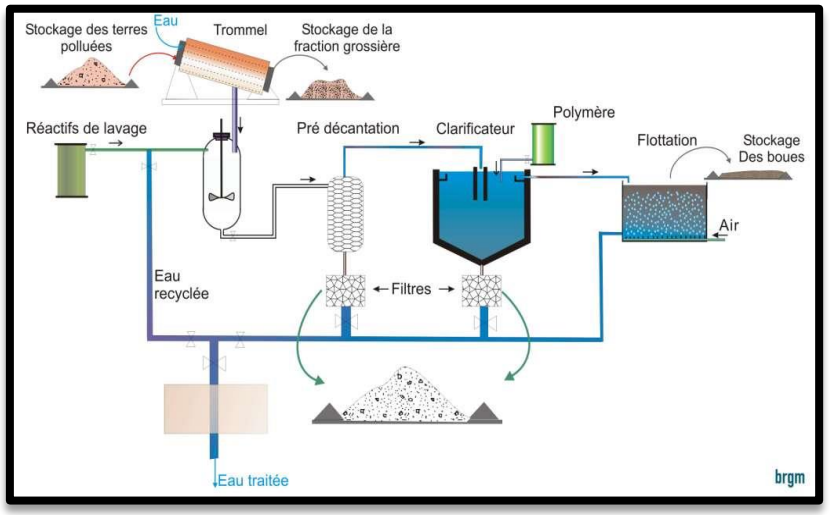
Remediation techniques

- Physico-chemical and thermal techniques.

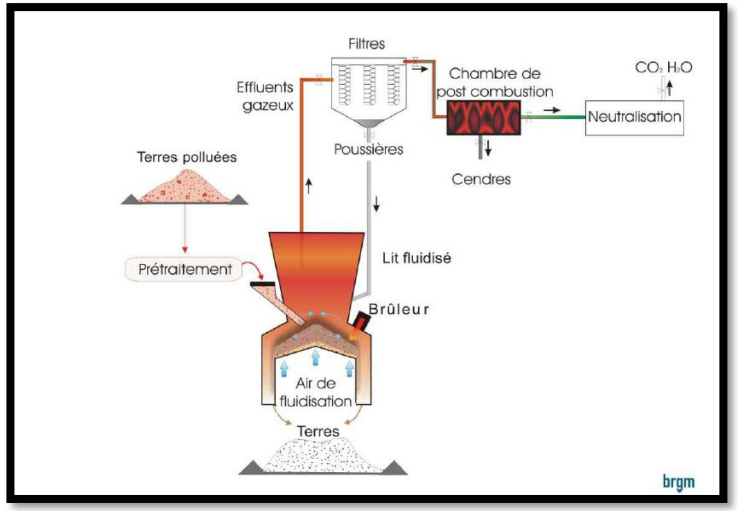
Excavate the soil



ex-situ soil cleaning



ex-situ incineration of soils



- Many constraints (difficult to set up on large surfaces, costly, disturb the balance of the soils,...).






There is an environmentally-friendly technology to economically remediate mining soil containing important concentration of As and Pb

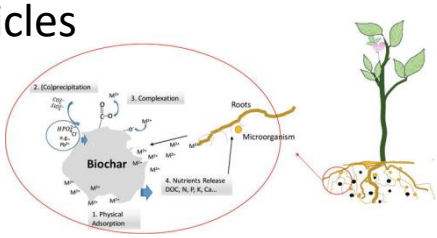
The main point consist to stabilize the pollutants in the soil and to allow the growth of plants

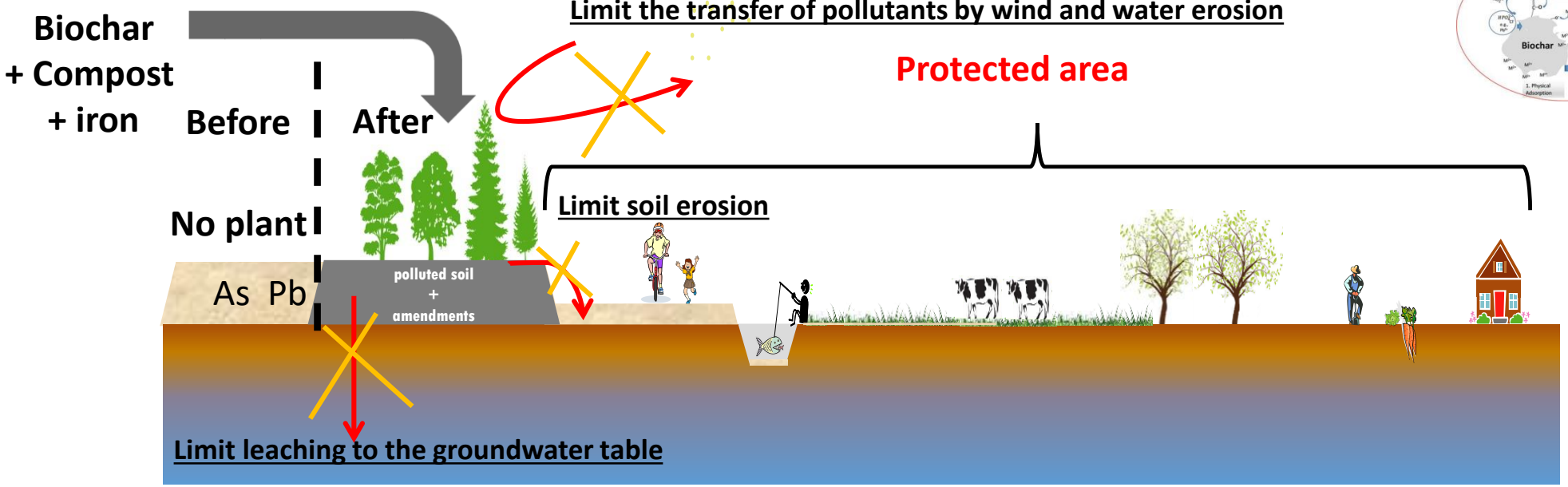
Using aided phytostabilization (**using amendments- Biochar**)

Considering that we produce a valuable biomass

PHYTOMANAGEMENT

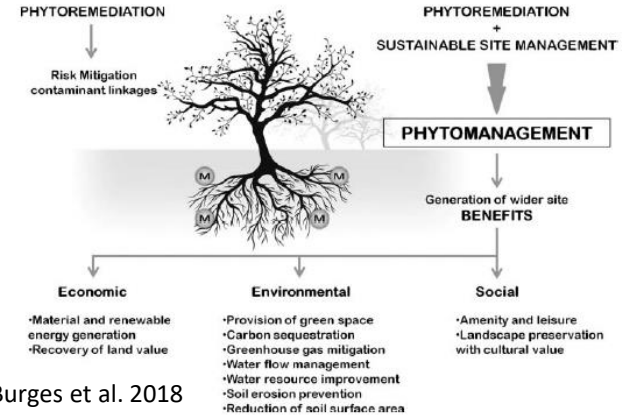
Addition of amendments to the soil ➡ Stabilize pollutants : on the amendment and on the soil particles





❖ When added to a soil it :

-Increase soil water holding capacity
-Provide nutrients
-Will decrease pollutant concentration in soil pore water
-Will make pollutant not phytoavailable
-Will increase soil microorganisms diversity and quantity

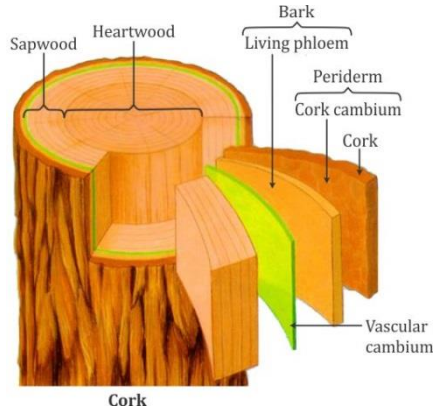


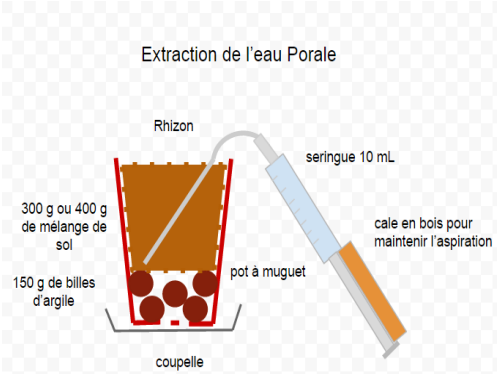
Aritz Burges et al. 2018

Mesocosm experiment

Preliminary mesocosm tests using an As and Pb polluted soil

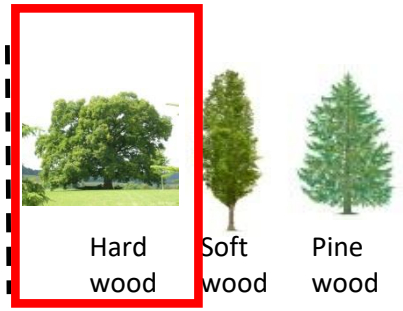
- Which biochar feedstock modulates the availability of As and Pb in the soil pore water?



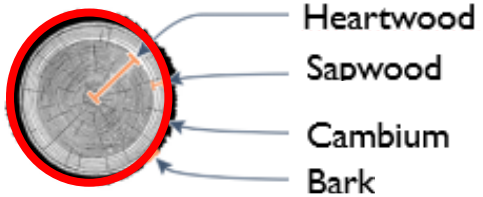


- Phytotoxicity test: using *Phaseolus vulgaris.*
  - → growth and final biomass
  - → Measured As and Pb concentration in the different plant organs

Preliminary mesocosm results



Wood feedstock



Tissues

Granulometry

Biochar with fine grain size is the most efficient to stabilize Pb but not for As.
For As addition of Iron sulfate

Contents lists available at ScienceDirect
Chemosphere
journal homepage: www.elsevier.com/locate/chemosphere

Assisted phytostabilization of a multicontaminated mine technosol using biochar amendment: Early stage evaluation of biochar feedstock and particle size effects on As and Pb accumulation of two *Salicaceae* species (*Salix viminalis* and *Populus euramericana*)

Manhattan Lebrun [a, b], Florie Miard [a], Romain Nandillon [a], Jean-Christophe Léger [c], Nour Hattab-Hambli [a], Gabriella S. Scippa [b], Sylvain Bourgerie [a], Domenico Morabito [a, *]

Contents lists available at ScienceDirect
Chemosphere
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Biochar effect associated with compost and iron to promote Pb and As soil stabilization and *Salix viminalis* L. growth

Manhattan Lebrun [a, b], Florie Miard [a], Romain Nandillon [a, c, d, e], Gabriella S. Scippa [b], Sylvain Bourgerie [a], Domenico Morabito [a, *]

RESEARCH PAPER
Soil
CLEAN Soil Air Water
www.clean-journal.com

Effect of Biochar and Amendments on Pb and As Phytotoxicity and Phytoavailability in a Technosol

*Romain Nandillon, Florie Miard, Manhattan Lebrun, Marie Gaillard, Stéphane Sabatier, Sylvain Bourgerie, Fabienne Battaglia-Brunet, and Domenico Morabito**

Contents lists available at ScienceDirect
Journal of Environmental Management
journal homepage: www.elsevier.com/locate/jenvman

Research article

Mobility of Pb, Zn, Ba, As and Cd toward soil pore water and plants (willow and ryegrass) from a mine soil amended with biochar

Marie-Paule Norini [a, *], Hugues Thouin [a], Florie Miard [c], Fabienne Battaglia-Brunet [a, b], Pascale Gautret [a], Régis Guégan [a], Lydie Le Forestier [a], Domenico Morabito [c], Sylvain Bourgerie [c], Mikael Motelica-Heino [a]

ENVIRONMENTAL FUNCTIONS OF BIOCHAR

Cd, Pb, and Zn mobility and (bio)availability in contaminated soils from a former smelting site amended with biochar

Tania Lomaglio [1,2] · Nour Hattab-Hambli [1] · Florie Miard [1] · Manhattan Lebrun [1,2] · Romain Nandillon [1,2] · Dalila Trupiano [2] · Gabriella Stefania Scippa [2] · Armand Gauthier [4] · Mikael Motelica-Heino [3] · Sylvain Bourgerie [1] · Domenico Morabito [1]

Environmental Science and Pollution Research
https://doi.org/10.1007/s11356-018-3247-9
RESEARCH ARTICLE

Effect of Fe-functionalized biochar on toxicity of a technosol contaminated by Pb and As: sorption and phytotoxicity tests

Manhattan Lebrun [1,2] · Florie Miard [1] · Sullivan Renouard [3] · Romain Nandillon [1] · Gabriella S. Scippa [2] · Domenico Morabito [1] · Sylvain Bourgerie [1]

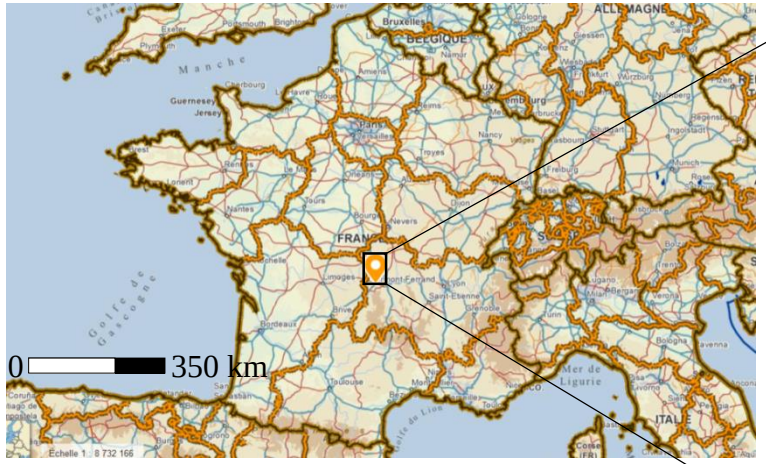
Contents lists available at ScienceDirect
Journal of Geochemical Exploration
journal homepage: www.elsevier.com/locate/gexplo

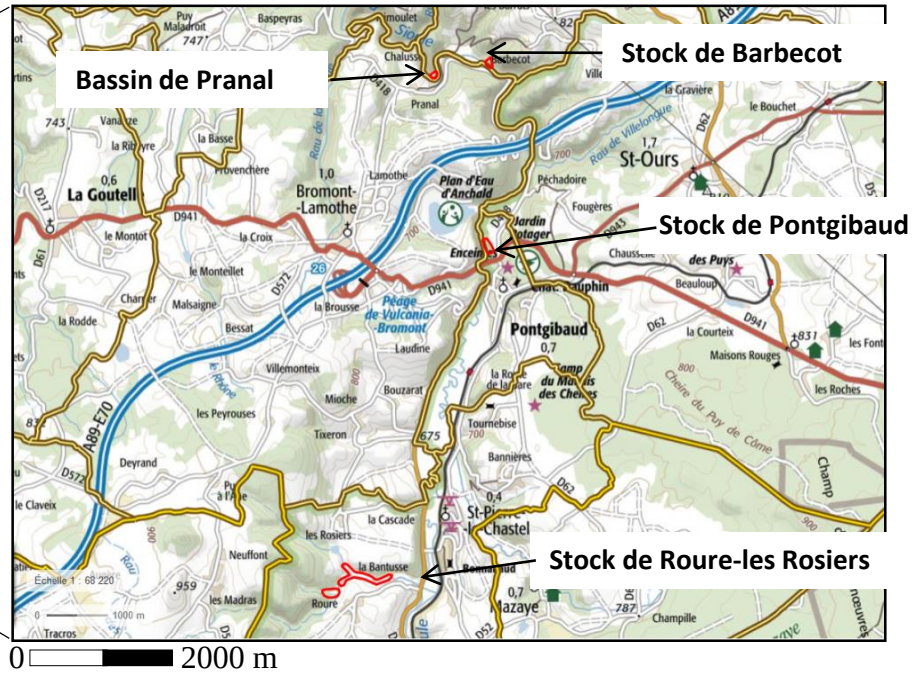
Effect of biochar amendments on As and Pb mobility and phytoavailability in contaminated mine technosols phytoremediated by *Salix*

Manhattan Lebrun [a,c], Carmelo Macri [a], Florie Miard [a], Nour Hattab-Hambli [a], Mikael Motelica-Heino [b], Domenico Morabito [a,*], Sylvain Bourgerie [a]

Field experiment

Field experiment: Pontgibaud (France) Pb and As polluted soil

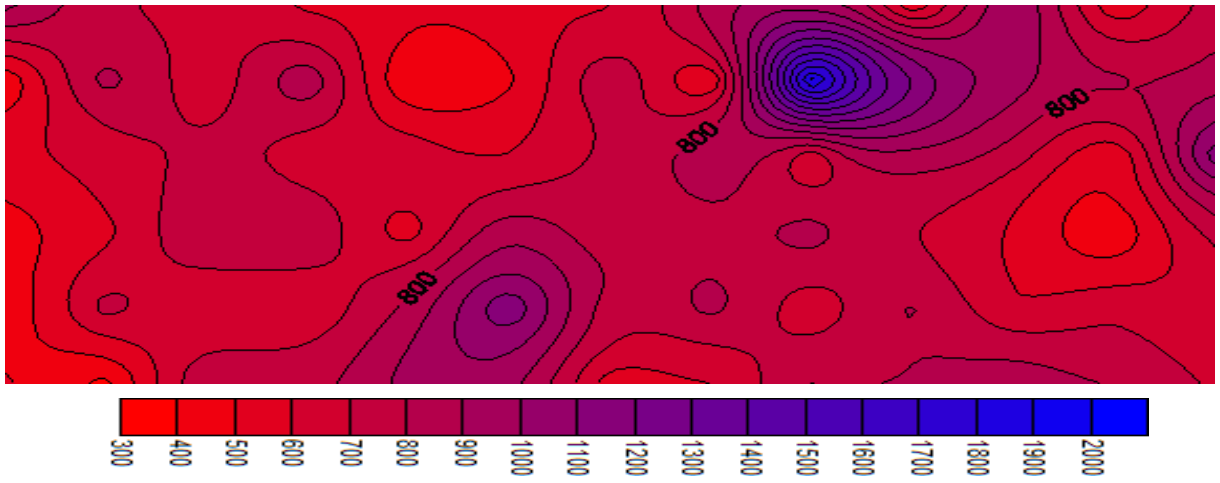




- Average altitude of 700 m
- Rainfall 770 mm
- Temperatures ranging from +40°C to -20°C.
- Sandy texture.

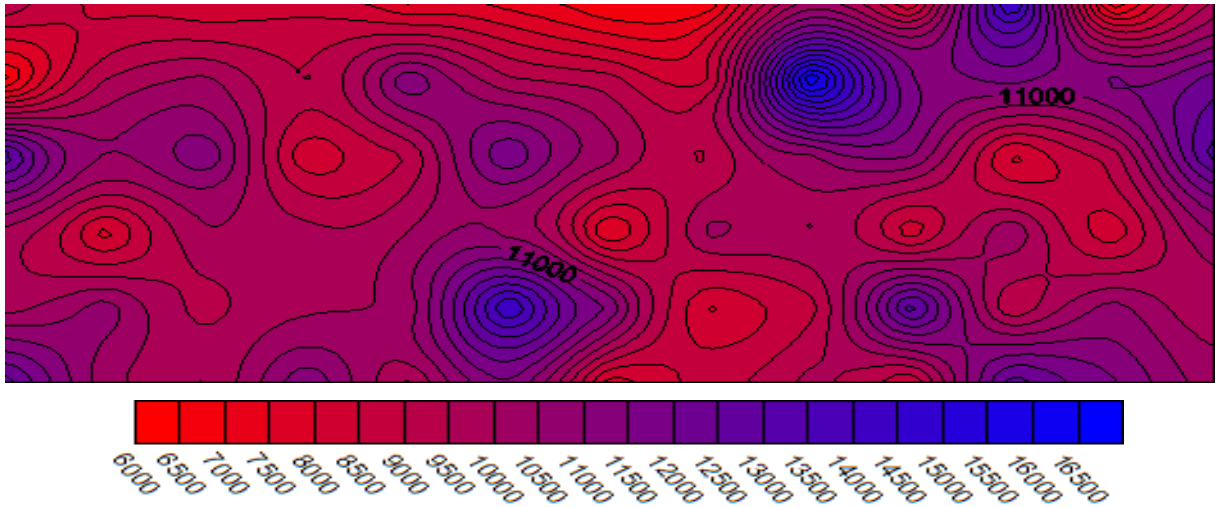
Metal(loid)s mapping of the studied area

[As] (mg/kg) (300-2000mg/kg)



- High metal content
- low pH (4)
- Very low OM
- Strong drainage
- No vegetation

[Pb] (mg/kg) (6000-16500 mg/kg)



Divided in 4 plots






Field experiment

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Photos of the plots after 1month (Mai /30/2017) Salix + clover

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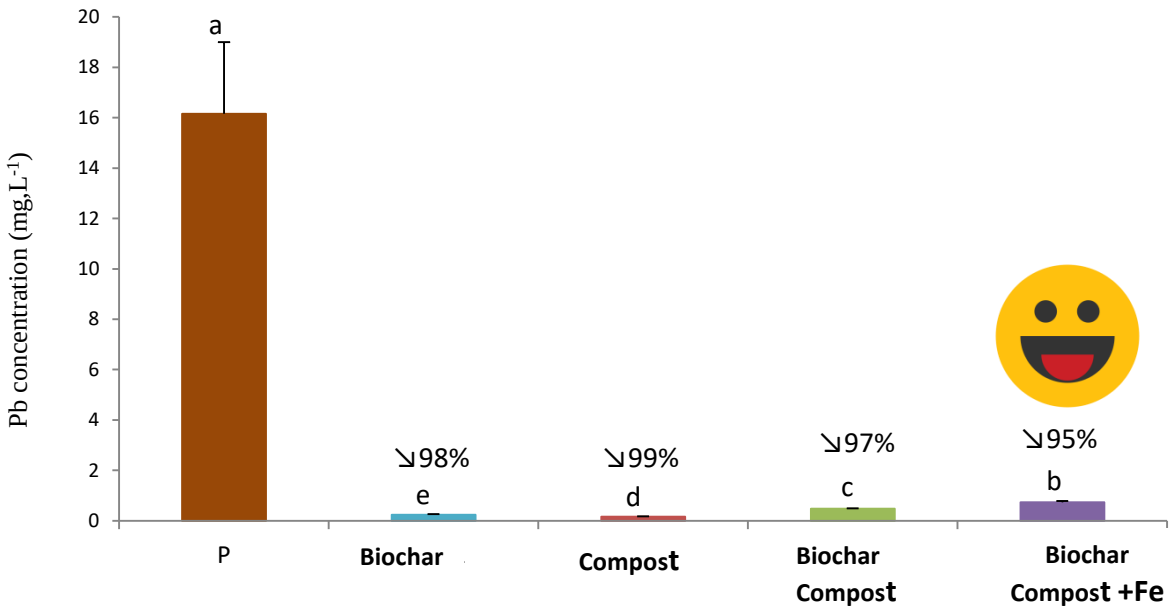
4 months

After 6 months

After 18 months

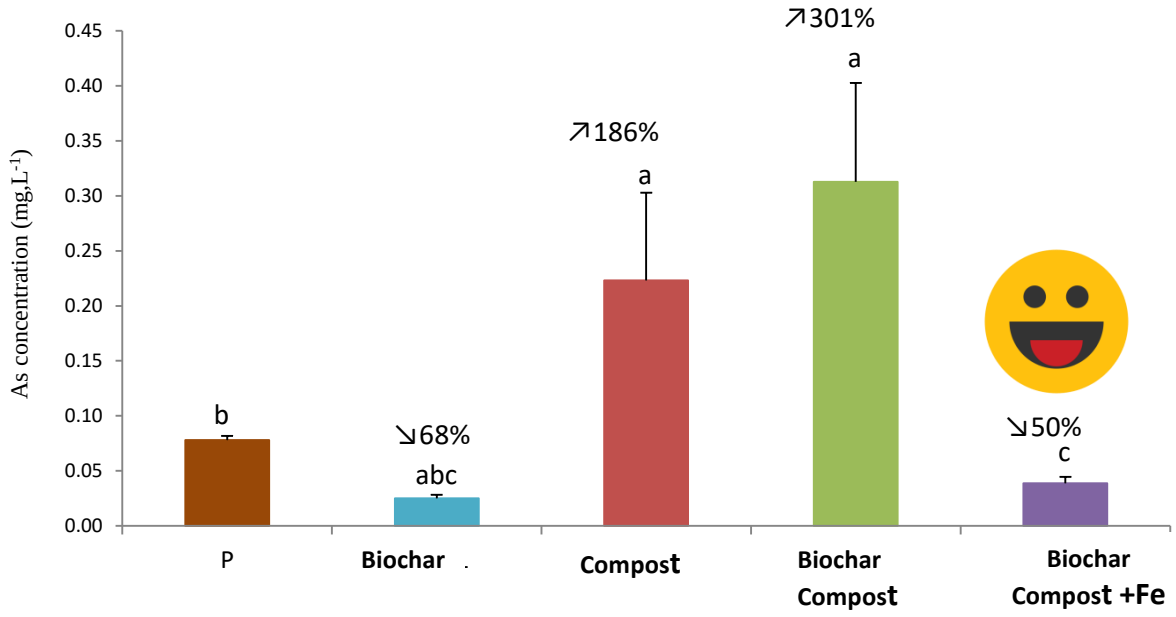
Pb and As concentration in SPW

Spw Pb



Pb SPW concentration at the time of incorporation of the amendments Bloc 1 : biochar (2%), bloc 2 : organic amendment (5%), bloc 3 biochar (2%) + organic amendment (5%) and bloc 4 : biochar (2%) + organic amendment (5%) + inorganic amendment (1,5%). P corresponds to unmodified technosol. The letters correspond to the comparison between each modality.

Spw As



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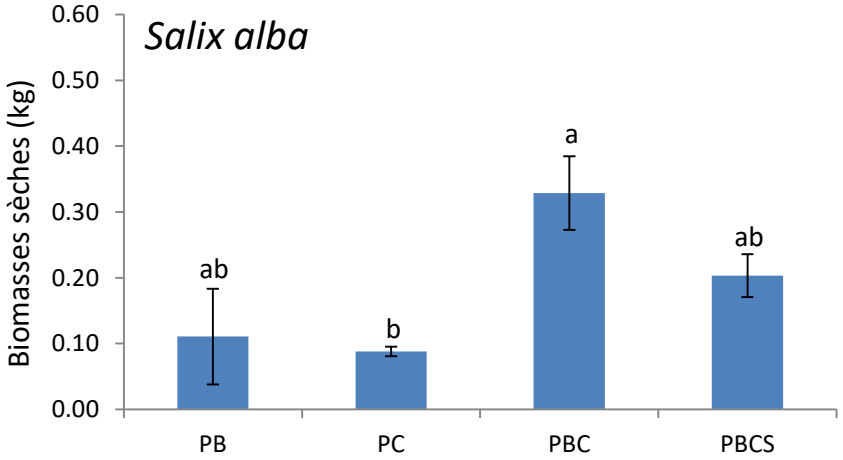

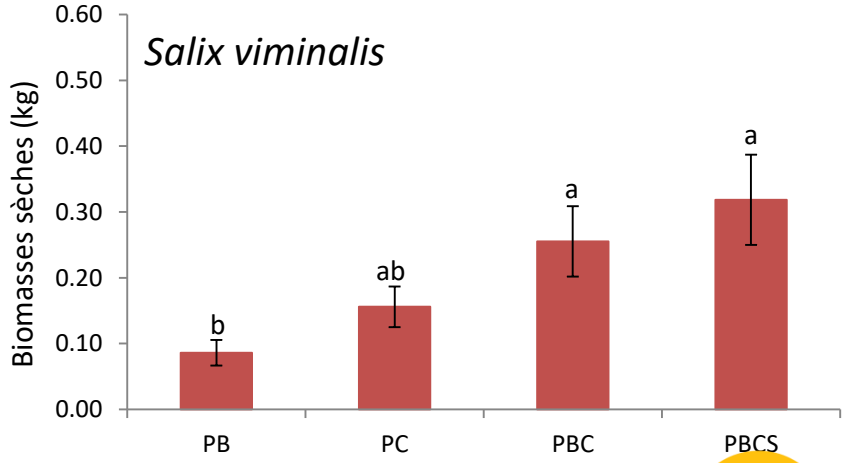

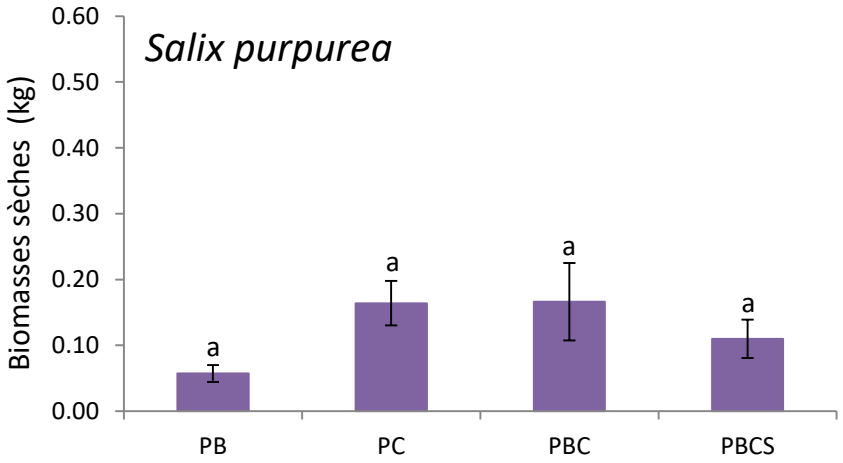

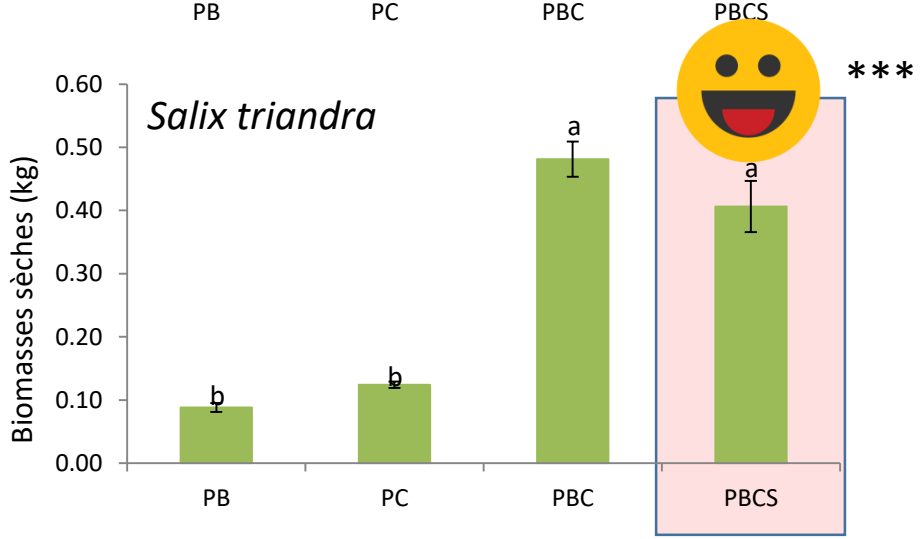

PB : biochar 2%
PC : compost 5%
PBC : compost 5% + biochar 2%
PBCS : compost 5% + biochar 2% + sulfate de fer 0,15%

Conclusion

Before field experiment it is necessary to proceed to :

-Mesocosm laboratory tests to define which are the best mixtures of amendments (Biochar + ……..) according to the metal(loids) present in the soil.

-To verify that pollutant are immobilized :

biochar alone is efficient to stabilize Pb  but mobilize As 

-Efficient plant growth

-No metal(loid)s translocation to the aerial part of the plant (to found the good plant genotype)

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RESEARCH ARTICLE

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Iron Biochar functionalization

-Improved As sorption in batch experiments

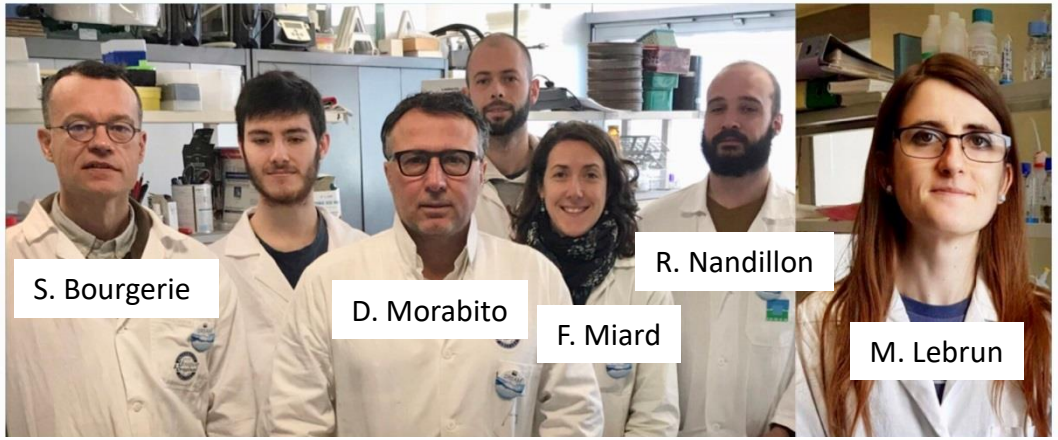
-No effect when incorporated into the soil

-Same results when using Biochar as As tolerant Bacillus carrier

Good or bad surprise !!

Our HW biochar does not seem to be stable over time, because the use of a two-year old biochar allowed to stabilize Pb and As in the soil, which was not the case for As when we used the same biochar immediately after its production


Zn
Cd
Pb
Cd
Pb
Zn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