Session SSS5.5
Tuesday, 5 May 2020

Effect of biochar application at a trace-elements polluted area on soil carbon stability

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What is biochar?

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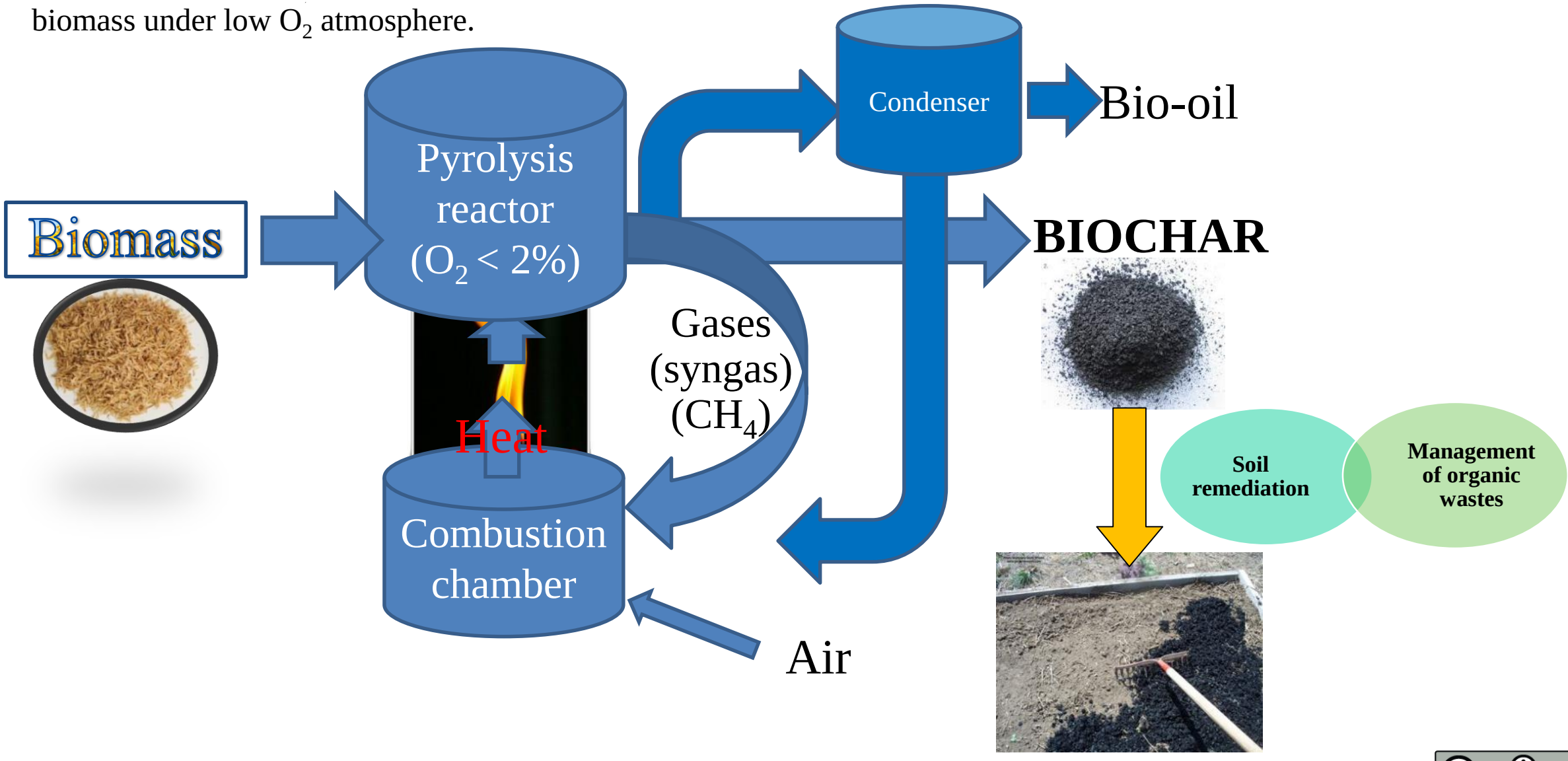
Biochar (BC) is the carbonaceous solid residue produced through the thermochemical conversion (pyrolysis) of biomass under low O_2 atmosphere.



Biochar applications

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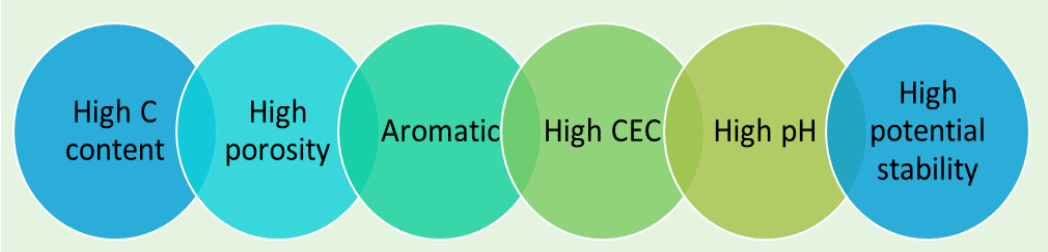
Biochar properties:



Different applications:

- Improvement of soil fertility, plant growth
- Reduction of soil nutrient leaching
- Mitigation of green house gases
- C sequestration
- Soil remediation

Biochar potential to immobilize trace elements

Direct mechanisms

Chemisorption
- Adsorption in oxygenated functional groups (release H^+)
- Cationic exchange (Na, Ca, S, K, Mg)

Physisorption
- Electrostatic attraction (π electrons)

Precipitation
- Mineral fraction / biochar ash

Indirect mechanisms

Changes in pH

Organic matter and soluble C
- Priming effect and DOC

Availability of P

Competition with As

Redox

Biochar stability?

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Stability of biochars under debate

$MRT_{biochar}$>1000 years, when H/C_{org}<0.4
$MRT_{biochar}$>500, when 0.4<H/C_{org}<0.7

(Lehmann and Joseph, 2015)

Reference	Scale of estimated MRT	MRT (years)
Masiello and Druffel (1998)	Millennial	2400-13900
Cheng et al. (2006)	Millennial	1000
Kuzyakov et al. (2009)	Millennial	2000
Novak et a. (2010)	Millennial	1400-51000
Zimmerman (2010)	Centennial to millennial	100-100000

De la Rosa et al. (2018)

	MRT_2 (years)
Pure Cambisol	5.7
Biochars+Cambisol	7.9-43.9

Dos Anjos Leal et al. (2019)

	MRT_2 (years)
Pure Cambisol	15.7
Biochar+Cambisol	17.4
Pure biochar	87

Main objetive: Determine the effects of biochar on C stability in trace element polluted soils.

Respiration experiment – C stability

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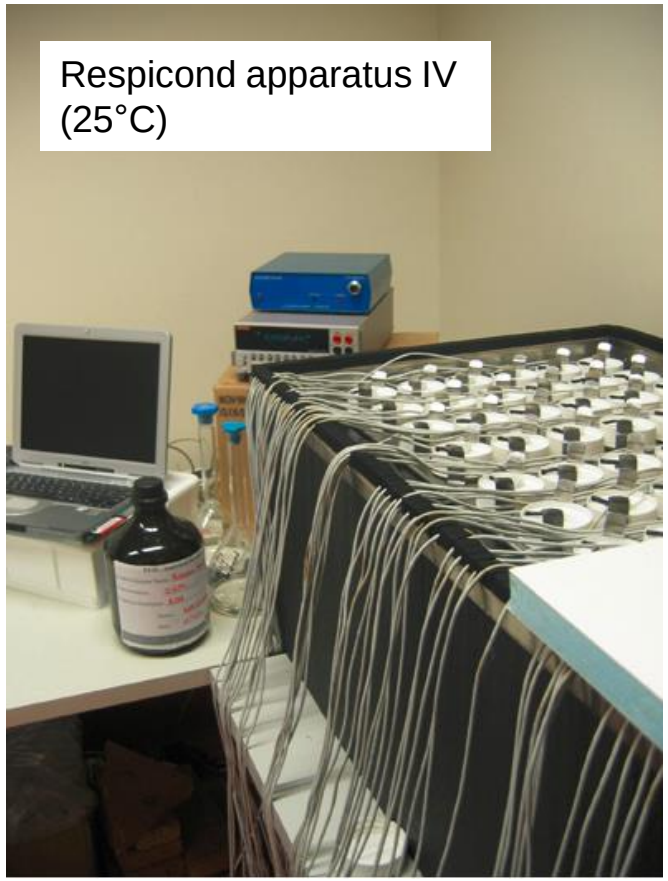

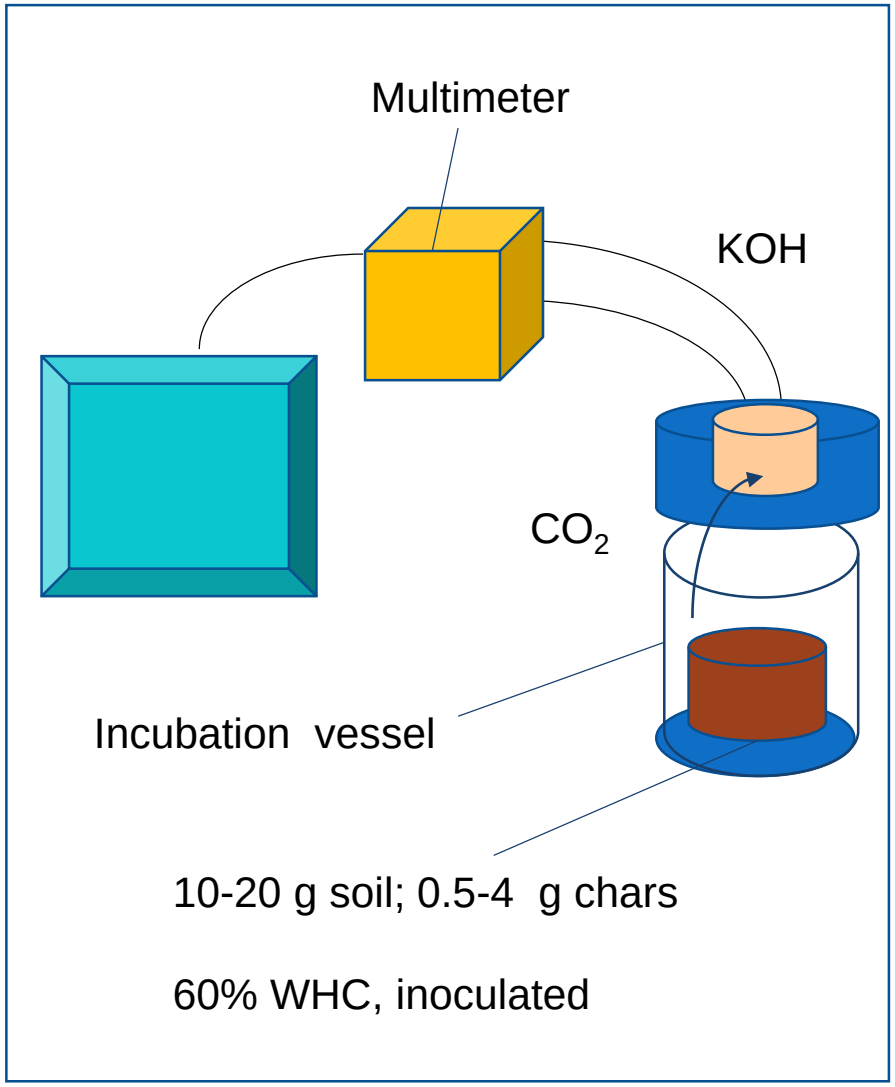

Respiration experiment – C stability

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1. CO_2 released by the sample is absorbed in the KOH-solution and forms carbonate, which decrease the conductivity.

2. This change is conductivity is measured by the respirometer.

3. From these values can be calculated:
   - Cumulative carbon loss
   - Degradation rates
   - Mean residence time.

Respiration experiment – C stability

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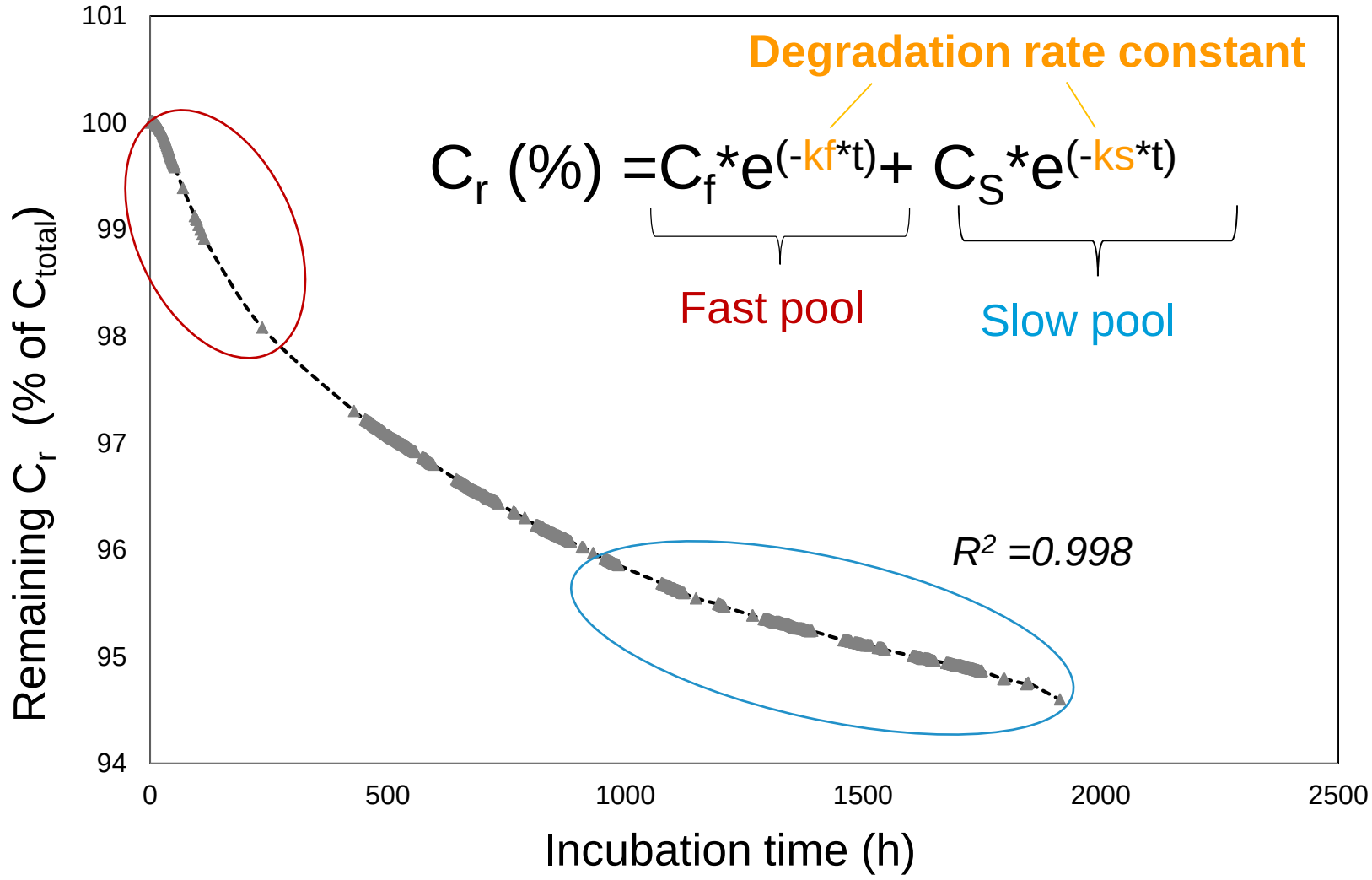

Materials: soils

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Green Corridor of Guadiamar (25 km north Seville)

2 soil (Typic Xerofluvent):

MPS: Moderately Polluted Soil

HPS: High Polluted Soil

	WHC (%)	Bulk density (g/ml)	pH ($CaCl_2$)	EC (µS/cm)	% C
HPS	32.73	1.1	3.62	3610	0.8
MPS	51.45	1.2	6.47	1809	1.7

The Aznalcóllar Mine Accident

MPS - Moderately Polluted Soil

HPS - Highly Polluted Soil

Materials: soils

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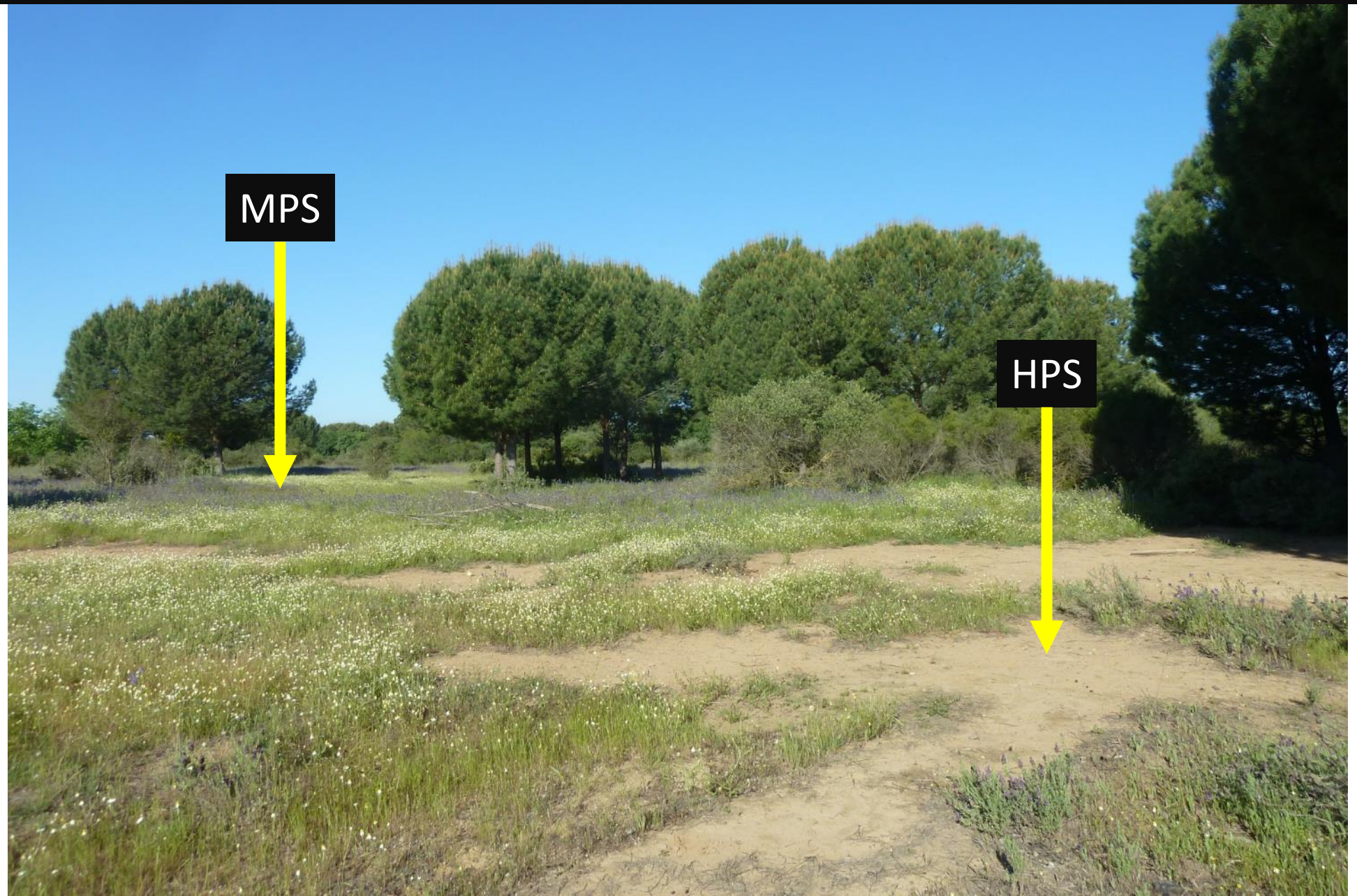

The Aznalcóllar Mine Accident

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Location:

-Iberian Pyrite Belt (SW Spain-Portugal)

-Aznalcóllar (30 km from Seville)

Fuente: elaboración propia. EL PAÍS

25th April 1998 (3:30 am)

- 4 millions m^3 acidic water
- 2 millions m^3 toxic mud

Materials: biochars

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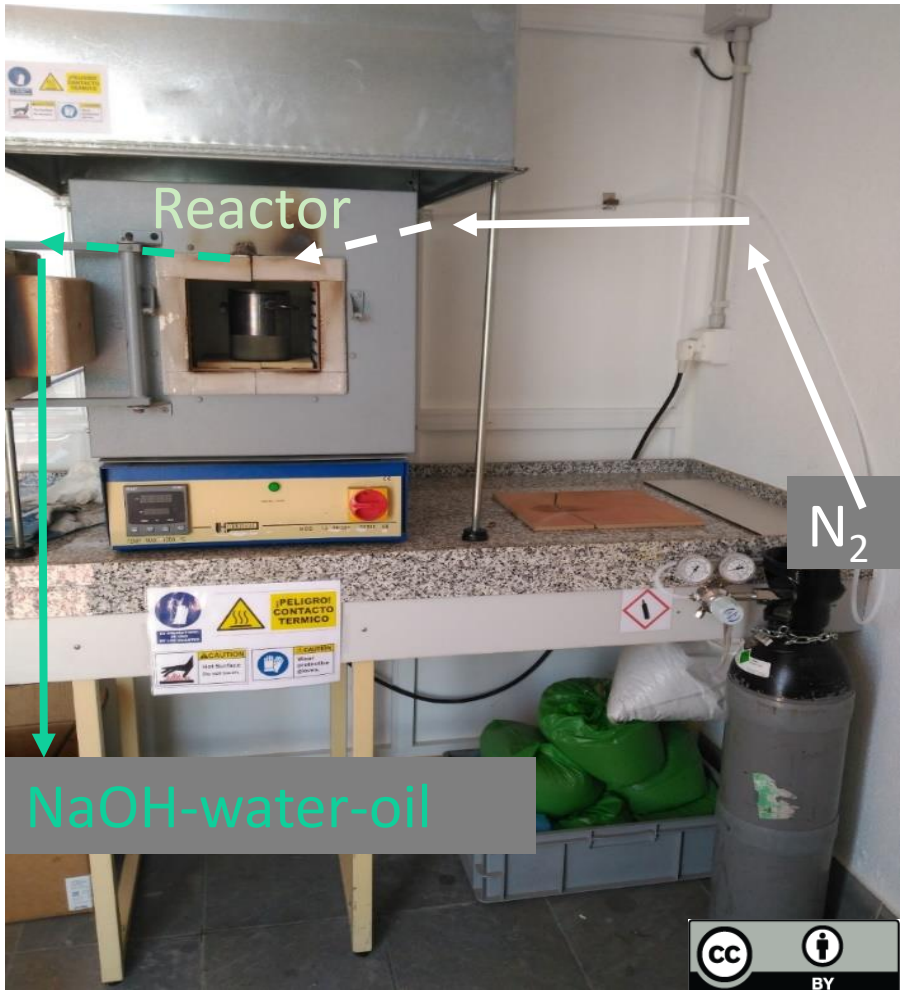
Feedstock → Biochar production

Pyrolysis conditions

- Temperature 500 ºC
- Time 2 h
- N_2 atmosphere
- Heating rate 20 °C min^{-1}



Certified biochar (B1)

- Material: Mixed wood sieving from wood chip
- Pyrolysis: 20 min, 620 ºC
- Swiss Biochar, Laussane, Switzerland

Biochars – C stability

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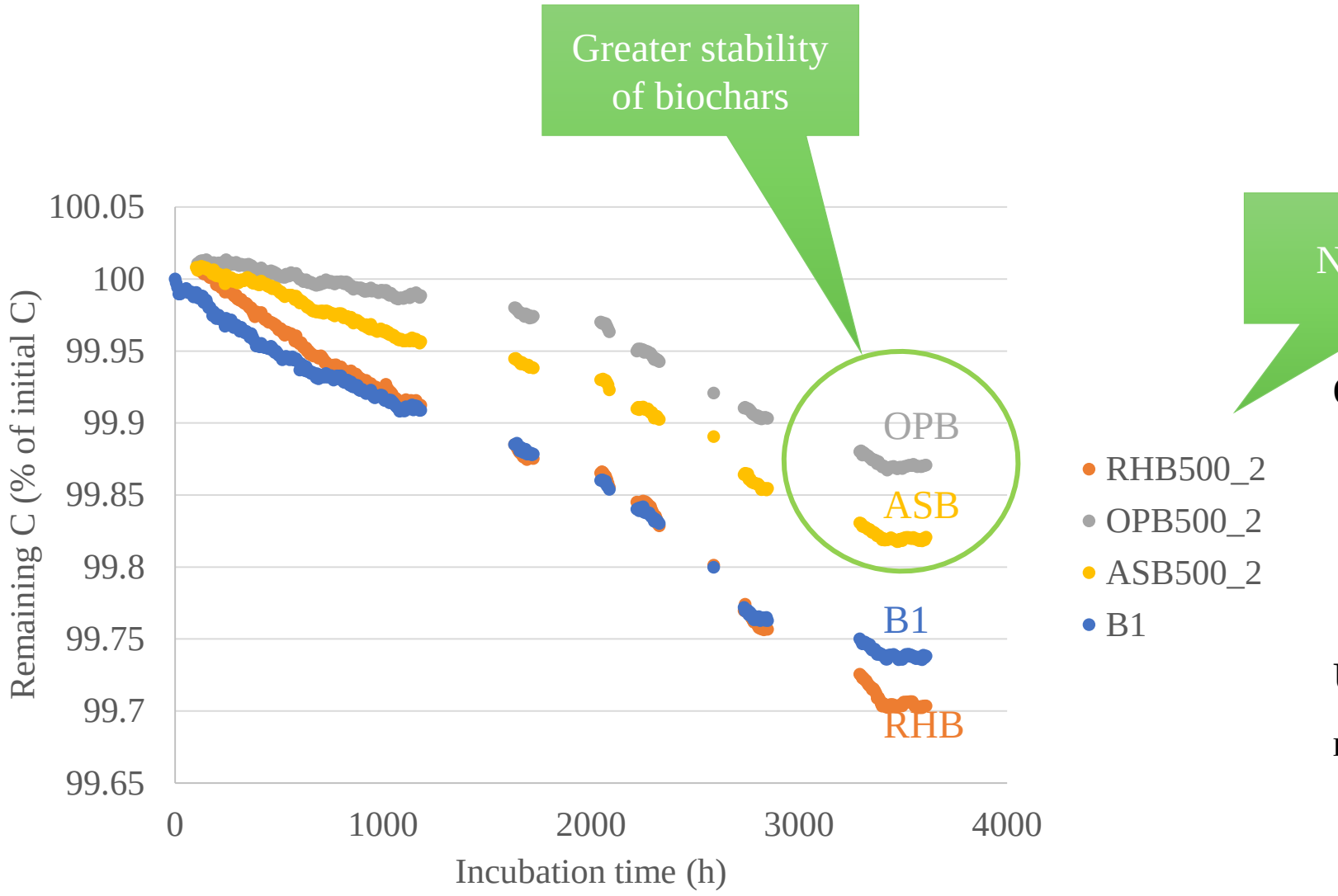

No fast pool

One-exponential model

$$A = A_2 \cdot e^{-k_2 t}$$

Underestimation of biochar stability?

Leng et al. (2019), Sci. Total Environ. 664, 11-23

Effects of biochar in MPS – C stability

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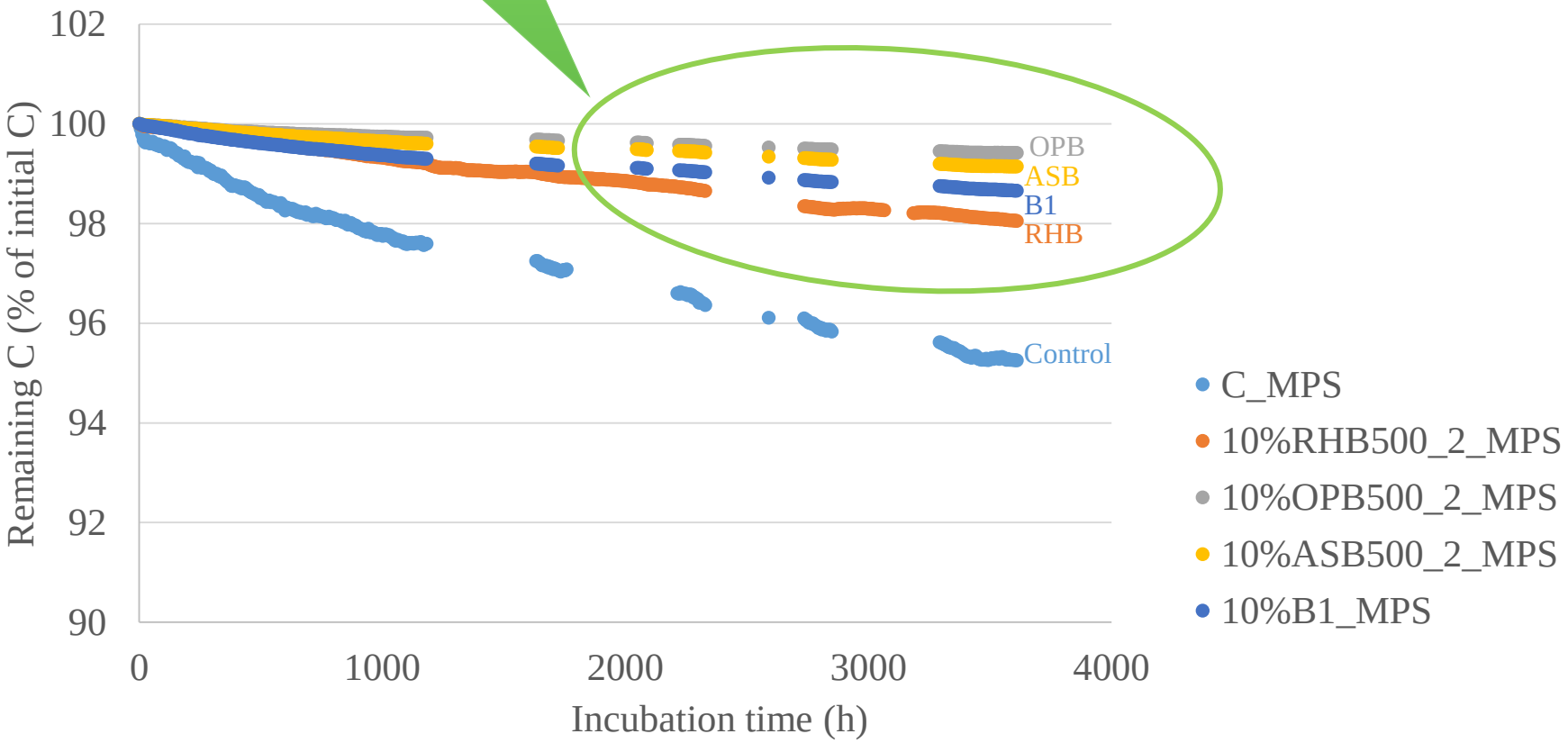
Greater stability of biochar amended soil



The curves were fitted by the following equation:

$$A(\mathrm{t}) = A_1 \cdot \mathrm{e}^{-k_1 t} + A_2 \cdot \mathrm{e}^{-k_2 t}$$

Effects of biochar in HPS – C stability

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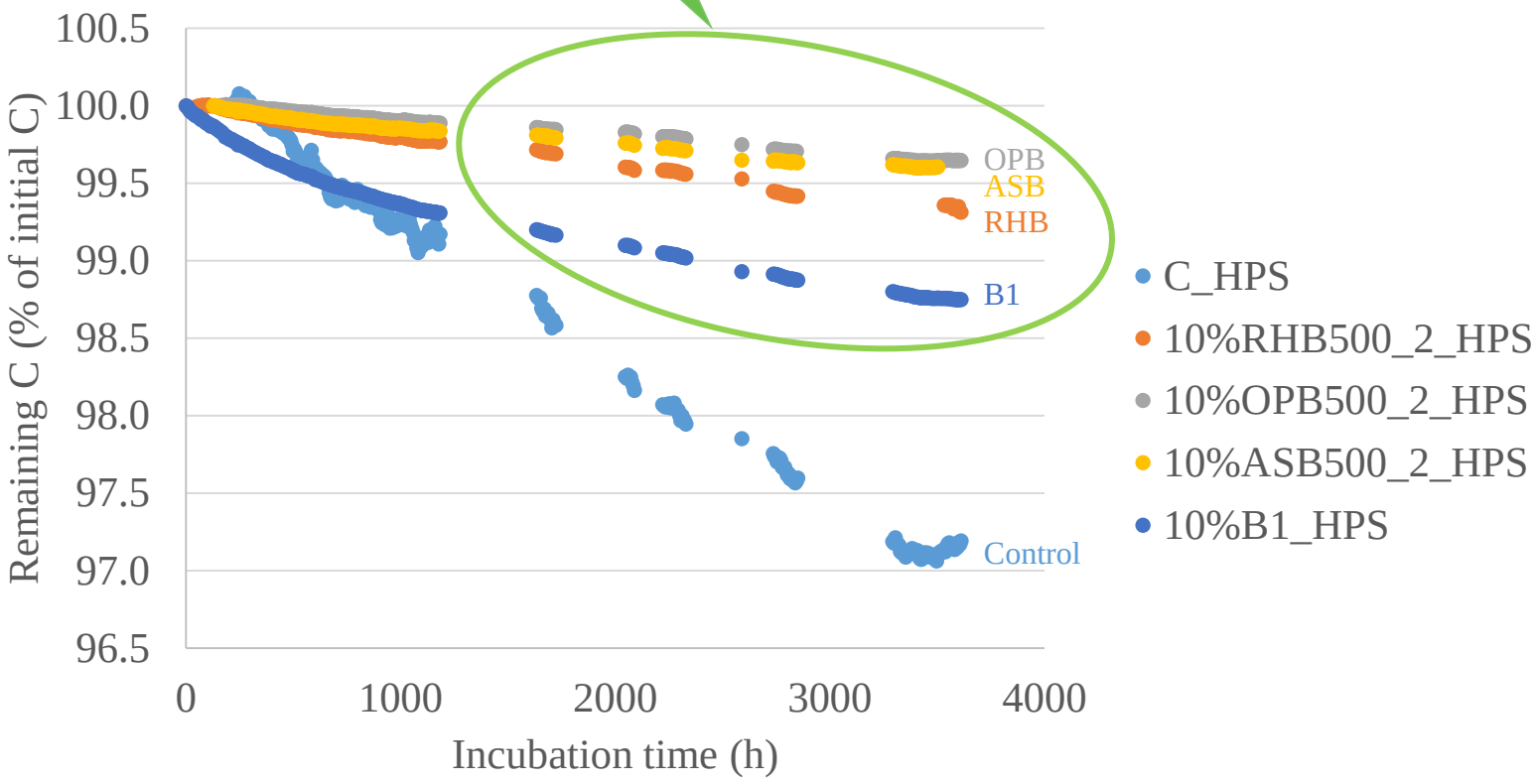
Greater stability of biochar amended soil



The curves were fitted by the following equation:

$$A(t) = A_1 \cdot e^{-k_1 t} + A_2 \cdot e^{-k_2 t}$$

Except C_HPS and 10%OPB500_2_HPS that were fitted by one-exponential model:

$$A = A_2 \cdot e^{-k_2 t}$$

Experiment long enough?
Underestimation of C stability?

Leng et al. (2019), Sci. Total Environ. 664, 11-23

Conclusions

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All biochars showed MRT > 100 years, being greater for OPB and ASB than RHB and the certified B1.

In moderately polluted soil, biochars:

- Did not modified the labile C fraction of soil.
- Increased MRT_2 in 2-10 times in comparison to the control soil.

In highly polluted soil, biochars :

- Enhanced the degradation of a small fraction of labile C.
- Increased in 2.8-13.1 times the MRT_2 of the more recalcitrant C fraction of soil.

Longer experiments would be recommended in order to distinguish if the C fraction found in control HPS was the labile fraction or all C in this soil has this degradability.

Thank you for your attention

Acknowledgements:

Grupo MOSS (IRNAS-CSIC)

MINEICO: CGL2016-76498-R and CGL2015-64811-P projects

Fundación Tatiana Pérez de Guzmán el Bueno

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