Phytomanagement of metal(loid)-contaminated soils within the EU Interreg PhytoSUDOE project: field trials in progress and option appraisals

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Rational – The PhytoSUDOE project

***Phytomanagement* : use of plants, associated microorganisms, and soil conditioners (1) to minimize pollutant linkages, as metal(loid) migration in the environmental compartments and into the food chain, (2) to enhance ecosystem services and (3) to produce crop biomass with profitable returns**

◄ **The PhytoSUDOE network of field sites**: PhytoSUDOE (Demonstration of the improvement in soil biodiversity, functionality and ecosystem services through phytomanagement in contaminated and degraded soils within the Interreg Sudoe; SOE1/P5/E0189) is a project started in 2016 and funded by the European Regional Development Fund (European Commission) through the V Interreg Sudoe Programme (Sudoe meaning Southwest Europe). Its main goal is the ecological remediation of degraded/contaminated environments by means of applying novel phytomanagement options that promote biodiversity, enhance ecosystem functionality and enable the sustainable use of resources. http://www.phytosudoe.eu/en/

Acronym	Organisation (Country)	Type of organisation
CSIC	Agencia Estatal Consejo Superior de Investigaciones Cientificas (España)	INST
USC	Universidade de Santiago de Compostela (España)	UNI
Neiker	NEIKER-Instituto Vasco de Investigación y Desarrollo Agrario, S.A. (España)	INST
UPV/EHU	Universidad del País Vasco/Euskal Herriko Unibertsitatea (España)	UNI
CEA	Centro de Estudios Ambientales de Vitoria-Gasteiz (España)	ADM

Acronym	Organisation (Country)	Type of organisation
INRA	Institut National de la Recherche Agronomique (Francia)	INST
CSIC	Centro Sup Investigacion	INST
FCTUC	Universidade de Coimbra (Portugal)	UNI
UCP-CRP	Universidad Católica Portuguesa (Portugal)	UNI
UAVR	Universidade de Aveiro	UNI
LNEG	Laboratorio Nacional de Energia e Geologia	INST

Aims

► Establish a network of contaminated/degraded sites under phytomanagement within the Interreg Sudoe region : Maintaining medium- to long-term field sites & Implementing new sites

► Characterize and demonstrate enhancements in biodiversity, soil functionality and ecosystem services through the phytomanagement

► Raise awareness of the benefits of phytomanagement to relevant stakeholders: Stakeholder workshops & Summer schools

- **Soil quality**
  - Plant nutrients
  - Organic matter
  - Physical properties
  - Microbial diversity
- **Soil processes**
  - Accumulation/mineralization of organic matter
  - Water absorption/infiltration
  - Contaminant adsorption
  - Soil structure
- **Ecosystem services**
  - Carbon sequestration
  - Nutrient cycling
  - Soil formation
  - Habitat and gene pool
  - Water storage and purification
  - Biomass production

Field sites & GRO

Site	Name (Localization)	Description (Contaminants)
S1	ST MÉDARD D'EYRANS (Gironde, France)	Abandoned industrial zone (Cu/PAH) (former wood preservation site)
S2	PARC AUX ANGÉLIQUES (Gironde, France)	Abandoned industrial zone in urban area (Metal(loids)/PAH/aliphatic hydrocarbons)
S3	BORRALHA (Montalegre, Portugal)	Mine area (Ag/W/Cu/Pb)
S4	SÃO DOMINGOS (Mértola, Portugal)	Mine tailings (Sb/As/Cu/Pb/Zn/Au)
S5	ARIÑEZ (Vitoria-Gasteiz, País Vasco, Spain)	Abandoned zone in peri-urban area (As/Pb/PCB/PAH/acetone/hydrocarbons)
S6	JUNDIZ (Vitoria-Gasteiz, País Vasco, Spain)	Abandoned zone in peri-urban area (metals)
S7	PIEDRAFITA (Galicia, Spain)	Mine tailings (Cd/Zn/Pb)
S8	TOURO (Galicia, Spain)	Mine tailings (Cu)
S9	ST SEBASTIEN D'AIGREFEUILLE (Gard, France)	Mine tailings (Pb/Zn/Cd/As)
S10	PENEDONO (Viseu, Portugal)	Mine tailings (As/Au/Cu)
S11	MARRANCOS (Vila Verde, Portugal)	Mine tailings (Au/Ag/As)

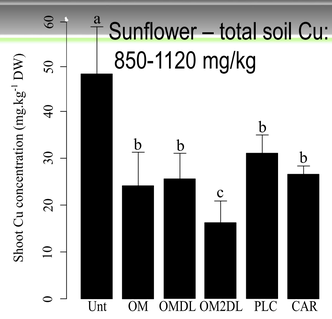
Main soil parameters

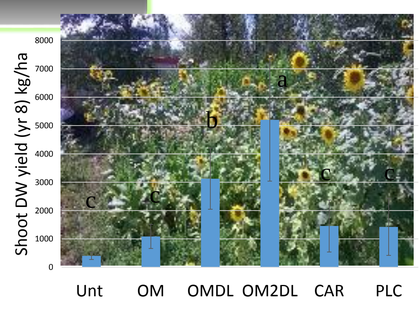
	unit	S1 (P1-3)	S1 (P7)	S2	S9
Sand	%	85.8	88.8	90	
Silt	%	8.3	4.8	9	
Clay	%	5.9	6.4	0.87	
pH (water)		5.9-7.4	6.4 – 7.8	7.6-8.6	7.4
EC					500
OM	%	1.3	2.2 -4.6		
C	%		1.28-2.67	0.0002-65	
N	%		0.05-0.12		
C/N		16	21.3-28	2-132	
CEC	cmol kg^{-1}	2.5	2.3 – 6.6		
Ca	mg kg^{-1}				243
Mg	mg kg^{-1}				129
Fe	%	0.6	0.077		> 10
As	mg kg^{-1}	9.8	9.4 – 17.3	41-182	264
Cd	mg kg^{-1}	0.12		1.7-9	29
Co	mg kg^{-1}	1.6 - 2	2.5 – 3.9		
Cu	mg kg^{-1}	163-1170	329 - 799	140-2838	23
Cr	mg kg^{-1}	16-21	21.4-33.5	17-51	88
Hg	mg kg^{-1}			0.4-3	
Ni	mg kg^{-1}	4.7 - 6	8.1-11.4	16-114	40
Pb	mg kg^{-1}	27		301-1306	19500
Zn	mg kg^{-1}	39-98	51 - 73	392-7899	3570
PAHs	mg kg^{-1}		40-163	4 - 4240	

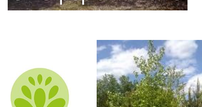
Field trials at the S1 & S2 sites


Phytoextraction


Phytostabilization





Phytostabilization
Rhizodegradation

Phytostabilization

S1 site: Unt untreated, OM compost 5%, OM2DL: 2 OM dressings + dolomitic limestone (DL), OMDL OM + DL, CAR: basic slag, PLC P-spiked basic slag

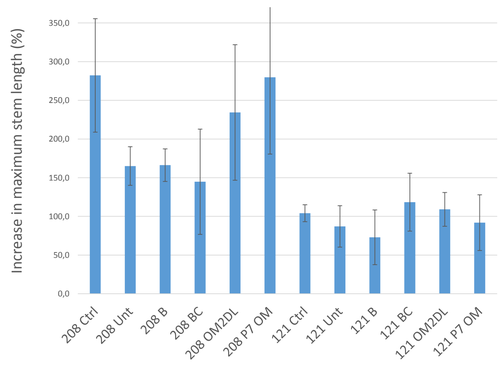
S2 site: poplar, ryegrass, alfalfa


Phytostabilization
Rhizodegradation

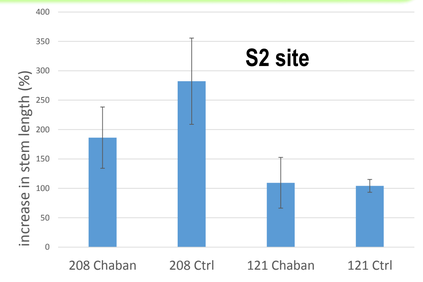


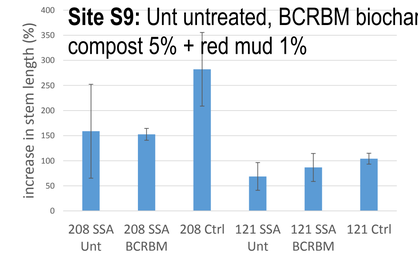
- S1: OM2DL displayed the highest biomass and lowest shoot Cu concentration for sunflower in year 8; short rotation coppice (poplar/willows/false indigo), Miscanthus, vetiver, and mixed tree stand annually produced a biomass and contributed to limit pollutant linkages
- Phytomanagement was successfully implemented at the S2 site; richness of plant species increased.

Pot experiment with *Eucalyptus grundal* cv. 208 & cv. 121



S1 site: Ctrl uncontaminated soil, Unt untreated, B biochar 2.5% w/w, BC biochar + compost 5%, OM compost 5%, OM2DL 2 compost dressings + dolomitic limestone



- **S1**: incorporation of compost and dolomitic limestone in year 1, followed by compost addition in year 7, and Cu phytoextraction (sunflower/tobacco rotation, OM2DL) resulted in a similar shoot yield and maximum stem length (MSL) for the 208 clone as compared to the Ctrl soil. Biochar with and without compost (in year 1), with poplar intercropped with giant reed, was less efficient. The MSL was lower for the 121 clone as compared to the 208 ones and did not differ for the 3 soil types (phytomanaged, untreated, and Ctrl)
- **S2**: both clones grew similarly in the Unt and Ctrl soils, despite the high soil contamination
- **S9:** MSL did not differ between the Unt and BCRM plants for both clones. For the clone 208, increase in MSL was higher (+42%) in the Ctrl soil than in the BCRM soil.

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