

Interreg Sudoe



European Regional Development Fund

RECOVERING CONTAMINATED SOILS THROUGH PHYTOMANAGEMENT IN SOUTHWEST EUROPE

The PhytoSUDOE project

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IIAG - CSIC
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RECOVERING CONTAMINATED SOILS THROUGH PHYTOMANAGEMENT IN SOUTHWEST EUROPE

PhytoSUDOE

Demonstrating improvements in soil biodiversity, functionality and ecosystem services of contaminated and degraded land under (phyto)management within the Interreg Sudoe region.

- Interreg Sudoe Programme (European Commission)
- Supports regional development in Southwest Europe via transnational projects
- European Regional Development Fund (ERDF)
- Eligible regions: Spain, Portugal, France (Poitou-Charentes, Limousin, Auvergne, Aquitaine, Midi-Pyrénées, Languedoc Roussillon), Andorra, Gibraltar
- Priority Axis 5: **Environment and Resource Efficiency**
- Specific objective: Reinforce cooperation between Sudoe stakeholders of natural sites through the development and use of common methods
- Thematic objective; Conserve and protect the environment and promote resource efficiency
- Project duration and funding: **28 months**; Total Budget: **947,910.39€**

RECOVERING CONTAMINATED SOILS THROUGH PHYTOMANAGEMENT IN SOUTHWEST EUROPE

PhytoSUDOE consortium – Ten full partners

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



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Universidad del País Vasco

Euskal Herriko Unibertsitatea



Centro de Estudios Ambientales

CEA

Ingurugiro Gaietarako Ikastegia



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



UNIVERSIDADE CATOLICA PORTUGUESA
PORTO



UNIVERSIDADE DE COIMBRA



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PhytoSUDOE consortium – Associated partners

Organisation	Country	Type
Centro de Valorización Ambiental del Norte SL	Spain	IND
Viveros Eskalmendi, SL	Spain	IND
Basoinsa SL	Spain	IND
Sociedad Publica de Gestion Ambiental (IHOBE)	Spain	ADM
Biocompost de Álava	Spain	IND
Bordeaux Métropole	France	ADM
LYONNET SA (Ets Joseph Lyonnet) (Francia)	France	IND
Instituto Politécnico de Beja (Portugal)	Portugal	UNI

- Industrial sector
- SMEs
- Administration
- Academia

PhytoSUDOE – Specific objectives

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

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➤ Soil

Essential and non-renewable resource

➤ Soil contamination

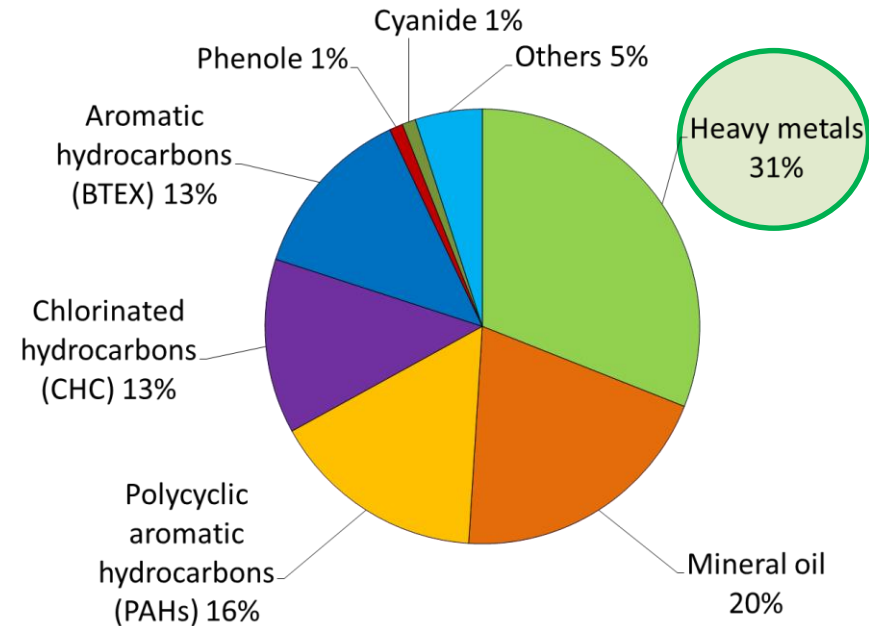
“The occurrence of pollutants in soil above a certain level causing a deterioration or loss of one or more soil functions” (EC)

➤ Europe (EEA, 2014)

Potentially polluting activities are estimated to have occurred at **2.5 million sites.**

≈300,000 sites in EEA member countries.

require clean-up



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➤ Traditional engineering techniques: excavation; landfilling...



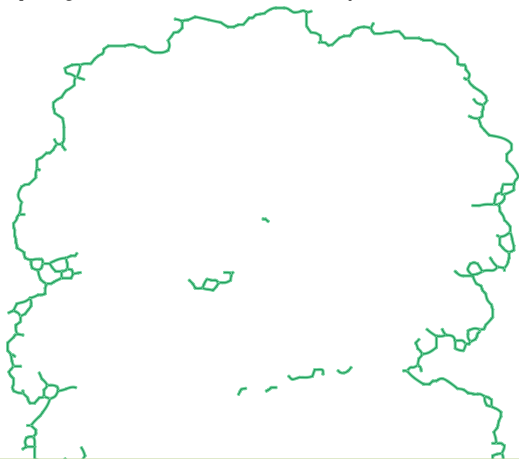
➤ GRO (Gentle Remediation Options)

Use of plants and their associated microbes for environmental clean-up



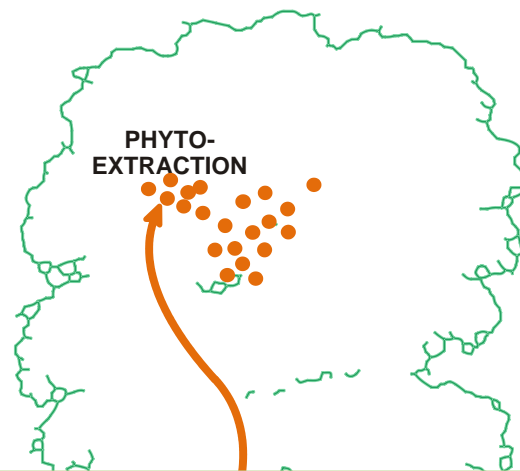
Phytostabilisation

Metal(loid)-excluding plants for the *in-situ* stabilisation of metal(loid)s in soils usually in combination with soil amendments (*aided phytostabilisation*)

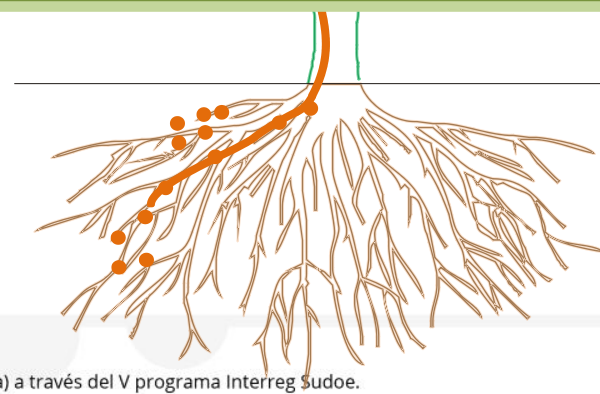
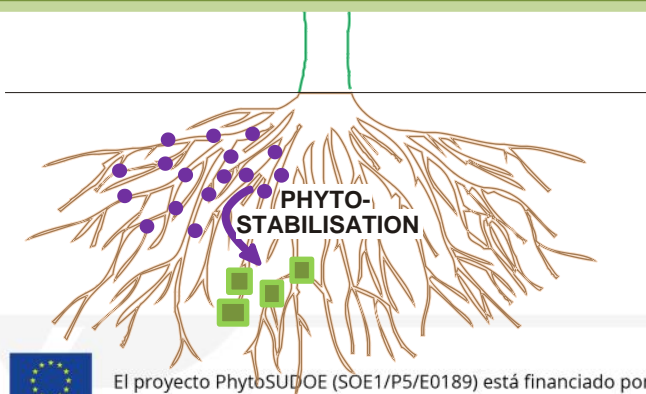


Phytoextraction

Cultivation of tolerant plants that concentrate soil contaminants in their aboveground tissues



Decrease the labile fraction which interacts with biological targets Q



➤ Phytomanagement – Sustainable management to quench pollutant linkages and restore or provide ecosystem services

PHYTOMANAGEMENT IN SOUTHWEST EUROPE



Plants transform contaminants into volatile compounds or absorb and transport (via transpiration) volatile compounds from the soil to the aboveground biomass where they are released into the atmosphere.



Plant roots release root exudates (and enzymes) into the rhizosphere, stimulating the diversity and activity of microbial communities involved in degradation of organic contaminants.

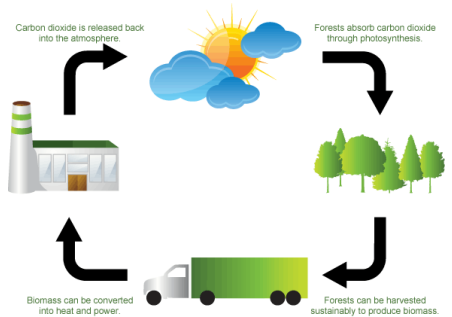
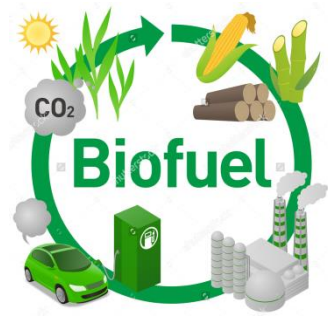


PHYTOMANAGEMENT

BIOMASS

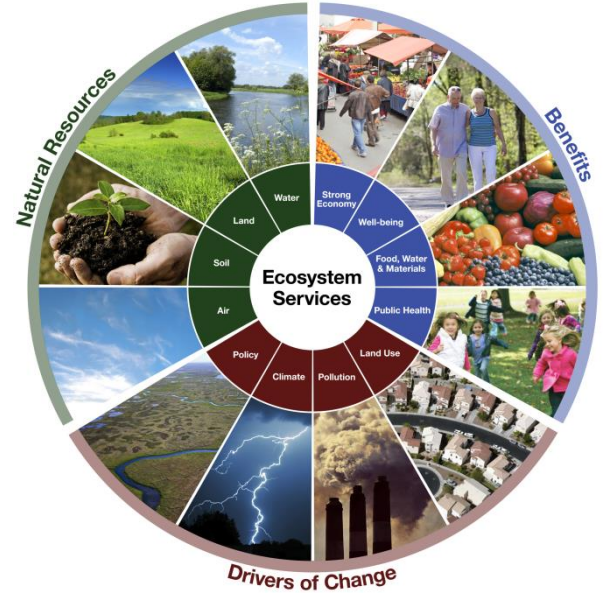


ECONOMICAL BENEFITS



ECOSYSTEM SERVICES

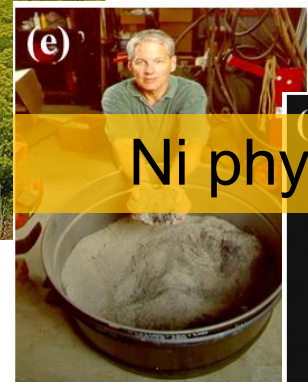
Social and environmental benefits



PHYTOMINING

Metal-enriched ash

“Bio-ore”



Ni phytomining



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Soil quality

- Plant nutrients
- Organic matter
- Physical properties
- Microbial diversity



Soil processes



PhytoSUDOE

itter

Ecosystem services

- Carbon sequestration
- Nutrient cycling
- Soil formation
- Habitat and gene pool
- Water storage and purification
- Biomass production



Working packages

- **GT1: Characterisation and risk assessment of contaminated/degraded sites** (Leader: INRA).
- **GT2: Characterisation and assessment of biodiversity in relation to phytomanagement options** (Leader: NEIKER).
- **GT3: Exploring prospects of improving phytomanagement efficiency** (Leader: UCP-CRP).
- **GT4: Recovery of key ecological functions in phytomanaged sites** (Leader: USC).

- **GT.T1: Project management** (Leader: CSIC)
- **GT.T2: Project communication** (Leader: CEA)

GT1: Characterisation and risk assessment of contaminated/degraded sites

- Establish a network of phytomanaged contaminated/degraded sites within the SUDOE region to evidence the efficiency of phytotechnologies for ecologically remediating soils and enhancing soil services.

3-tier system

(1) Risk assessment

(2) Option appraisal

(3) Remediation strategy

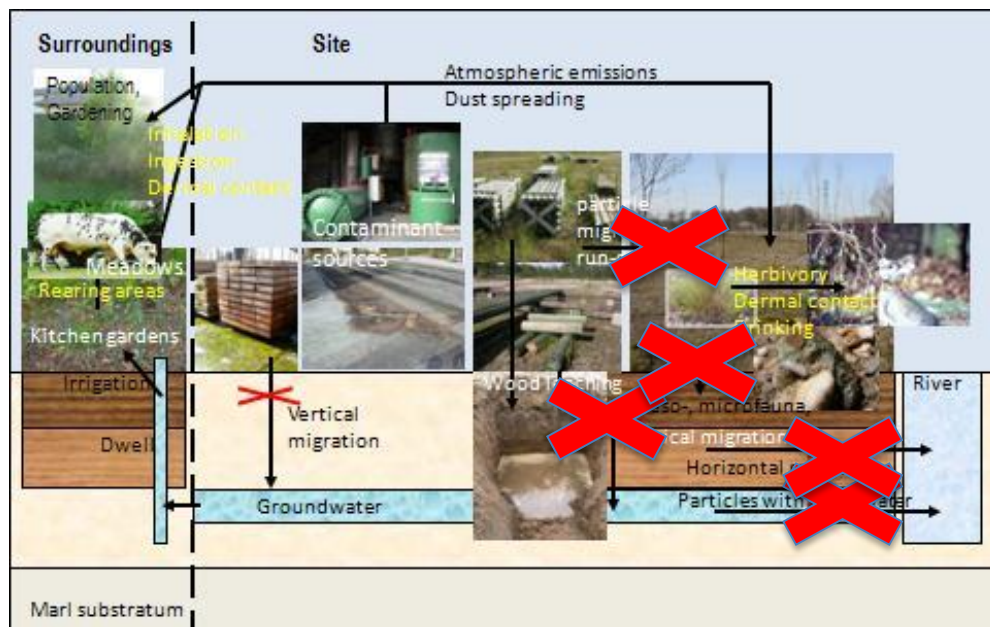
- Conceptual models

- Soil physicochemical analyses, TE phytoavailability & bioaccessibility; phytotoxicity, ecotoxicity, etc.

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GT1: Characterisation and risk assessment of contaminated/degraded sites

Conceptual model: contaminant types, sources, location; pollutant linkages, targeted objectives and residual risks; pathways & receptors; physical conditions on or around the site; water supply



Pollutant linkages

Soil – groundwater- plants- animals- microorganisms- humans- animals

Animals - humans

Water - humans

Plants - humans

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GT1: Characterisation and risk assessment of contaminated/degraded sites

- Establish a network of phytomanaged contaminated/degraded sites within the SUDOE region to evidence the efficiency of phytotechnologies for ecologically remediating soils and enhancing soil services.

Product: Guide of best practices for the phytomanagement of metal(loid)-contaminated soils: focus on risk assessment and phytomanagement and remediation strategy

Tool: For stakeholders involved in the management of contaminated sites.

PhytoSUDOE network of field sites

Site	Name (Localization)	Description (Contaminants)
S1	ST MÉDARD D'EYRANS (Gironde, France)	Abandoned industrial zone (Cu/PAH)
S2	PARC AUX ANGÉLIQUES (Gironde, France)	Abandoned industrial zone in urban area (Metal(loids)/PAH/aliphatic hydrocarbons)
S3	...	Mine area (As/W/Cu/Pb)
S5	ARIÑEZ (Vitoria-Gasteiz, País Vasco, Spain)	Abandoned zone in peri-urban area (As/Pb/Cd/PAH)
S7	PIEDRAFITA (Galicia, Spain)	Mine tailings (Cu/Pb/Zn)
S10	... (Gard, France)	...
S10	PENEDONO (Viseu, Portugal)	Mine tailings (As/Au/Cu)
S11	MARRANCOS (Vila Verde, Portugal)	Mine tailings (Au/Ag/As)

Phytomanagement under-utilised as practical remediation strategies in the European contaminated land sector.

Field evidence demonstrating the provision of ecosystem services as a result of phytomanagement options.

Permit the transfer the phytomanagement options to other sites in Sudoe and other similar EU regions.



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Industrial zones

- (wood treatment facility)
- Rhizoremediation
- Phytostabilization
- Phytoextraction

Climatic regions

Site characteristics

- Contaminant type
- Degradation process
- Land use

Phytomanagement option

Urban / Peri-urban areas

- Phytostabilization
- Sustainable re-vegetation



Mining areas

- Phytostabilisation
- Phytoextraction

GT2: Characterisation and assessment of biodiversity in relation to phytomanagement options

- Aim is to study the links between structural (taxonomic) and functional biodiversity in phytomanaged soils

Phytomanaged soils (compare different options)

Non-phytomanaged contaminated soils

Non-contaminated reference soils

PRINCIPAL PRODUCT: Guide of Best Phytomanagement Practices for Biodiversity Restoration in Degraded and Contaminated Sites

GT2: Characterisation and assessment of biodiversity in relation to phytomanagement options

- Aim is to study the links between structural (taxonomic) and functional biodiversity in phytomanaged soils with physicochemical properties and plant diversity.
- Long-term sites
- Two sampling episodes
(Spring 2017 and 2018)
- Macrofauna

Phytomanaged soils (compare different options)

Non-phytomanaged contaminated soils

Non-contaminated reference soils

Next generation sequencing; shot-gun sequencing

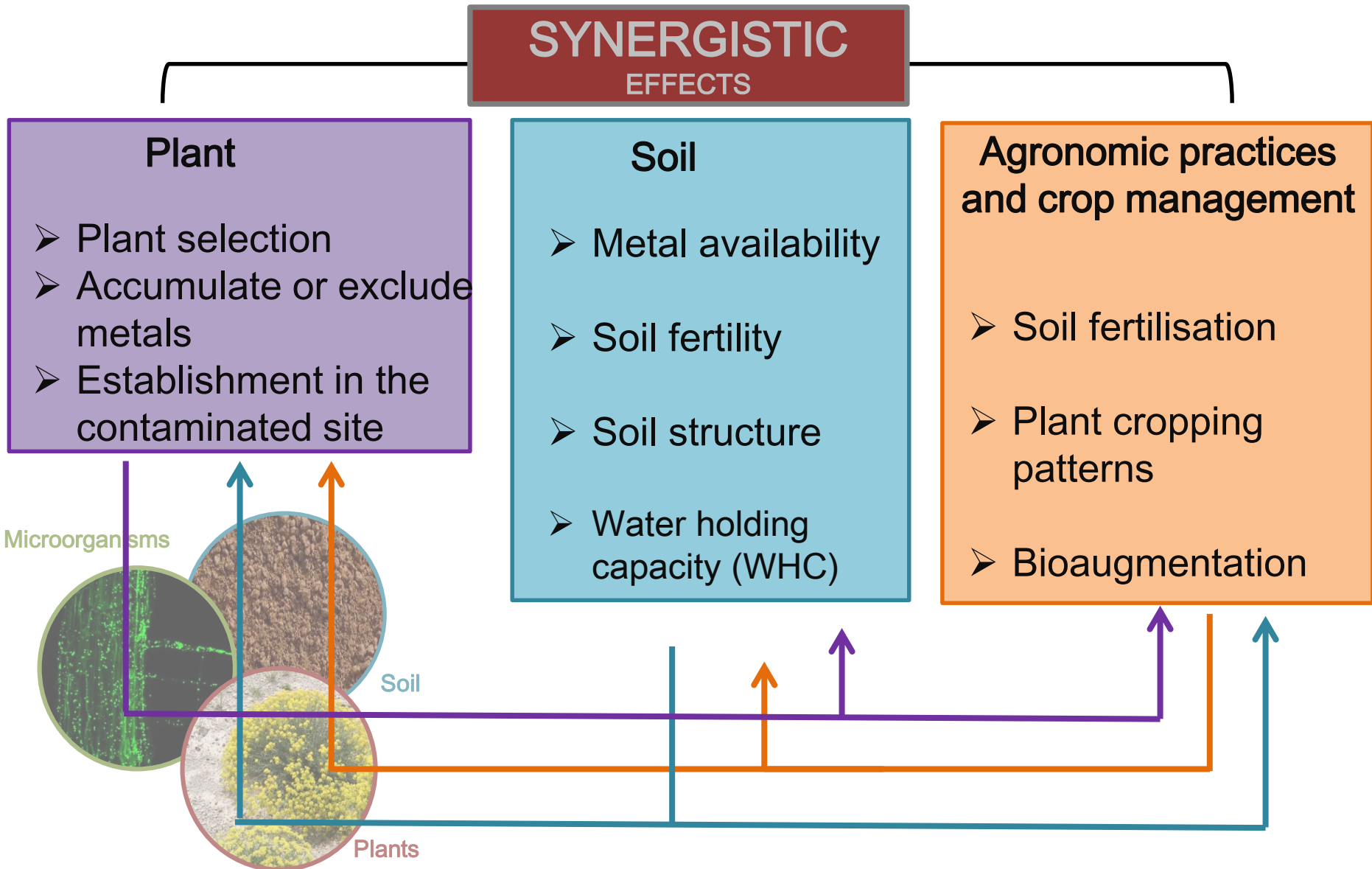
Conventional methods: soil enzymatic activities, community level physiological profiling

GT3: Exploring prospects of improving phytomanagement efficiency

Specific objectives are to assess:

- (1) effect of **cropping patterns** on soil fertility, functional diversity and TE mobility;
- (2) **bioinoculant influence** for improving plant performance and soil functionality/diversity;
- (3) effect of **biostimulants** on plant performance, TE mobility and uptake and soil functionality;
- (4) **crops with economic value** (e.g. energy crops) while mitigating soil contamination and pollutant linkages

Factors influencing phytomanagement success/optimization



Soil metal availability

Plant selection

Soil amendments

OPTIMISATION

Plant cropping patterns

Bioaugmentation



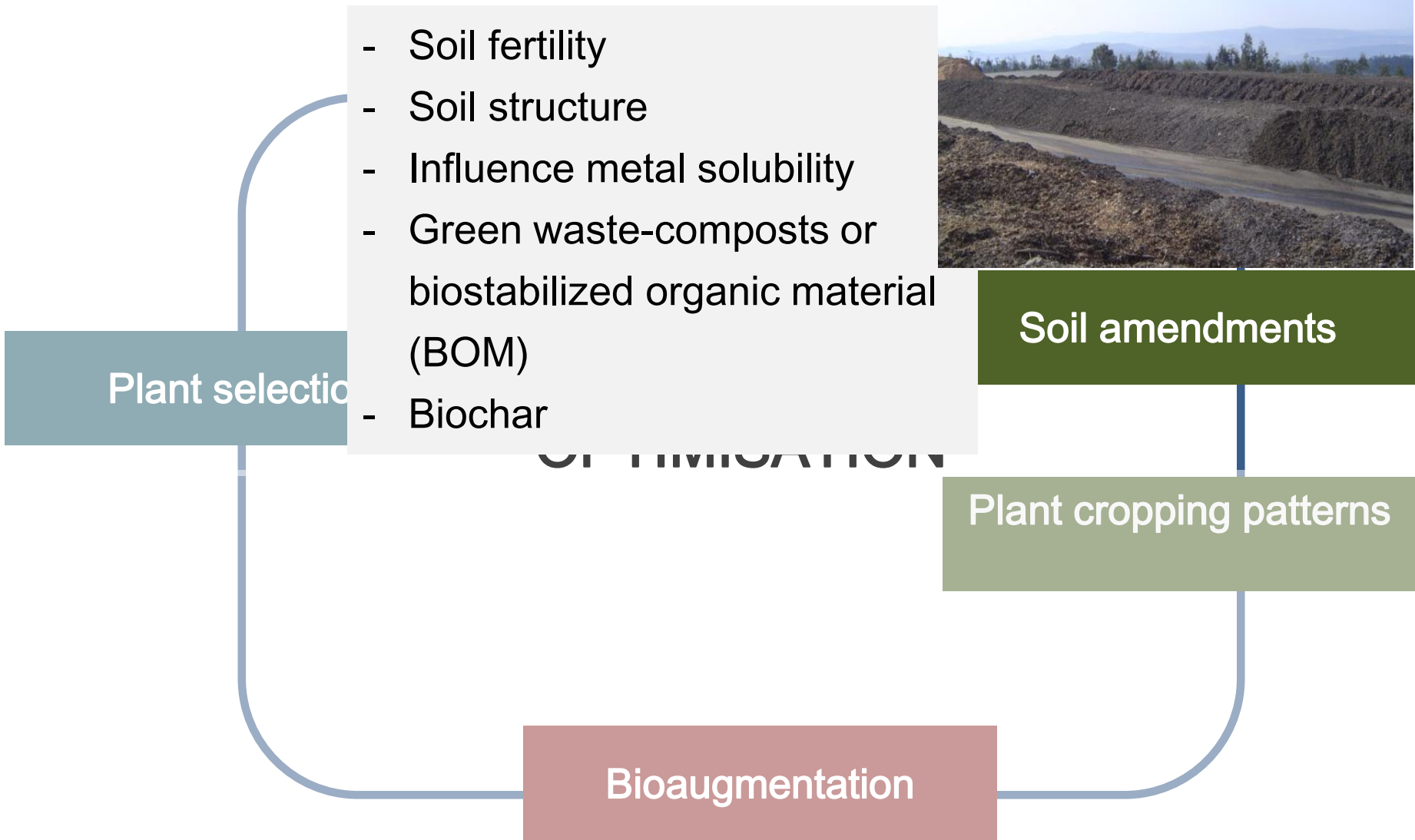
HYPERACCUMULATORS



WOODY CROPS



**HIGH BIOMASS
ANNUALS**



Soil metal availability

Soil amendments

Plant selection

OPTIMISATION

- Soil fertility
- pH changes
- Metal solubility
- Plant health
- Rotation, Intercroppings, winter cover crops

Plant cropping patterns



Soil metal availability

- Plant Growth Promoting microorganisms
- ↑ Growth, metal tolerance
- ↑ Metal solubility and plant uptake

Soil amendments

Plant cropping patterns

OPTIMISATION



PRINCIPAL PRODUCT: Bioinocula formulations with efficient microorganisms for the establishment and growth of energy crops and woody trees for phytomanagement

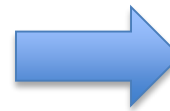


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GT4: Key ecological functions in phytomanaged sites which provide ecosystem services

- Assess improvements in soil processes, focusing on:

- 1) General physicochemical properties,
- 2) Dynamics of soil organic matter,
- 3) Soil fertility and nutrient cycling,
- 4) Total and available soil contaminants
- 5) Soil structure and water r



GT1
(Physicochemical
characterisation;
bioavailability)



GT2
(Relationships between
structural and functional

are different

PRINCIPAL PRODUCT: Harmonized methodology guide for assessing and monitoring key soil processes in phytomanaged sites

RECOVERING CONTAMINATED SOILS THROUGH PHYTOMANAGEMENT IN SOUTHWEST EUROPE

Principal product of PhytoSUDOE

- A cluster of research groups and associates phytomanaging a transnational network of contaminated sites and developing methods, protocols, and conceptual models.

R&D sector

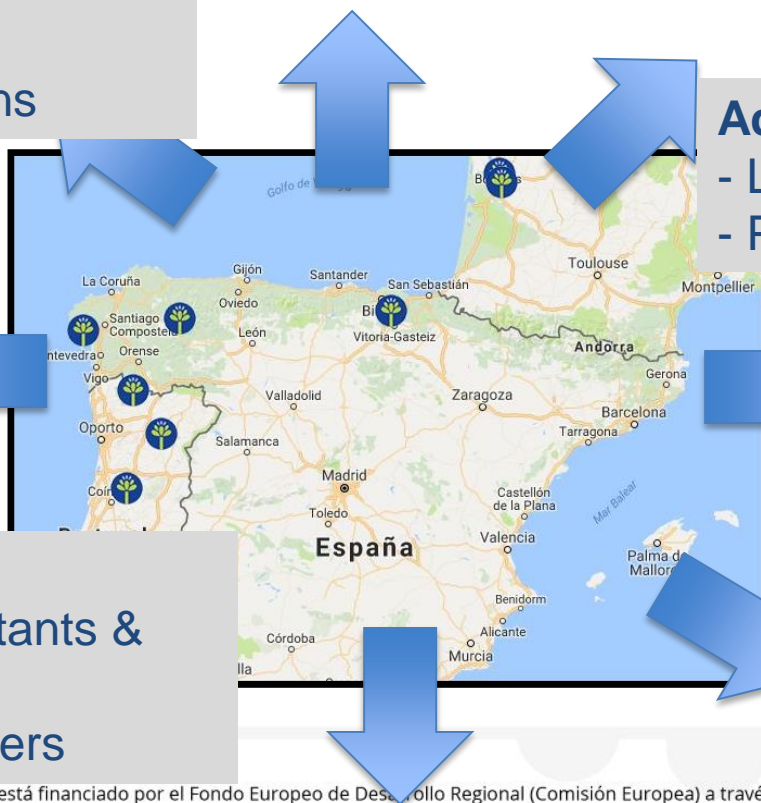
- Academia
- Research institutes
- Professional associations

Primary sector

- Agriculture
- Silviculture/Forestry
- Plant production
- Mining

Technological sector

- Environmental consultants & managers
- Environmental engineers



Administrative sector

- Local/regional authorities
- Public bodies

Industrial sector

- Construction
- Bioenergy
- Ecomaterials
- Green chemistry

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