3RD WORKSHOP

Phytomanagement for soil remediation and the creation of value

Interreg Sudoe

EUROPEAN UNION

Phy2SUDOE

European Regional Development Fund

Abstract Book

6th October 2022

Santiago de Compostela

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PROJECT SUMMARY

Phy2SUDOE (SOE4/P5/E1021): "Advancing in the application of innovative phyto-management strategies in contaminated areas of the SUDOE space"
Start date: 01/11/2020
End date: 30/04/2023
Project length: 30 months
ERDF grant: 838.424,25 €

Soil contamination is a widespread problem in Europe with adverse consequences for biodiversity, ecosystem functioning and human health. Phy2SUDOE project promotes a wider use of phytomanagement strategies by managers and owners of contaminated lands. Phytomanagement is a multi-objective management strategy, based on the use of plants (trees, shrubs, herbaceous) to control contamination-induced risks in contaminated sites, while generating products (e.g., wood, resin, essential oils, bioenergy, ecocatalysts) from harvested biomass and enhancing the supply of ecosystem services (e.g., carbon sequestration, erosion control, creation of habitats).
Phy2SUDOE project also aims to implement strategies for the conservation of endemic biodiversity in contaminated sites due to its intrinsic and utilitarian value (e.g., biotechnological applications).

PROJECT WEBSITE

https://www.phytosudoe.eu/

CONTACT

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Phy2SUDOE project (SOE4/P5/E1021) is financed by the Interreg Sudoe Programme through the European Regional Development Fund (ERDF).

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Universidade Católica Portuguesa, UCP-CRP (Portugal)

Fertil'Innov Environnement (Francia)

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3RD PHY2SUDOE WORKSHOP: PHYTOMANAGEMENT FOR SOIL REMEDIATION AND THE CREATION OF VALUE

6TH OCTOBER 2022
MBG-CSIC-SANTIAGO DE COMPOSTELA

VENUE: MBG-sede Santiago, Avenida de Vigo s/n, Campus vida 15705 Santiago de Compostela; Tel: +34 981 59 09 58

PROGRAMME

All times are in Spanish time.

9:00 – 9:30
Registration

9:30 – 9:40
Welcome
M. Concepción Sánchez Fernández (MBG-CSIC, Spain)
Ángeles Prieto-Fernández (MBG-CSIC, Spain)
Beatriz Rodríguez-Garrido (MBG-CSIC, Spain)
M. Carmen Monterroso Martínez (USC, Spain)

9:40 – 11:30
Session 1 –The Phy2SUDOE network of phytomanaged sites: monitoring activities and biodiversity studies.
Chair: *Sofia Almeida Pereira* (UCP, Portugal) and *M. Carmen Monterroso Martínez* (USC, Spain)

9:40 – 9:55
Introduction to Phy2SUDOE project.
Carlos Garbisu (Neiker, Spain) ONLINE

10:00 – 10:15
Phytomanagement on Les Avinières site.
Souhir Soussou (Fertil'Innov Environnement, France) ONLINE

10:15 – 10:30
Progress of phytomanagement at five French sites
Michel Mench (INRA, France)

10:30 – 10:45
Experiences of phytomanagement in the Basque Country
José María Becerril (UPV, Spain)

10:45 – 11:00
Experiences of phytomanagement in Galician sites
Ángeles Prieto-Fernández (MBG-Santiago, Spain)

11:00 – 11:15
Biodiversity of the Phy2SUDOE contaminated sites
Helena Gomes Moreira (UCP, Portugal)

11:15 – 11:30
Q&A

11:30 – 12:00
Break (30 min) & Photograph of participants

12:00 – 14:00
<u>Session 2</u> – Vision and lessons from other private and public soil managers (1)
Chair: *Helena Gomes Moreira* (UCP, Portugal) and *Carmen Trasar Cepeda* (MBG-CSIC, Spain)

12:00 – 12:20
Soil protection strategy: reaping the benefits from healthy soils for people, food, nature and climate. The contribution of the Basque Country.
Ana Alzola (IHOBE, Spain) ONLINE

12:20 – 12:40
Management of contaminated soils in Galicia.
Susana Franco Maside and *Águeda Pardo del Río* (Servizo de IPPC- Consellería de Medio Ambiente, Territorio e Vivenda - Xunta de Galicia, Spain)

12:40 – 13:00
Technosoils. Improving soil conditions in degraded areas.
Felipe Macías (USC, Spain)

13:00 – 13:20
The green infrastructure of Vitoria-Gasteiz. Strategies for the recovery of degraded soils and case studies.
Juan Vilela Lozano (CEA- Ayuntamiento de Vitoria-Gasteiz, Spain)

13:20 – 13:40
Establishing Site Specific Target Values for a Large Scale Soil Remediation — a real case.
Álvaro Nunes de Sousa (CloverStrategy, Portugal)

13:40 – 14:00
Q&A

14:00 – 15:30
Lunch break (MBG-Santiago)

15:30 – 17:15

<u>Session 3</u> – Vision and lessons from other private and public soil managers (2)

Chair: *Michel Mench* (INRA, France) and *Rocío Millán Gomez* (CIEMAT, Spain)

15:30 – 15:50

Use of hyperaccumulating plant species for Ni phytomining

Guillaume Echevarria (Econick, France)

15:50 – 16:10

Casuarinaceae and associated soil organisms, useful resources for the recovery of ultramafic soils from Malesia.

Celestino Quintela-Sabarís (Universidade de Vigo, Spain)

16:10 – 16:30

Project ReCROP - Bioinocula and CROPping systems: an integrate approach for improving crop yield, biodiversity and REsilience of Mediterranean agro-ecosystems.

Sofia Almeida Pereira (UCP, Portugal)

16:30 – 16:50

TERRAMATER: A tool for post-fire rehabilitation and restoration of soils.

Juan Antelo (USC, Spain)

16:50 – 17:15

Q&A

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Session 1 –The Phy2SUDOE network of phytomanaged sites: monitoring activities and biodiversity studies.

Introduction to Phy2SUDOE project.

C. Garbisu[1]

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Phyto-management is a phytotechnology, arising from phytoremediation, based on the use of plants (trees, shrubs, herbaceous) to control the risk associated with the presence of contaminants in degraded sites, while: (i) they are generated products (eg, wood, resin, essential oils, bioenergy, ecocatalysts) from harvested biomass; and (ii) the supply of ecosystem services is enhanced (e.g., C sequestration, erosion control, creation of habitats).

Phy2SUDOE aims to value sites contaminated with metals-metalloids and / or organic compounds in the SUDOE region through the use of phyto-management strategies aimed at the generation of ecosystem products and services in these sites, while minimizing the environmental impact of pollutants. could cause. Likewise, this project aims to implement strategies for the conservation of endemic biodiversity typical of some contaminated sites (e.g., metallurgical flora, plant growth-promoting bacteria, etc.) due to their intrinsic and utilitarian value (e.g., biotechnological applications).

Phy2SUDOE is a continuation of the PhytoSUDOE project in which a network of sites was formed, mainly contaminated with metal-metalloids, phyto-managed in the SUDOE region. Phy2SUDOE intends to: (i) consolidate the network formed in the previous project; (ii) expand the aforementioned network of sites with new contamination cases (soils contaminated with organic compounds or with mixed contamination) and innovative phyto-management strategies based on the mixture of plant species; and (iii) promote the conservation of endemic biodiversity in some sites that host biota of conservation and biotechnological interest, while promoting biodiversity through the implementation of phyto-management strategies.

A novel aspect of Phy2SUDOE is the presence of partners of very diverse types: in addition to universities and R&D centers, companies, administrations and site managers participate, which favors the link between the creation of solutions and management strategies.

There are many contaminated sites in the SUDOE area. Phytomanagement is a remediation strategy that combines the reduction of the risk associated with pollutants with the creation of value through the generation of products and ecosystem services. The PhytoSUDOE project created a network of sites (PhytoSUDOE Network) in which the benefits of various phytomanagement options on soil quality were demonstrated, mainly on sites contaminated with trace elements. Phy2SUDOE aims to transfer this knowledge, acquired by mainly academic centres, to managers of contaminated sites included as partners and associated partners (administrations, companies). To this end, new sites have been incorporated with different pollution casuistry (type/use of the land, organic pollutants/mixtures) where new phytomanagement strategies will be applied using the harmonised methodology developed in PhytoSUDOE.

Spanish version

Introducción al proyecto Phy2SUDOE

C. Garbisu[1]

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La fitogestión es una fitotecnología, surgida a partir de la fitorremediación, basada en el uso de plantas (árboles, arbustos, herbáceas) para controlar el riesgo asociado a la presencia de contaminantes en emplazamientos degradados, a la vez que: (i) se generan productos (e.g., madera, resina, aceites esenciales, bioenergía, ecocatalizadores) a partir de la biomasa cosechada; y (ii) se potencia el suministro de servicios ecosistémicos (e.g., secuestro de C, control de erosión, creación de hábitats).

Phy2SUDOE pretende valorizar emplazamientos contaminados con metales-metaloides y/o compuestos orgánicos en la región SUDOE mediante el empleo de estrategias de fitogestión encaminadas a la generación de productos y servicios ecosistémicos en dichos emplazamientos, a la vez que se minimiza el impacto ambiental que los contaminantes pudieran ocasionar. Asimismo, este proyecto aspira a implantar estrategias de conservación de la biodiversidad endémica propia de algunos emplazamientos contaminados (e.g., flora metalícola, bacterias promotoras del crecimiento vegetal, etc.) por su valor intrínseco y utilitario (e.g., aplicaciones biotecnológicas).

Phy2SUDOE es continuación del proyecto PhytoSUDOE en el que se formó una red de emplazamientos, principalmente contaminados con metales-metaloides, fitogestionados en la región SUDOE. Phy2SUDOE pretende: (i) consolidar la red formada en el anterior proyecto; (ii) ampliar la citada red de emplazamientos con nuevas casuísticas de contaminación (suelos contaminados con compuestos orgánicos o con contaminación mixta) e innovadoras estrategias de fitogestión basada en la mezcla de especies de plantas; y (iii) potenciar la conservación de la biodiversidad endémica en algunos emplazamientos que albergan biota de interés conservacionista y biotecnológico, a la vez que se promueve la biodiversidad a través de la implementación de estrategias de fitogestión.

Un aspecto novedoso de Phy2SUDOE es la presencia de socios de tipologías muy diversas: además de universidades y centros de I+D, participan empresas, administraciones y gestores de emplazamientos, lo que favorece el vínculo entre creación de soluciones y estrategias de gestión.

En el espacio SUDOE hay muchos emplazamientos contaminados. La fitogestión es una estrategia de remediación que combina la reducción del riesgo asociado a los contaminantes con la creación de valor mediante la generación de productos y servicios ecosistémicos. El proyecto PhytoSUDOE creó una red de emplazamientos (PhytoSUDOE Network) en la que se demostraron los beneficios de diversas opciones de fitogestión sobre la calidad del suelo, principalmente en lugares contaminados con elementos traza. En Phy2SUDOE se pretende transferir ese conocimiento, adquirido por centros mayoritariamente del ámbito académico, a gestores de emplazamientos contaminados incluidos como socios y socios asociados (administraciones, empresas). Para ello se han incorporado nuevos emplazamientos con distintas casuísticas de contaminación (tipo/uso del terreno, contaminantes orgánicos/mezclas) donde se aplicarán nuevas estrategias de fitogestión utilizando la metodología armonizada desarrollada en PhytoSUDOE.

Phytomanagement on Les Avinières site

Soussou S.[1]*, Geoffroy A.[1], Finck J.[1], Rossler P.[2], Jacquemin P.[3], Cleyet-Marel JC.[1]

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The Avinières site in Saint Laurent le Minier (Gard) was a lead and zinc mining area in France. Near this site, the old industrial installations have been gradually replaced by dwellings which are exposed to the flight of dust loaded with lead, zinc and cadmium.

The ADEME, in accordance with the prescriptions of the prefectural decree of official works n ° 2019-04-010 of April 8, 2019, was mandated to carry out safety work. The works consist, among other operations, in the revegetation of the Avinières waste rock pile in order to reduce the emission of dust loaded with Trace Metal Elements (ETMs) which presents a danger for the population living below.

The rehabilitation operation undertaken on the Avinières site is a long-term one and includes several stages:

- Control and improvement of the quality of the mining substrate: In addition to the high content of ETMs (5% lead, 10% zinc), the substrate has a low content of organic matter and major elements essential for plant growth. A specific strategy has been developed to provide amendments with high organic matter content in large quantities.

- Laboratory tests: Seeds of all native species were collected and then tested in the laboratory to determine their level of ETMs resistance. We have thus identified 18 plant species adapted to the conditions of the site and a set of symbiotic microorganisms.

- *In situ* tests: Before carrying out the rehabilitation of the old mine, *in situ* tests were carried out in order to confirm the effectiveness of the contribution of organic matter and to optimize the associations of the different plant and microbial species to quickly cover the tailings.

- Establishment of an in situ nursery to multiply native species: The aim was to produce seeds in sufficient quantities to phytostabilize the waste rock of Avinières.

- Site earthworks: the objective of this work was to lower the slopes which were high in order to improve their stability, limit surface erosion and promote the regrowth of vegetation. The earthworks were carried out under misting, with cut and fill balanced by zone, in order to allow the work to be carried out using small mechanized machinery and to prevent the emission of dust.

- Amendment of the substrate: to guarantee the good development of the vegetation, an organic amendment based on compost of green waste has been made. Particular attention was paid to the quantities of compost and to the homogeneity of the incorporation of the compost in the first 30 centimeters of the mining substrate through the performance of specific and regular controls of the substrate after preparation. Coconut fiber geonets were then placed on the embankments to help the seeds stick.

- Installation of the irrigation system: in order to guarantee the germination and the correct development of the autochthonous plants during the first years, it was necessary to set up an irrigation system. The water supplies are programmed to promote the development of the root system of the plants in depth.

- Revegetation work: the final sowing of native plants was done by hydraulic sowing.

- For all stages, air and water monitoring is carried out in order to verify the impact of the work on the environment.

Progress of phytomanagement at five French sites

Mench M[1], Beaujean S[1], Henrion M[1], Segura R[1], Marchand L[2], Delzon S[1], Jouveau S[1], Dudoit L[3], Corneau R[4], Delerue F[5], Paille-Barrere Ch[6], Rodriguez B[7], Prieto-Fernandez A[7]

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Two contaminated sites around Bordeaux city (St-Médard d'Eyrans and Chaban-Delmas), included in the GT1 of the Phy2SUDOE project, displayed long-term field trials with phytomanaged plots (e.g. annual crops, perennial grasses, and short rotation coppices) for the Bioeconomy. Three new sites (Sentein, Bordes, and Durandeau) were included in the Phy2SUDOE GT2, and another one (Les Avinières) managed by Soussou et al (Fertil'Innove Environnement partner) as well.

St-Médard d'Eyrans: Besides soil analysis of all plots, after Miscanthus in December and vetiver /Amorpha fruticosa in March, winter barley was harvested (June) in two field trials. Foliar Si and Se fertilization were assessed. Shoot, ear and straw DW yields were determined. Winter barley in plots with less inputs of organic matter and more mineralisable ones were more affected by the drought. Intermediate wheat (Kerzna) was suffering from five heatwaves (influence of climate change) and would be harvested in late autumn if sufficient rainfall occurs. Drone (UAV) flights were done to assess the vegetation cover and its growth traits across the field plots.

Chaban-Delmas: Both grassland trials with compost, alone and combined with biochar, and foliar Si and Se fertilization were maintained. The hay harvest in end of June was delayed due to the drought induced by the summer heatwaves, to avoid too much stress. Again, this harvest will depend on the potential autumn rainfalls. Soil samples were analyzed. In poplar dotted-grasslands, aliquots from the poplar rhizosphere were sampled and sent to Neiker (Epelde et al). UAV flights were monitoring the status of the vegetation cover and its growth traits.

Sentein: Soil samples were analyzed for Le Bocard, La Plagne, and Chichoué subsites, showing the influence of substrate, soil pH, total soil metal(loid)s, and soil organic matter on the metal(loid) availability. Soil samples (> 50 kg, Le Bocard) were collected in July 2022, for the GT3 and a pot experiment that will be carried out by the UPC partner for assessing the bioaugmentation and soil amendments. In addition, the presence of insects and mesofauna was investigated, notably at the La Plagne subsite. In parallel, a pot experiment was carried out to assess the influence of compost and dolomite. The shoot DW yield of dwarf bean plants evidenced a beneficial effect of the compost addition, but no synergy with the dolomite supply. A second pot experiment was started in Sept. 2022, to assess the influence of a higher compost addition rate, alone and combined with biochar, a metal-tolerant population of *Agrostis capillaris*, combined with bioaugmentation and earthworms.

Bordes: Soil samples from six subsites were analyzed. The harvested vegetation cover (mainly grasses and white clover) was dried, wet-digested, and analyzed. A pot experiment was carried out to assess the seed bank, the soil phytotoxicity (Plantox test with dwarf bean) and the influence of compost addition. These soil samples from the phytomanaged areas did not induce

visible symptoms on the aboveground plant parts. The compost addition increased the vegetation cover and the plant species richness.

Durandeau: the plant community implemented in March was surveyed on July and August. Most plant species have survived and well developed thanks to the irrigation system (only 2 poplars died in the compost-amended lysimeters) showing water supply as a key-player face to the climate change. Sampling of lysimeter leachates, soils and shoots is ongoing. Events and open-doors with scholars are prepared.

Soil enzyme activities were determined by the CSIC for Bordes, St-Médard d'Eyrans and Sentein soils.

This project is funded by the Interreg SUDOE. INRAE is member of the INRAE Ecotox network and the PlantMetals COST Action 19116.

French version

Progrès du phytomanagement sur 5 sites contaminés en France

Mench M[1], Beaujean S[1], Henrion M[1], Segura R[1], Marchand L[2], Delzon S[1], Jouveau S[1], Dudoit L[3], Corneau R[4], Delerue F[5], Paille-Barrere Ch[6], Rodriguez B[7], Prieto-Fernandez A[7]

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Deux sites contaminés situés à proximité de Bordeaux (St-Médard d'Eyrans et Chaban-Delmas), inclus dans le GT1 du projet Phy2SUDOE, présentent des essais à long terme avec des parcelles phytomanagées (e.g., cultures annuelles, graminées pérennes, taillis à courte rotation) pour la bioéconomie. Trois nouveaux sites (Sentein, Bordes et Durandeau), et un autre (Les Avinières) géré par Soussou et al (partenaire Fertil'Innove Environnement), ont été inclus dans le GT2 de Phy2SUDOE.

St-Médard d'Eyrans : Outre l'analyse du sol de toutes les parcelles, après le miscanthus en décembre et le vétiver et les Amorpha fruticosa en mars, l'orge d'hiver a été récoltée (juin) dans 2 essais en plein champ. Les fertilisations foliaires en Si et Se ont été évaluée. Les rendements en parties aériennes, épis et paille ont été déterminés. L'orge d'hiver dans les parcelles avec moins d'apports de matières organiques, et compost plus facilement minéralisable a été plus affectée par la sécheresse. Le blé intermédiaire (Kerzna) a souffert de 5 vagues de chaleur (influence du changement climatique) et sera récolté à la fin de l'automne si les précipitations sont suffisantes. Des survols de drones ont été effectués pour évaluer le couvert végétal et ses caractéristiques de croissance selon les parcelles de terrain.

Chaban-Delmas : Les 2 essais de prairie, avec apport de compost, seul ou combiné avec du biochar, et la fertilisation foliaire en Si et Se ont été maintenus. La récolte du foin à la fin du mois de juin a été retardée en raison de la sécheresse induite par les canicules de l'été, afin d'éviter un stress trop important. La récolte dépendra des pluies potentielles de l'automne. Des échantillons de sol ont été analysés. Dans les prairies sous peupliers, des aliquotes de sol rhizosphérique du peuplier ont été échantillonnés et envoyés à Neiker (Epelde et al). Des survols de drones ont permis de suivre l'état du couvert végétal et ses caractéristiques de croissance.

Sentein : Des échantillons de sol ont été analysés pour les stations Le Bocard, La Plagne et Chichoué, montrant l'influence du substrat, du pH du sol, des métaux/métalloïdes) totaux et de la matière organique sur la disponibilité des métaux/métalloïdes. Des échantillons de sol (> 50 kg, Le Bocard) ont été collectés en juillet 2022, pour le GT3 et une expérience en pot qui sera réalisée par le partenaire UPC pour évaluer la bioaugmentation et les amendements du sol. La présence d'insectes et de mésofaune a été étudiée, notamment sur la station de La Plagne. En parallèle, une expérience en pot a été réalisée pour évaluer l'influence du compost et de la dolomie. La biomasse des parties aériennes des plants de haricots nains a montré un effet bénéfique de l'ajout de compost, mais peu de synergie avec l'apport de dolomie. Une seconde expérience en pot a été lancée en septembre 2022, pour évaluer l'influence d'un taux d'apport de compost plus élevé, seul et associé à du biochar, avec une population d'*Agrostis capillaris* tolérante à Cu, associée à une bioaugmentation et des vers de terre.

Bordes : Des échantillons de sol provenant de six stations ont été analysés. La couverture végétale récoltée (principalement des graminées et du trèfle blanc) a été séchée, minéralisée par voie humide et analysée. Une expérience en pot a été réalisée pour évaluer la banque de graines, la phytotoxicité du sol (test Plantox avec haricot nain) et l'influence de l'ajout de compost. Ces échantillons de sol provenant des zones phytomanagées n'ont pas induit de symptômes visibles sur les parties aériennes des plantes. L'ajout de compost a augmenté le couvert végétal et la richesse spécifiques en espèces végétales.
Durandeau : la communauté végétale mise en place en mars a été étudiée en juillet et août. La plupart des espèces végétales ont survécu et se sont bien développées grâce au système d'irrigation (seulement 2 peupliers sont morts dans les lysimètres amendés avec du compost) montrant que l'approvisionnement en eau est un acteur clé face au changement climatique. L'échantillonnage des lixiviats des lysimètres, des sols et des végétaux est en cours. Des événements pédagogiques et des portes ouvertes avec des universitaires et scolaires sont en préparation.
Les activités enzymatiques des sols ont été déterminées par le partenaire CSIC (Santiago de Compostela) pour les sols de Bordes, St-Médard d'Eyrans et Sentein.

Ce projet Phy2SUDOE est financé par l'Interreg SUDOE. L'INRAE est membre du réseau INRAE Recotox et de l'action COST 19116 PlantMetals.

Experiences of Phytomanagement in the Basque Country

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In the frame of the Phyt2SUDOE project, several phytomanagement strategies are being applied in three sites with mixed contamination in the Basque Country (Gernika, Ariñez/ Vitoria-Gasteiz and Zumabakotxa/ Vitoria-Gasteiz). Experts in Plant Biology and Animal Biology from UPV/EHU, in Microbial Ecology from NEIKER and Botany from CEA work together in these sites to implement microbial-assisted phytoremediation and/or vermiremediation technologies to reduce pollution and ecotoxicity, recover soil functions, ecosystem services and soil health. To this end, we jointly developed a set of complementary monitoring methodologies based on biological indicators to assess soil toxicity.

Ariñez/ Vitoria-Gasteiz site was implemented in the past PhytoSudoe project and presently we are carrying out long-term maintenance and monitoring in this site. Here we assessed the benefits of co-culture of fast-growing trees with alfalfa plants and inoculation with mychorrhiza. Plant biodiversity increased over time being colonized at present by native grasses and leguminous plants. Presence of trees mobilized some organic pollutants towards the soil surface, and presence of alfalfa and mycorrhization increased fungal and bacterial abundance. Ongoing work in this site will give us information on the evolution of structural composition of microbial communities, plant performance and level of pollutants.

In the frame of the new network sites of Phyt2SUDOE project in the mixed contaminated site of Gernika we assessed the effectiveness of microbial augmentation, phytoremediation and vermiremediation alone or in combination. Biological remediation technologies reduced pollution level, especially for pesticides as dieldrin, when they are applied combined, decreasing toxicity for plants and earthworms, with no effect on native microbial populations. In the new peri-urban site of Zumabakotxa/ Vitoria-Gasteiz, with a very heterogeneous distribution of low/medium level of organic pollutants, we implemented a new strategy combined with landscape restoration criteria. Vegetation (willows, poplar, holm oak, gall oak, meadow, and scrub) were selected for each contaminated plot according with edaphoclimatic conditions of the plot and future land use of the site as a public park. Soil pollution (TPH, b(a) pyrene, aldrin, PCBs), soil qualitative analysis, and performance of vegetation are being assessed. So far, organic soil pollution decreased in most of plots vegetated.

Cooperation among experts from different fields is an essential strategy to develop and address the recovery of contaminated sites with new diagnostic and treatment tools.

Acknowledgments :

We thanks to the ten beneficiary and associated partners, particularly IHOBE, and the City Hall of Vitoria-Gazteiz and Gernika.

Spanish version

Experiencias de Fitogestión en el País Vasco

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RESUMEN

En el marco del proyecto Phyt2SUDOE, se están aplicando diversas estrategias de fitogestión en tres emplazamientos con contaminación mixta del País Vasco (Gernika, Ariñez/ Vitoria-Gasteiz y Zumabakotxa/Vitoria-Gasteiz). Expertos en Biología Vegetal y Biología Animal de la UPV/EHU, en Ecología Microbiana de NEIKER y en Botánica del CEA trabajan juntos en estos emplazamientos para implementar tecnologías de fitorremediación y/o vermiremediación asistidas por microorganismos para reducir la contaminación y la ecotoxicidad del suelo, recuperar sus funciones, y los servicios ecosistémicos y la salud. Con este fin, hemos desarrollado conjuntamente varias metodologías complementarias de monitorización basadas en indicadores biológicos con el fin de evaluar la toxicidad del suelo. El emplazamiento de Ariñez/Vitoria-Gasteiz se implementó en el pasado proyecto PhytoSudoe y actualmente estamos realizando un mantenimiento y monitorización a largo plazo en este lugar. Aquí evaluamos los potenciales beneficios del co-cultivo de árboles de rápido crecimiento con plantas de alfalfa y la inoculación con micorrizas. La biodiversidad vegetal ha aumentado con el tiempo, siendo colonizado en la actualidad por gramíneas y leguminosas nativas. La presencia de árboles ha movilizado algunos contaminantes orgánicos hacia la superficie del suelo, y la presencia de alfalfa y la micorrización ha aumentado la abundancia de hongos y bacterias. El trabajo en curso en este sitio nos dará información sobre la evolución de la composición estructural de las comunidades microbianas, el estado fisiológico de las plantas y el nivel de contaminantes del suelo. En el marco de la ampliación de los nuevos emplazamientos en la red del proyecto Phyt2SUDOE en el emplazamiento con contaminación mixta de Gernika, evaluamos la efectividad de tratamientos de bioaumentación microbiana, fitorremediación y vermiremediación, sólos o en combinación. Las tecnologías de remediación biológica aplicadas redujeron el nivel de contaminación, especialmente de pesticidas como el dieldrín, cuando se aplicaron combinados, disminuyendo la toxicidad para plantas y lombrices, y sin causar efectos sobre las poblaciones microbianas nativas. En el nuevo emplazamiento periurbano de Zumabakotxa/ Vitoria-Gasteiz, con una distribución muy heterogénea de niveles bajos/medios de contaminantes orgánicos, implantamos una nueva estrategia de remediación combinada con criterios de restauración paisajística. Para cada parcela contaminada se seleccionó una vegetación diferente (sauces, chopos, encinas, quejigos, prados y matorrales) en función de las condiciones edafoclimáticas de la parcela y del futuro uso del suelo como parque público. Actualmente se está evaluando la contaminación del suelo (TPHs, PAHs, aldrin, PCBs), el análisis cualitativo del suelo y el estado de la vegetación. A pesar del poco tiempo transcurrido la contaminación orgánica del suelo ha disminuido por debajo de los valores de referencia en la mayoría de las parcelas con vegetación.

La cooperación entre expertos de diferentes campos es una estrategia fundamental para desarrollar y abordar la recuperación de sitios contaminados con nuevas herramientas de diagnóstico y tratamiento.

Agradecimientos: Agradecemos a los diez socios beneficiarios y asociados, en especial a IHOBE, y al Ayuntamiento de Vitoria-Gazteiz y Gernika.

Experiences of phytomanagement in Galician sites

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The network of phytomanaged sites established in the frame of the projects PhytoSUDOE and Phy2SUDOE, funded by the Interreg SUDOE programme, included experiences in several sites across the SUDOOE region, covering a wide range of climatic conditions and edaphic characteristics. The network included 3 sites located in Galicia (NW Spain) established in tailings of two abandoned mining sites (a Zn, Pb and Cd mining site, and a Cu mining site) as well as serpentine quarry dedicated to the extraction of ballast.

In the Zn-Pb-Cd tailing the management involved the use of the short-rotation coppice *Salix smithiana* planted (in monocropping or in co-cropping with *Alnus* sp.) in soil non amended, fertilised with NPK, or amended with compost. In the Cu mine, three different amendments were tested (compost and 2 technosols enriched in Fe or Al) and the performance of two plant species (*Salix viminalis* and *Agrostis capilaris*) was evaluated. Finally in the serpentine quarry two different doses of compost were applied and a phytomining trial using the Ni hyperaccumulators *Bormuellera emarginata* and *Bormuellera tymphaea* was established.

The monitoring for more than 10 years of the phytomanagement in the mine tailings demonstrated the successful establishment of a vegetation cover and the long-term improvement of essential soil physic, chemical and biological properties directly involved in the provision of important soil ecosystem services. The Mediterranean Ni hyperaccumulators could thrive in the quarry substrate amended with compost, showing a good survival and yielding a biomass at harvest of up to 400 kg of *B. emarginata* ha^{-1} and 130 kg of *B. tymphaea* ha^{-1}.

Spanish version

Experiencias de fitogestión en emplazamientos de Galicia

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La red de emplazamientos fitogestionados establecida en el marco de los proyectos PhytoSUDOE y Phy2SUDOE, financiados por el programa Interreg SUDOE, incluyó estudios en varios emplazamientos a lo largo de la región SUDOOE, cubriendo un amplio rango de condiciones climáticas y características edáficas. La red incluyó 3 emplazamientos situados en Galicia (noroeste de España) establecidos en escombreras de dos explotaciones mineras abandonadas (una explotación de Zn, Pb y Cd, y otra de Cu), así como una cantera de serpentina dedicada a la extracción de balasto.

En la mina de Zn-Pb-Cd se estableció un ensayo de campo en el que se está evaluando la capacidad de fitoextracción de Cd/Zn y el potencial de producción de biomasa de un sistema forestal de especies de ciclo corto. El ensayo incluyó la plantación de *Salix smithiana* BOKU 03 CZ-001, una planta acumuladora Pb/Zn, en monocultivo o en cocultivo con *Alnus glutinosa,* y con fertilización orgánica (compost de residuos sólidos municipales) o inorgánica (NPK). En la mina de Cu, se probaron tres enmiendas diferentes (compost y 2 tecnosoles enriquecidos en Fe o Al) y se evaluó el rendimiento de dos especies vegetales (*Salix viminalis y Agrostis capilaris*). Por último, en la cantera de serpentina se aplicaron dos dosis diferentes de compost y se estableció un ensayo de fitominería utilizando dos hiperacumuladoras de Ni: *Bormuellera emarginata* y *Bormuellera tymphaea*.

El seguimiento, durante más de 10 años, de estos ensayos de fitogestión en las escombreras de mina, demostró el éxito en el establecimiento de una cubierta vegetal y la mejora a largo plazo de las principales propiedades físicas, químicas y biológicas del suelo, directamente implicadas en la prestación de importantes servicios ecosistémicos del suelo. Las hiperacumuladoras mediterráneas de Ni plantadas en el sustrato de la cantera enmendado con compost mostraron una buena supervivencia y una producción de biomasa de hasta 400 kg de *B. emarginata* ha^{-1} y 130 kg de *B. tymphaea* ha^{-1}.

Biodiversity in Phy2SUDOE contaminated sites

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ABSTRACT:

Contaminated sites, such as mining areas, harbor a unique and valuable biodiversity that includes different species of plants, animals, and microorganisms. This biodiversity, sometimes endemic, is adapted to high concentrations of metals and metalloids and holds great importance for its intrinsic and conservation value, and for its potential usefulness in biotechnological applications.

Biodiversity surveys, namely of metallicolous plants, metal-tolerant microorganisms (bacteria and fungi); and of macroinvertebrates such as slugs, earthworms, and snails, were conducted at four metal-contaminated sites of the Phy2SUDOE project network: 1. Bandeira quarry (Spain); 2. Mina da Borralha (Portugal); 3. Sentein-Bulard, (France); and 4. Lanestosa (Spain). The most representative and/or endemic plants were collected, and the concentration of metals was assessed in their shoots and in the soil to identify metal tolerance strategies. Bacterial strains were isolated from the rhizospheric soil of the most representative plants in each site and characterized according to their tolerance to metals and their growth-promoting traits (e.g., siderophores production, P solubilization, indole-acetic acid (IAA) production). Arbuscular mycorrhizal fungi were also collected and isolated through the trap-culture method. Macroinvertebrates were collected and identified, and samples were treated for histological, biochemical, molecular biology, and analytical chemistry studies.

Several plant species with interest for conservation were identified, along with those with metal exclusion or (hyper)accumulation mechanisms that can be used in phytoremediation and phytomanagement approaches in similar sites. *In-situ* (physical barriers and control of possible threats to the survival of the selected plant species) and *ex-situ* conservation measures through germplasm and plant tissue banks will be implemented for plants of conservation concern. Over 150 bacterial strains were isolated and characterized. The best-performing strains will subsequently be tested in greenhouse experiments with different soils and plant species and

stored in a biobank. Several of the macroinvertebrates collected were already stored in the Biscay Bay Environmental Biospecimen Bank.

The collection of plants, microorganisms, and macroinvertebrates established under this project will become a repository of native specimens of interest to local/regional/national governments and research institutions, and their use can be extended for reclamation activities at other sites with similar pollution problems.

Acknowledgments

The authors would like to thank the CBQF scientific collaboration under the FCT project UIDB/50016/2020.

Portuguese version

A biodiversidade nos locais contaminados da rede Phy2SUDOE

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Resumo:

As áreas contaminadas, como é o caso das zonas mineiras, albergam uma biodiversidade única e valiosa que inclui diferentes espécies de plantas, animais e microrganismos. Esta biodiversidade, por vezes endémica, está adaptada a elevadas concentrações de metais e metalóides e tem grande importância pelo seu valor intrínseco e de conservação, e pela sua potencial utilidade em aplicações biotecnológicas.

O levantamento da biodiversidade, nomeadamente de plantas metalícolas, microrganismos tolerantes a metais (bactérias e fungos); e de macroinvertebrados, tais como lesmas, minhocas e caracóis, foram realizados em quatro locais contaminados por metais da rede do projeto Phy2SUDOE: 1. Bandeira (Espanha); 2. Borralha (Portugal); 3. Sentein-Bulard (França); e 4. Lanestosa (Espanha). As plantas mais representativas e/ou endémicas foram recolhidas, e a concentração de metais foi avaliada nos seus tecidos e no solo para identificar as suas estratégias de tolerância. Estirpes bacterianas foram também isoladas da rizosfera destas plantas e caracterizadas de acordo com a sua tolerância aos metais e as suas características promotoras de crescimento (ex., produção de sideróforos, solubilização de P, produção de ácido indoleacético). Fungos micorrízicos arbusculares foram também isolados da rizosfera com recurso a culturas-armadilha. Os macroinvertebrados foram recolhidos e identificados, e as amostras foram tratadas para posteriores estudos histológicos, bioquímicos, biologia molecular, e de química analítica.

Foram identificadas várias espécies vegetais com interesse para a conservação, juntamente com aquelas com mecanismos de exclusão ou (hiper)acumulação de metais que podem ser utilizadas em abordagens de fitoremediação e de fitogestão em locais com condições similares. Medidas de conservação *in-situ* (barreiras físicas e controlo de possíveis ameaças à sobrevivência das espécies vegetais selecionadas) e *ex-situ*, através da conservação de germoplasma e tecidos vegetais em bancos, serão implementadas para estas plantas. Mais de 150 estirpes bacterianas

foram isoladas e caracterizadas. As estirpes com melhor desempenho serão testadas em experiências em estufa com diferentes solos e espécies vegetais, e armazenadas num biobanco. Vários dos macroinvertebrados recolhidos foram já armazenados no Banco de Bioespécimes Ambientais da Baía de Biscaia.

A coleção de plantas, microrganismos e macroinvertebrados estabelecida no âmbito deste projeto tornar-se-á um repositório de espécimes nativos de interesse para governos locais/regionais/nacionais e instituições de investigação, e a sua utilização poderá ser alargada para atividades de recuperação noutros locais com problemas idênticos de contaminação.

Agradecimentos

Os autores gostariam de agradecer a colaboração científica do CBQF no âmbito do projeto FCT UIDB/50016/2020.

Session 2 – Vision and lessons from other private and public soil managers (1)

Soil protection strategy: reaping the benefits from healthy soils for people, food, nature and climate. The contribution of the Basque Country.

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The Soil Protection Strategy 2030 of the Basque Country, approved on 6 June 2022, sets the objective of avoiding, through sustainable soil management, the degradation of soil in net terms while guaranteeing its health. It assumes, however, that human activities affect soil quality and that social and economic development inevitably involves soil use. In this context, the aim of this strategy is to minimise soil occupation through the valorisation of already anthropised soils and, on the other hand, to compensate for the effects of virgin land use, without forgetting the need to restore soils subject to degradation processes.

According to the vision for 2050, all soils in the Basque Country will be managed in a sustainable way and threats will be successfully tackled, thus guaranteeing the long-term health and functions of the soil for use by future generations.

Based on this vision, five strategic objectives are set out, namely:

- reduction of soil consumption,
- land use management, avoiding the occupation of virgin or agricultural land,
- soil protection against impacts and threats erosion, soil organic matter, artificialisation-urbanisation, acidification, contamination, salinisation, compaction, biodiversity loss, desertification, landslides and nutrient imbalance.
- restoration of degraded soils with the aim of restoring soil functions, taking into account their location and
- soil protection through management and sustainable use by trained professionals and an aware public.

To achieve these objectives, the strategy is structured into four areas of action. The first two are the foundations on which soil protection policy will be based: knowledge and the incorporation of soil protection into the different spheres of competence from an integral and coordinated perspective. Actions of a more executive nature are included in the third area in order to promote, from the fourth area, such a decisive aspect as raising the awareness of society as a whole through awareness-raising, education and training.

The diagnosis of the current situation, together with the exercise of consensus between the administrations and institutions with competencies and the contributions of the agents involved in the participation process, have resulted in the definition of 69 actions incorporated in a first action plan that constitutes the starting point for the deployment of the strategy.

These 69 actions are framed in 7 areas of action: transversal actions, territorial planning, agriculture, livestock and forestry, natural soils; contaminated sites of industrial origin, excavated soil and circular economy and mitigation and adaptation to climate change.

The aim of the presentation will be to briefly present the key points of the strategy as well as some of the actions that are already in progress.

Spanish version

Estrategia de protección del suelo: aprovechar los beneficios de los suelos saludables para las personas, los alimentos, la naturaleza y el clima. La contribución de Euskadi.

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La *Estrategia de protección de suelo 2030* de Euskadi, aprobada el 6 de junio de 2022, marca el objetivo de evitar, a través de la gestión sostenible del suelo, la degradación de este medio en términos netos a la vez que se garantiza su salud. Asume, sin embargo, que las actividades humanas afectan a la calidad del suelo y que el desarrollo social y económico conlleva inevitablemente su utilización. En este contexto, se trata con esta estrategia, por un lado, de minimizar su ocupación, a través de la valorización de los suelos ya antropizados y por otro, de compensar los efectos del uso de suelo virgen, sin olvidar la necesidad de restaurar los suelos sometidos a procesos de degradación.

De acuerdo con la visión a 2050 todos los suelos de Euskadi serán gestionados de forma sostenible a la vez que las amenazas se afrontan con éxito, garantizando así la salud y las funciones del suelo a largo plazo para su uso por las generaciones futuras.

Partiendo de esta visión se establecen cinco objetivos estratégicos, a saber:

- reducción del consumo de suelo,
- gestión de la ocupación del suelo, evitando la ocupación de suelo virgen o agrícola,
- protección del suelo contra los impactos y amenazas erosión, materia orgánica del suelo, artificialización-calificación urbanística, acidificación, contaminación, salinización, compactación, pérdida de biodiversidad, desertificación, deslizamientos y desequilibrio de nutrientes.
- restauración de los suelos degradados con el objeto de recuperar las funciones que le son propias teniendo en cuenta su ubicación y
- protección del suelo a través de la gestión y el uso sostenible por profesionales formados para ello y por una ciudadanía sensibilizada.

Para alcanzar estos objetivos, la estrategia se vertebra en cuatro áreas de acción. Las dos primeras constituyen las bases sobre las cuales se fundamentará la política de protección del suelo: el conocimiento y la incorporación de la protección del suelo a los diferentes ámbitos competenciales desde una perspectiva integral y coordinada. Las acciones de carácter más ejecutivo se engloban dentro de la tercera área para impulsar desde la cuarta un aspecto tan decisivo como es la sensibilización de la sociedad en su conjunto a través de la concienciación, educación y formación.

El diagnóstico de la situación actual, junto al ejercicio de consenso entre las administraciones e instituciones con competencias y las aportaciones de los agentes involucrados en el proceso de

participación, han dado como resultado la definición de 69 acciones incorporadas en un primer plan de acción que constituye la base de partida para el despliegue de la estrategia.

Estas 69 acciones se enmarcan en 7 ámbitos de actuación: acciones transversales, planificación territorial, agricultura, ganadería y silvicultura, suelos naturales; suelos contaminados de origen industrial, tierras excavadas y economía circular y mitigación y adaptación al cambio climático.

El objeto de la ponencia será presentar brevemente los puntos clave de la estrategia, así como algunas de las acciones que ya se encuentran en marcha.

Management of contaminated soils in Galicia.

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The aim of this paper is to explain the management of contaminated land from the point of view of the administration. To this end, a brief review will be made of the regulations on contaminated land developed to date, the obligations of the owners of industrial installations considered as potentially soil-polluting activities will be highlighted and the way in which these activities are monitored and controlled by the Galician administration will be indicated.

Acknowledgments

To the staff of "Sección de suelos Contaminados de la Dirección General de Calidad Ambiental. Sostibilidade e Cambio Climático" for technical support.

Spanish version

La gestión de los suelos contaminados en Galicia

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Este trabajo tiene como finalidad exponer la gestión de los suelos contaminados desde el punto de vista de la administración. Para ello se hará un breve repaso de la normativa en materia de suelos contaminados desarrolla hasta este momento, se destacarán las obligaciones de los titulares de instalaciones industriales que tiene la consideración de actividades potencialmente contaminantes del suelo y se indicará de que forma se realiza el seguimiento y control de estas actividades por parte de la administración gallega.

Agradecimientos: Al personal de la Sección de suelos Contaminados de la Dirección General de Calidad Ambiental. Sostibilidade e Cambio Climático por apoyo técnico.

Technosols: Improving edaphic conditions in degraded soils

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ABSTRACT: The rehabilitation of degraded soils requires recovering the soil functions (environmental and productive) and the role in the control of the biogeochemical cycles of the elements of the biosphere. Regardless of the composition and toxicity of the elements that either natural processes or anthropic actions put on the earth's surface, Nature will always try to put soil at the interface of the *gea* with the atmosphere, the hydrosphere and the biosphere. It will take more or less time, but through the processes of dilution, mixing, dissolution-precipitation, redox, acid-base, surface reactions, and endless biogeochemical reactions that are part of the surface geochemical cycle, natural processes tend to form soil from any material that has no congruent solution. For this reason, imitating Nature, when a soil is degraded or contaminated, one of the best alternatives is to design and install soil, a means of life, that evolves over time towards equilibrium conditions, correcting the limitations that had degraded it, and making the system evolve towards the conditions that allow its rehabilitation. *Technosols*, according to the WRB definition, are soils that contain more than 20% artifacts (by weight or volume), meaning artifacts that have been made, manipulated or moved by man. There are many negative experiences in which man-made artifacts have led to unproductive systems and a source of contamination for water, ecosystems and even man. However, there have also been successful cases that have improved the soils of a certain place, making them more productive or eliminating the contaminants that affected the surrounding soils, waters and biotic systems. This is the case of the *plaggen*, *black soils*, *chinanmpas*, *terras pretas and mulatas*, *sambaqui*, *historical Maori soils*, etc. Learning from them, and from the natural soils that best fulfill the productive functions, and applying the knowledge of soil science and biogeochemistry, and imitating natural soils, soils can be designed (*Technosols "a la carte"* or "*tailor-made* ") that correct the degrading limitations and improve the edaphic properties for a more adequate fulfillment of the soil functions and to achieve a rehabilitation process that satisfies human needs in harmony with natural processes.

Spanish version

Tecnosoles: Mejora de las condiciones edáficas en suelos degradados

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RESUMEN: La rehabilitación de los suelos degradados exige recuperar las funciones edáficas (ambientales y productivas) y el papel de control de los ciclos biogeoquímicos de todos los elementos que se encuentran en la biosfera. Sea cual sea la composición y toxicidad de los elementos que los procesos naturales o las actuaciones antrópicas ponen en la superficie terrestre, la Naturaleza siempre intentará poner un suelo en la interfaz de la *gea* con la atmósfera, la hidrosfera y la biosfera. Tardará más o menos, pero, a través de los procesos de dilución, mezcla, disolución-precipitación, redox, ácido-base, reacciones superficiales y un sinfín de reacciones biogeoquímicas que forman parte del ciclo geoquímico superficial, los procesos naturales tienden a formar un suelo a partir de cualquier material que no tenga disolución congruente. Por ello, imitando a la Naturaleza, cuando un suelo se degrada o contamina, una de las mejores alternativas es diseñar y poner un suelo, medio de vida, que evolucione en el tiempo hacia las condiciones de equilibrio, corrigiendo las limitaciones que lo habían degradado y haciendo evolucionar el sistema hacia las condiciones que permiten su rehabilitación. Los *Tecnosoles*, de acuerdo con la definición de la WRB, son suelos que contienen más de un 20% de artefactos (en peso o volumen), entendiendo por artefactos, lo que el hombre ha hecho, ha manipulado o ha cambiado de sitio. Muchas son las experiencias negativas en que los artefactos generados por el hombre han conducido a sistemas improductivos y fuente de contaminación para el agua, los ecosistemas e, incluso, el hombre. Sin embargo, también ha habido casos de éxito que han mejorado los suelos de un determinado lugar, haciéndolos más productivos o eliminando los contaminantes que afectaban a los suelos, aguas y sistemas bióticos de su entorno. Es el caso de los *plaggen*, *black soils*, *chinanmpas*, *terras pretas y mulatas*, *sambaqui*, *historical maori soils*, etc. Aprendiendo de ellos, y de los suelos naturales que mejor cumplen con las funciones productivas, y aplicando los conocimientos de la ciencia del suelo y la biogeoquímica, e imitando a los suelos naturales, pueden diseñarse suelos (*Tecnosoles "a la carta"* o *"a medida"*) que corrijan las limitaciones degradantes y mejoren las propiedades edáficas para un cumplimiento más adecuado de las funciones del suelo y para conseguir un proceso de rehabilitación que satisfaga las necesidades humanas en armonía con los procesos naturales.

The green infrastructure of Vitoria-Gasteiz. Strategies for the recovery of degraded soils and case studies.

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In 2013 the European Commission published the European Green Infrastructure Strategy with the aim of promoting the development of Green Infrastructures in all territorial areas. The city of Vitoria-Gasteiz has been committed over the last decades to the environmental improvement of the municipality and sustainable development policies in the management of the territory, having been awarded as European Green Capital 2012.

Assuming that the current scenario of Global Change - with the loss of biodiversity, Climate Change, the depletion of resources, the energy and economic crisis as some of its main manifestations - makes it necessary to rethink cities, seeking an urgent reduction of their ecological footprint and environmental impact, the conception and implementation of a new system of urban infrastructure is proposed: an URBAN GREEN INFRASTRUCTURE SYSTEM OF VITORIA-GASTEIZ, based on ecosystemic functions that allow the urban system to evolve towards a more resilient and biophilic space.

The Urban Green Infrastructure System in Vitoria-Gasteiz, as a green mesh and through actions to improve urban and peri-urban spaces, ultimately seeks to build a more habitable, efficient and sustainable city. Specifically, in peri-urban areas, given the situation of contamination and soil degradation of numerous public plots, the use of phytoremediation techniques (decontamination with plants) and phyto-management (obtaining ecosystemic benefits through plants) has been used to establish green areas. The PhytoSudoe and Phy2Sudoe projects have made it possible, through the establishment of experimental plots, to make progress in the recovery of the landscape of the urban periphery of Vitoria-Gasteiz, especially in the area surrounding the Jundiz Industrial Estate.

Spanish version

La infraestructura verde de Vitoria-Gasteiz. Estrategias de recuperación de suelos degradados y casos prácticos

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En 2013 la Comisión Europea hizo pública la Estrategia Europea de Infraestructura Verde con el objetivo de impulsar el desarrollo de Infraestructuras Verdes en todos los ámbitos territoriales. La ciudad de Vitoria-Gasteiz ha venido apostando durante las últimas décadas por la mejora ambiental del municipio y las políticas de desarrollo sostenible en la gestión del territorio, habiendo sido premiada como European Green Capital 2012.

Asumiendo que el escenario actual de Cambio Global –con la pérdida de biodiversidad, el Cambio Climático, el agotamiento de recursos, la crisis energética y económica como algunas de sus principales manifestaciones– obliga a repensar las ciudades, buscando la disminución urgente de su huella ecológica y de su impacto ambiental, se propone la concepción e implantación de un nuevo sistema de infraestructura urbana: un SISTEMA DE INFRAESTRUCTURA VERDE URBANA DE VITORIA-GASTEIZ, basado en funciones ecosistémicas que permitan al sistema urbano evolucionar hacia un espacio más resiliente y biofílico.

El Sistema de Infraestructura Verde Urbana en Vitoria-Gasteiz a modo de malla verde y a través de actuaciones de mejora de espacios urbanos y periurbanos busca en último término la construcción de una ciudad más habitable, eficiente y sostenible. En concreto, en las zonas periurbanas, ante la situación de contaminación y degradación del suelo de numerosas parcelas públicas se ha apostado por el empleo de técnicas de fitorremediación (descontaminación con plantas) y fitogestión (obtención de beneficios ecosistémicos a través de las plantas) para poder establecer las zonas verdes. Los proyectos PhytoSudoe y Phy2Sudoe han permitido, mediante el establecimiento de parcelas experimentales, avanzar en la recuperación del paisaje de la periferia urbana de Vitoria-Gasteiz, especialmente en el entorno del Polígono Industrial de Jundiz.

Establishing Site-specific Target Values for a Large Scale Soil Remediation — a real case.

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ABSTRACT:

Phy2Sudoe's new experimental site in Estarreja, Portugal (NS8) was set on the close vicinity of a recently remediated area, within the scope of Project ERASE. This presentation covers the contamination mapping and risk assessment that established the basis for the remediation project, aiming at the control of risks of exposure to Hg and As to human receptors. The historical use of the site, the nature and effects of the contamination and the physical and economical constrictions to the project are presented and discussed. Such constrictions have led the project to a RBCA (Risk-based Corrective Action) approach. Risk-scenarios and relevant receptors, and the derivation of Site-specific Target Levels are exemplified, and the approaches and tools used to characterise the contamination in soil and groundwater are presented. A special focus is given to the operational control of the remediation operations, combining pre-calibrated EDXRF in situ measurements and site-specific variable excavation-depth, established by the risk assessment. Finally, the environmental monitoring programme for this project is discussed.

Acknowledgments: We would like to acknowledge all the support received from ERASE ACE, and Bondalti Chemicals, SA. Two special thanking notes are due to Eng. Diogo Almeida Santos (Bondalti, ERASE) and Eng. David Lewis Barry (W.S.Atkins, DLB Environment) whose knowledge, experience, commitment and perseverance made the ERASE remediation project possible. The remediation project described in this presentation was partly funded by POSEUR (contract POSEUR-17-2017-01).

Session 3 – Vision and lessons from other private and public soil managers (2)

Use of Hyperaccumulating Plant Species for Nickel Phytomining

G. Echevarría[1, 2] and many collaborators…

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ABSTRACT: Since their first discovery in the seventies, there have been more than 700 species reported as metal hyperaccumulators among which >500 are nickel Hyperaccumulators. In 1983, the concept of cropping some of these species to produce metals was put forward as phytomining by Rufus Chaney. Since then, efforts to develop the agronomy of several species such as Alyssum murale (syn. Ondontarrhena chalcidica) and Berkheya coddii have increased and field experiments were mainly set up in the US and in Albania. In the 2010s, further attempts in Europe and in Malaysia have led to the concept of designing a full chain of metal production including Agronomy of these species but also Chemical Engineering. Agromining targets the recovery of Nickel products that can be used for several industrial purposes including the production of coloured glass, stainless steel or nickel salts used in the production of batteries (e.g. Li-ion batteries). The outcome of these applied research projects shows that nickel Agromining is now viable and can reach the production of 150–250 kg of Ni per hectare per year. Tropical Agromining was also successfully developed with perennial trees/shrubs. Many commercial opportunities for nickel agromining could now be developed. ECONICK, a 6-year old spin off from the University of Lorraine is now aiming at scaling up agromining in several ultramafic regions of the World.

Acknowledgments This work was supported by The French National Research Agency through the national “Investissements d’avenir” programme (ANR-10-LABX-21, LABEX RESSOURCES21) and by the project LIFE AGROMINE (LIFE15 ENV/FR/000512) funded by the European Commission.

Casuarinaceae and associated soil organisms, useful resources for the recovery of ultramafic soils from Malesia.

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Ultramafic soils are derived from fragments of the outer layer of Earth's mantle which were desplaced to the surface as a result of plate tectonics. The particular composition of ultramafic soils put these substrates in a delicate situation: they are at the same time global biodiversity hotspots and source of strategic elements such as nickel.

Malesia is a biogeographic region that spreads from Malay Peninsula to New Guinea. This region is one of the main centres of tropical plant diversity and hosts extensive ultramafic areas, some of which are being affected by nickel mining on laterites.

She-oaks (Casuarinaceae) are a group of tropical trees with extremely reduced vegetative morphology which are adapted to grow on nutrient-poor soils, including ultramafic areas affected by landslides or mining. These trees rely on root symbioses (with Frankia actinobacteria) to fix atmospheric nitrogen and create thick layers of recalcitrant litter whose degradation process is not clear. In this presentation, I will talk with more detail about Casuarinaceae and soil organisms, and the research I am performing within the MSCA project CASUABIOTA.

Project ReCROP - Bioinocula and CROPping systems: an integrate approach for improving crop yield, biodiversity, and REsilience of Mediterranean agro-ecosystems

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ABSTRACT:

Agricultural productivity and sustainability in Mediterranean region are under serious threat due to climate change, soil degradation, and depletion of water resources. This scenario is worsened by poor management practices, including the overuse of chemical fertilizers and pesticides, overgrazing, and monoculture farming. Hence, intensive agricultural systems have a major impact on the loss of organic matter and biodiversity in farmlands, while favouring erosion, compaction, and contamination of soil.

ReCROP aims at fostering the sustainability and resilience of agricultural production systems in the Mediterranean region through the combined use of biotechnological tools, such as bioinoculants (mycorrhizal fungi and plant growth-promoting bacteria), and environmentally friendly agronomic practices, including plant intercropping and crop rotation, application of amendments, as well as the use of local adapted and/or tolerant varieties. ReCROP covers the Mediterranean Geographical Area (MGA), involving Morocco, Egypt, Tunisia (South MGA), Italy and France (North MGA), and Portugal and Spain (West MGA), and incorporates major crops cultivated in these countries - vineyards, cereals, and aromatic/medicinal plants. Agricultural practices are tested and monitored across different edaphoclimatic conditions from experimental plots in a climatic area with Atlantic influence (N Portugal and NW Spain) to others in drier and hotter regions on the N of Africa. RECROP encompasses established and new fields to tackle the specific objectives: i) to implement and validate widely adaptable agro-ecological farming; ii) devise new bioinoculant formulations to enhance soil biodiversity and functioning, plant health and yields of the target crops; iii) provide a new tool based on omics technologies to help farmers in the decision-making process through the assessment of soil biodiversity profiles for prediction of crop suitability.

ReCROP further intends to characterize from a socioeconomic perspective the main drivers to encourage farmers to switch towards greener practices and promote their acceptability. Also, aims to foster innovative sustainable solutions for ecological farming systems involving the views of local stakeholders and providing guidelines to improve the resilience of Mediterranean target crops.

Acknowledgments

This work was supported by Project ReCROP - Bioinocula and CROPping systems: an integrated biotechnological approach for improving crop yield, biodiversity and REsilience of Mediterranean agroecosystems, co-funded by PRIMA. The authors would like to thank the CBQF scientific collaboration under the FCT project UIDB/50016/2020.

Portuguese version

Projecto ReCROP - Bioinóculos e sistemas de cultivo: uma abordagem biotecnológica integrada para melhorar o rendimento das culturas, a biodiversidade e a resiliência dos agroecossistemas mediterrânicos

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Resumo:

A produtividade agrícola e a sustentabilidade na região do Mediterrâneo estão sob séria ameaça devido às alterações climáticas, degradação do solo e esgotamento dos recursos hídricos. Este cenário é agravado pelo uso de práticas agrícolas desadequadas, incluindo o uso excessivo de fertilizantes químicos e pesticidas, sobrepastoreio e monoculturas. Assim, os sistemas agrícolas intensivos têm um grande impacto na perda de matéria orgânica e biodiversidade dos solos agrícolas, enquanto favorecem a erosão, compactação e contaminação dos mesmos.

O ReCROP visa promover a sustentabilidade e a resiliência dos sistemas de produção agrícola na região do Mediterrâneo através do uso combinado de ferramentas biotecnológicas, como bioinoculantes (fungos micorrízicos e bactérias promotoras de crescimento vegetal) e práticas agronómicas sustentáveis como a aplicação de corretivos orgânicos, uso de sistemas de cultivo e de variedades locais adaptadas e/ou tolerantes. O ReCROP abrange a Área Geográfica Mediterrânica (AGM), envolvendo Marrocos, Egipto, Tunísia (AGM Sul), Itália e França (AGM Norte), e Portugal e Espanha (AGM Oeste), e tem como foco as principais culturas produzidas nestes países - vinha, cereais, e plantas aromáticas/medicinais. As práticas agrícolas são testadas e monitorizadas em diferentes condições edafoclimáticas desde parcelas experimentais estabelecidas numa zona climática de influência atlântica (N de Portugal e NW de Espanha) a outras em regiões mais secas e quentes do N de África. O ReCROP contempla campos estabelecidos assim como novos campos por forma a atingir os seguintes objetivos específicos: i) implementar e validar uma agricultura agroecológica amplamente adaptável; ii) conceber novas formulações de bioinoculantes para melhorar a biodiversidade e o funcionamento do solo, a saúde das plantas e o rendimento das culturas alvo; iii) fornecer uma nova ferramenta

baseada em tecnologias ómicas para auxiliar os agricultores no processo de tomada de decisão por meio da avaliação dos perfis de biodiversidade do solo para previsão da adequação das culturas.

O ReCROP pretende ainda caracterizar do ponto de vista socioeconómico os melhores meios para encorajar os agricultores a mudar para práticas agrícolas mais verdes, assim como promover a sua aceitabilidade. Além disso, visa promover soluções sustentáveis inovadoras para sistemas agrícolas ecológicos que envolvam os pontos de vista das partes interessadas, assim como fornecer diretrizes para melhorar a resiliência das culturas-alvo no Mediterrâneo.

Agradecimentos:

Este trabalho foi apoiado pelo Projeto ReCROP - Bioinocula and CROPping systems: an integrated biotechnological approach for improving crop yield, biodiversity and REsilience of Mediterranean agroecosystems, cofinanciado pelo PRIMA. Os autores agradecem a colaboração científica do CBQF no âmbito do projeto FCT UIDB/50016/2020.

TERRAMATER: A tool for post-fire rehabilitation and restoration of soils

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6Recursos y Valorización Ambiental, S.L. Spain

The main objective of the TERRAMATER project is the recovery of the environmental, ecological and productive functions of burnt areas, reducing soil losses due to erosion and increasing soil resilience to future episodes of wildfire. This will be achieved by remediation actions conducted in soils affected by wildfires or prescribed fires, including the application of soil amendments based on the use of technosols obtained from organic wastes and industrial byproducts. The soil plots selected for the study correspond to areas in the north of Portugal and northwest of Spain, dominated by either Atlantic-type or Mediterranean-type shrublands. The amendments will be previously formulated and tested under controlled conditions according to the soil information obtained and the local knowledge of post-fire ecological conditions. Also, the biogeochemical processes associated with the recovery and improvement of the quality of the affected soils will be taken into account. The application of the technosol amendments, will produce an increase in the organic carbon pools and promote the protection and improvement of the soil quality, which will result in an opportunity for ecological restoration of burnt areas and the subsequent reduction in emissions of greenhouse gases. Finally, this application will help to minimize the pollution of water bodies close to the burnt areas resulting from the runoff of nutrients and suspended materials from ashes.

Spanish version

TERRAMATER: Una herramienta para la rehabilitación y restauración de suelos quemados

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El objetivo principal del proyecto TERRAMATER es la recuperación de las funciones ambientales, ecológicas y productivas de las zonas quemadas, reduciendo las pérdidas de suelo por erosión y aumentando la resiliencia del suelo ante futuros episodios de incendios forestales. Para ello se llevarán a cabo acciones de remediación de los suelos afectados por incendios forestales o quemas controladas, incluyendo la aplicación de enmiendas del suelo basadas en el uso de tecnosoles obtenidos a partir de residuos orgánicos y subproductos industriales. Los suelos seleccionados para el estudio corresponden a zonas del norte de Portugal y noroeste de España, dominadas por matorrales de tipo atlántico o mediterráneo. Las enmiendas serán previamente formuladas y ensayadas en condiciones controladas según la información edáfica obtenida y el conocimiento local de las condiciones ecológicas post-incendio. Asimismo, se tendrán en cuenta los procesos biogeoquímicos asociados a la recuperación y mejora de la calidad de los suelos afectados. La aplicación de tecnosoles, producirá un aumento de las reservas de carbono orgánico y promoverá la protección y mejora de la calidad del suelo, lo que supondrá una oportunidad para la restauración ecológica de las zonas quemadas y la consiguiente reducción de las emisiones de gases de efecto invernadero. Por último, esta aplicación contribuirá a minimizar la contaminación de las aguas cercanas a las zonas quemadas, derivada de la escorrentía de nutrientes y materiales en suspensión procedentes de las cenizas.

https://www.phytosudoe.eu/

Phy2SUDOE (SOE4/P5/E1021): “Advancing in the application of innovative phyto-management strategies in contaminated areas of the SUDOE space”

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The project Phy2SUDOE (SOE4/P5/E1021) is supported by the European Regional Development Fund (European Commission) through the V Interreg Sudoe Programme.