SITE MONITORING AND CHARACTERISATION

Practice Abstract #1

BACKGROUND

Monitoring soil and plant system health is central to pHYBi. The project investigates phytomanagement strategies for five types of contaminated land: **(1)** soil impacted by historical wastewater irrigation, **(2)** a postindustrial brownfield, **(3)** land affected by an oil spill , **(4)** a former petroleum site, and **(5)** a salt-impacted mining area.

pHYBi combines remote sensing with integrated soil, plant and biomass analyses, including physicochemical and microbiological characterisation to establish site-specific baselines and assess phytomanagement under different contamination conditions. A harmonised multisite data model ensures consistent sampling and analysis, capturing spatial and temporal variability across all case studies.

THE pHYBi PRACTCE

The project draws on a wide range of indicators to assess the health of soil under various stress conditions (i.e. salinity, the presence of metals and/or organic pollutants, which may occur individually or together), focusing on its physical, chemical and biological properties. Monitoring plant growth and biomass yield is equally important, as these will be influenced by the soil's health and its ability to remediate pollutants.

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Circular Bio-based Europe Joint Undertaking
Bio-based Industries Consortium
Co-funded by the European Union

1 Site Attributes

pHYBi monitors key site attributes using **UAV remote sensing, GIS tools**, and **Veris® EC** mapping to capture salinity levels and real-time field conditions. Baseline and follow-up surveys track spatial and temporal changes across the sites. The monitoring covers **geolocation, climate, topography,** and **vegetation structure** to assess plant health and environmental stress. In addition, pHYBi analyses **land-use history**, **management practices,** and **landscape features** such as habitat connectivity and surrounding land use. Together, these indicators help explain how past and current site conditions shape the effectiveness of phytomanagement interventions.

2 Harmonised soil characterisation

Soil assessment follows a standardised composite sampling protocol (LUCAS-based) across all sites to ensure consistent and reliable data collection. Sampling includes topsoil and subsoil where feasible and is supported by reproducible handling, sieving, and preparation. Key monitoring components include:

- **Soil structure and physicochemical properties**: soil type/texture, organic matter, soil organic carbon, pH/Eh, buffer index, cation exchange capacity, water holding capacity, electrical conductivity (salinity), and 3D GIS-based soil maps.
- **Nutrient and contamination profile:** major nutrients (Ca, K, Mg, Na, N and P), trace elements (total and phytoavailable), organic pollutants (TPH, PAH) and salt content.
- **Vegetation and ecosystem structure:** indicators of soil stability and ecosystem recovery.

This systematic dataset supports the identification of limiting factors for plant growth, pollutant mobility, and overall soil functionality.

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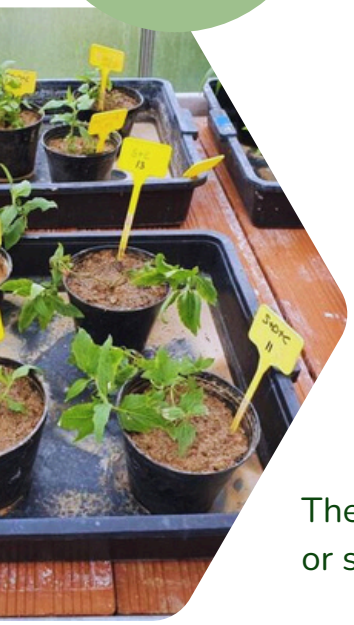
3 Microbial health and functional indicators



Understanding soil microbial communities is essential for evaluating the success of phytomanagement, since microbes are responsible for nutrient cycling and pollutant degradation. pHYBi monitors:

- **Basal respiration and microbial biomass carbon** as indicators of microbial activity and abundance.
- **Key soil enzymes** linked to organic matter decomposition and nutrient transformations.
- **Microbial community profiling** (fungi: bacteria ratio, metabarcoding) to characterise diversity and functional potential.
- **Toxicity assays** (phytotoxicity, carbon transformation tests) to evaluate contaminant impacts on microbial processes.

These indicators reveal whether the soil environment is recovering, stable, or still under chemical stress.

4 Plant health, stress response, and biomass yield

Plant performance functions both as a bioindicator and as the basis for future lignocellulosic feedstock. Monitoring therefore covers:

- **Growth and morphology:** height, stem diameter, growth rate, and phenological stage.
- **Biochemical stress indicators:** ROS, MDA, antioxidant enzymes, and VOCs, which indicate physiological stress caused by pollutants or salinity.
- **Biomass yield and pollutant fate:** above- and below-ground biomass, moisture content, and pollutant uptake (trace elements, TPH/PAH) analysed through GC–MS.
- **Chemical composition:** lignin, cellulose, hemicellulose, extractives.
- **Quality indicators:** C/N ratio, ash content, fibre purity and length. These measurements confirm the suitability of harvested biomass for fractionation and subsequent industrial processing, while also providing evidence that contaminants do not compromise feedstock safety.

This helps pHYBi assess if plants tolerate pollutants and produce usable biomass.

OVERVIEW

SITE ATTRIBUTES

- **Geolocation** (lat/long, elevation)
- **Climate** (temperature, rainfall, wind)
- **Topography** (slope, drainage)
- **Vegetation structure** (cover, diversity, NDVI/LAI)
- **Land Management & Disturbance** (landuse history, amendment history, remediation practices, irrigation, practices, natural & artificial barriers, perturbations)
- **Land Ecology** (connectivity, fragmentation, land use)

PLANT & BIOMASS CHARACTERISATION

- **Plant Sample Parameters** (condition, age, genotype, height, diameter, growth rate, growth stage)
- **Biochemical Stress Indicators** (hormones, protein content, antioxidant enzymes, antioxidants, stress biomarkers, VOCs)
- **Biomass Production & Contamination Fate** (above/belowground biomass, pollutant uptake, dry matter)
- **Composition Indicators** (C/N ratio, ash content)
- **Fractionation Components** (lignin, cellulose, hemicellulose, extractives)
- **Fibre Quality** (purity, length)

SOIL PARAMETERS

- **Soil Structure** (total carbon, SOC stock, herbaceous layer, soil map, bulk density)
- **Soil Properties** (texture, EC, CEC, water holding capacity, organic matter, pH, redox potential, buffer index)
- **Nutrients & Contaminants** (nutrient profile; trace elements; organic pollutants; salinity)

MICROBIAL HEALTH

- **Microbiological Indicators** (basal respiration, microbial biomass, enzymatic activity, microbial profile, metabarcoding)
- **Toxicity Indicators** (phytotoxicity bioassay, carbon transformation test)

RECOMMENDATIONS & KEY LEARNINGS

Integrate digital and field-based monitoring for comprehensive assessment: This approach enhances spatial resolution, reduces sampling bias, and allows continuous monitoring of plant health and environmental factors.

Harmonise sampling and analysis protocols across sites: Standardised protocols for soil composite sampling, plant tissue collection, and biomass processing ensure methodological consistency, enabling reliable interpretation of site-specific data.

Consider site history, context, and resource constraints in monitoring design: Flexible, site-adapted protocols allow for meaningful data collection and practical implementation across diverse conditions while supporting the generation of actionable datasets for phytomanagement evaluation, contaminant fate assessment, and biomass valorisation.

About

pHYBi - Phytomanagement for a Bio-Based Textile Industry

pHYBi is an initiative funded by the Circular Bio-based Europe Joint Undertaking (CBE JU) that aims to combine the phytoremediation of polluted soils with the valorisation of lignocellulosic biomass to contribute to soil health and a bio-based circular textile industry.

Key Facts

4
Years:
Okt. 2024 - Sept. 2028

5
Million €:
European Commission, Horizon Europe

10
Partners:
In Spain, Italy, France, Croatia, Germany

4
Case Studies:
In France, Spain and Coratia

Project Partners

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