SOIL MONITORING AT SCALE: FROM DIGITAL DATA TO PRACTICAL DECISIONS

Practice Abstract #3

Background:

Digital Soil Monitoring for Effective Phytoremediation

pHYBi develops sustainable phytomanagement strategies for contaminated, degraded and saline soils by combining industrial crops such as poplar, hemp and Miscanthus with beneficial microorganisms and soil amendments.

The resulting non-food biomass is intended for high-value bio-based products, particularly textile applications. Reliable soil and vegetation monitoring is essential because contamination, salinity, soil moisture and plant stress can vary considerably within and between sites. Conventional soil sampling and laboratory analyses provide detailed information but can be costly and time-consuming across large and heterogeneous areas. Digital technologies, including sensors, drones, satellite imagery, spectroscopy, artificial intelligence and spatial modelling can complement conventional methods by increasing spatial coverage and enabling repeated observations. However, reliable decisions still require field measurements, local calibration and clear recommendations adapted to users' needs.

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Circular Bio-based Europe Joint Undertaking
Bio-based Industries Consortium
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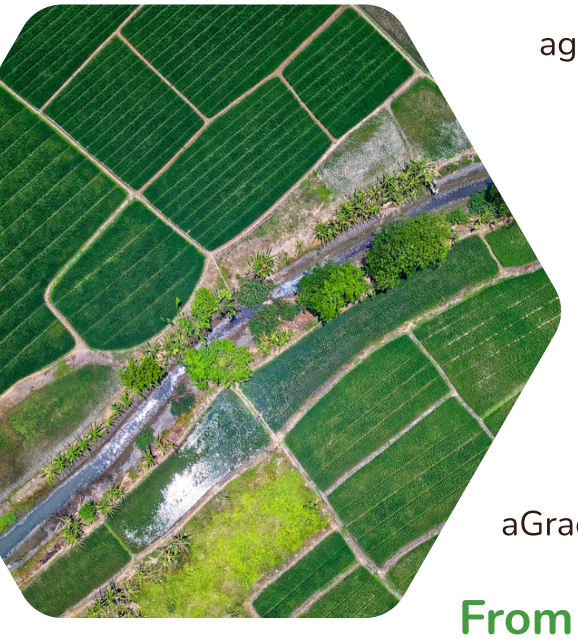
To explore these opportunities and challenges, pHYBi organised the online stakeholder workshop “Soil Monitoring at Scale: Advances in Digital Methods and Modelling” on 30 June 2026. The two-hour workshop brought together 49 participants from academia,



agriculture, forestry, the wood sector, technology companies, finance, textiles and the chemical industry reflecting the relevance of digital soil monitoring for a multi-actor approach. The speakers and experts were Andrea Martos from IDENER.AI, Lorena Salgado from INDUROT University of Oviedo, Carlos Cambra from the University of Burgos, Julien Parelle from the University Marie et Louis Pasteur, Fabio Castaldi from the Institute of BioEconomy of the Italian National Research Council, Sara Gallego from aGrae and the moderator Sergio López Manjón from DIH-LEAF.

From Monitoring Technologies to Practical Decisions

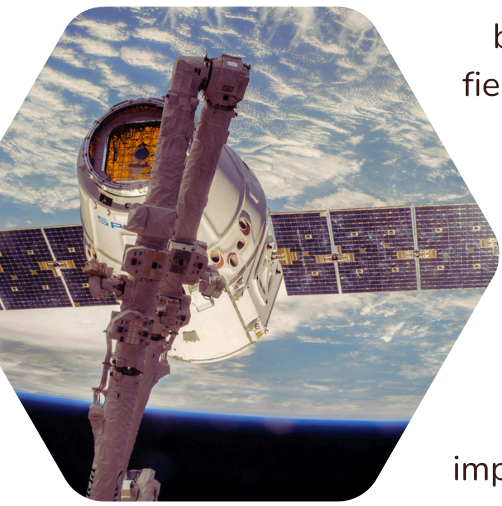
The contributions covered full monitoring process, from field data collection and site assessment to modelling, upscaling and agronomic decision support. Examples from pHYBi sites affected by arsenic contamination, hydrocarbons and mining-related salinity showed how targeted soil sampling can be combined with drone imagery, remote sensing indices, electrical conductivity measurements and plant indicators. These approaches can help detect vegetation stress, identify contamination patterns and generate detailed salinity maps, supporting more targeted interventions.

Sensor-based monitoring can also support water management. Soil moisture measurements at different depths, combined with drone imagery, remote sensing indices, electrical conductivity measurements and plant indicators. These approaches can help detect vegetation stress, identify contamination patterns and generate detailed salinity maps, supporting more targeted interventions.

Sensor-based monitoring can also support water management. Soil moisture measurements at different depths, combined with atmospheric data and satellite or drone imagery, can feed irrigation models adapted to crop development and soil water availability. This can improve water-use efficiency and reduce the risk of secondary salinisation.

Optical remote sensing provides further information on plant response. Reflectance data can support estimates of chlorophyll content, biomass production and metal accumulation. Nevertheless, the reliability of these approaches depends on monitoring objective, crop characteristics and field conditions.

At large scales, Earth observation and Geo-AI can support soil-property mapping, including soil organic carbon assessment. Satellite time series provide broad and frequent observations and can help identify suitable bare-soil periods. AI can integrate multiple data sources, but field measurements and transparent models remain necessary to ensure reliable and understandable results.



The workshop also demonstrated how monitoring data can be converted into agronomic recommendations. Apparent electrical conductivity mapping can identify management zones, which are then characterised through targeted soil sampling. Combining soil, crop and yield information can support site-specific fertilisation strategies, improve nutrient-use efficiency and reduce unnecessary inputs.

Practical Lessons

Combine complementary data sources. Field observations, laboratory analyses, sensors, drones and satellite imagery provide different but complementary information.

Calibrate methods locally. Digital approaches cannot be transferred automatically between sites or crops. Ground-truth data and local validation remain essential.

Link monitoring to specific decisions. Results should support actions such as targeted sampling, irrigation adjustment, contamination management or site-specific fertilisation.

Provide clear and accesible outputs. Farmers, land managers and technical teams need understandable recommendations rather than complex datasets or model outputs.

Consider operational barriers. Costs, connectivity, weather conditions, data availability and regulatory requirements can limit implementation.

Promote collaboration and data sharing. Cooperation between researchers, technology providers and end users is necessary to validate methods and expand their practical application.

Digital technologies do not replace field observations or laboratory analyses, but they can make monitoring more frequent, spatially detailed and efficient. Their value depends on robust validation and on transforming reliable data into informed, site-specific management decisions.

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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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