SOIL MONITORING AT SCALE: FROM DIGITAL DATA TO PRACTICAL DECISIONS

Practice Abstract #3

Background:

Digital Soil Monitoring for Effective Phytoremediation

pHYBi promotes the sustainable use of contaminated, degraded and saline land through phytomanagement approaches that combine industrial crops, beneficial microorganisms and soil amendments. Beyond improving soil health and reducing environmental risks, the approach generates renewable non-food biomass for high-value bio-based products, including textile applications. Successful phytomanagement requires reliable information on soil health, contamination, salinity, water availability and plant performance. However, these factors often vary considerably across and within sites, making conventional soil sampling alone costly and insufficient for large-scale monitoring.

Digital soil monitoring technologies such as sensors, drones, satellite imagery, spectroscopy, artificial intelligence (AI) and spatial modelling can complement field measurements by providing continuous, spatially explicit information. These tools support site assessment, early detection of plant stress and more informed management

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Circular Bio-based Europe Joint Undertaking
Bio-based Industries Consortium
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decisions. However, reliable implementation still depends on local calibration, field validation and the translation of monitoring results into practical recommendations for land managers.

From Monitoring Technologies to Practical Decisions

The pHYBi stakeholder workshop “Soil Monitoring at Scale: Advances in Digital Methods and Modelling” demonstrated that effective phytomanagement depends not only on collecting data, but on transforming that data into practical, site-specific decisions.

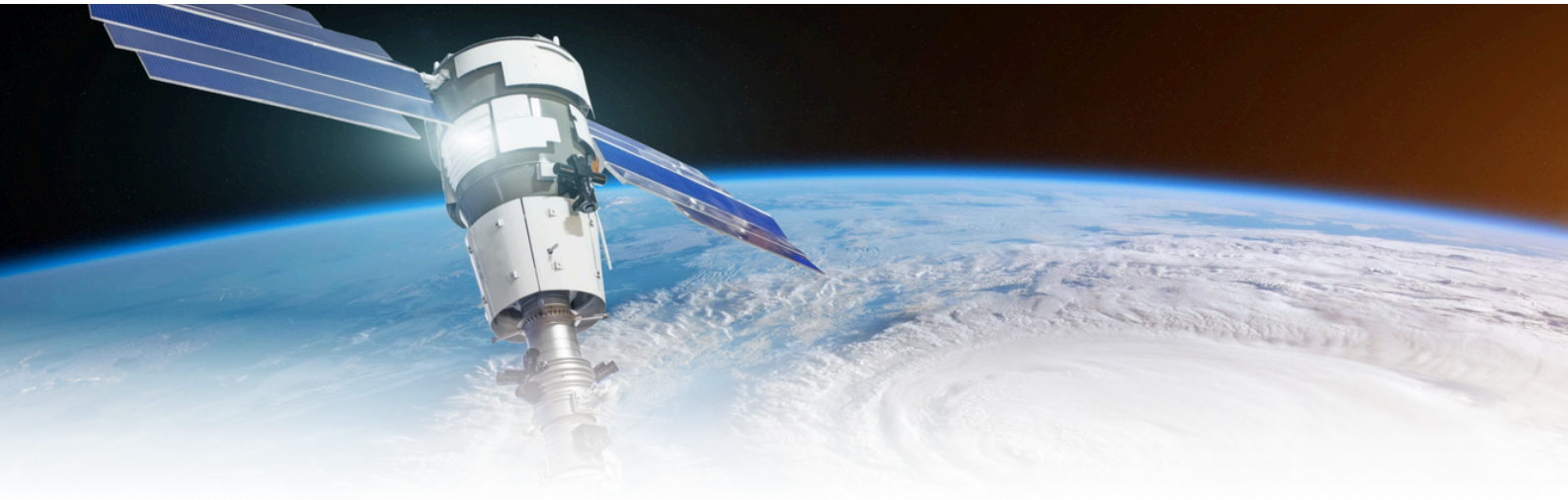
A key takeaway was that digital technologies can significantly improve the understanding of complex and heterogeneous sites. By combining conventional soil sampling with sensors, drone imagery, remote sensing and spatial modelling, land managers can obtain a more complete picture of soil conditions, contamination patterns, salinity, water availability and plant performance. This enables earlier detection of problems and more targeted management interventions.

The examples presented showed that digital monitoring can support a wide range of management decisions. 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. Similarly, the integration of soil, crop and yield data can support site-specific fertilisation, helping to reduce unnecessary inputs while maintaining productivity. 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.

The workshop also highlighted the growing potential of Earth observation and AI-based tools to assess soil properties and monitor larger areas more efficiently. However, participants stressed that digital technologies are most effective when combined with field measurements and local expertise. Apparent electrical conductivity mapping can identify management zones,

which are then characterised through targeted soil sampling. Reliable calibration and validation remain essential to ensure that monitoring results accurately reflect site conditions. Ultimately, the discussions confirmed that the value of digital soil monitoring lies not in generating more data, but in providing actionable insights. When translated into clear recommendations, digital tools can help farmers, land managers and practitioners make better-informed decisions, improve resource efficiency and enhance the long-term success of phytomanagement strategies.



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.

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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