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# Microbes on a mission to clean up Europe's toxic soils

EU-funded researchers are turning to nature's very own clean-up crew to tackle toxic industrial soil pollution.

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Outside the mountain town of Sabiñánigo in northern Spain, an abandoned chemical factory stands on land still scarred by decades of Lindane production – a pesticide now banned worldwide – which left behind thousands of tonnes of toxic waste.

Production ended in the 1980s, but the pesticide's main by-product, hexachlorocyclohexane (HCH), continues to leach into the surrounding soil and groundwater.

HCH is toxic to humans, animals and aquatic life. It also bioaccumulates, meaning it can build up in the tissues of living organisms and move up the food chain. This makes it an important target for environmental clean-up actions.

An EU-funded team of scientists is exploring how to harness nature's own cleaners – bacteria and microorganisms living in the soil – to break down the pollution naturally. If successful, their method could be applied across Europe, where soil health has been in steady decline for decades.

"We are trying to understand which microbes perform which specific functions and how they collaborate. If the microbiome of the soil is healthy, the soil can start to recover," said Dr Rocio Barros García, a leading environmental biotechnologist at the University of Burgos in Spain.

The soil's microbiome is the unique community of microbes that live there. Just as the gut microbiome helps the body digest food, microbes in soil and water can produce enzymes that break down organic pollutants in the environment. This process is known as bioremediation.

## From soil samples to lab insights

In Spain, Dr Barros Garcia works at the International Research Centre in Critical Raw Materials.

She and her team have collected soil samples from Sabiñánigo and recreated the local soil environment in the lab as part of an EU-funded research initiative called BIOSYSMO. The aim is to better understand the soil microbiome.

The Sabiñánigo site is one of five locations being studied by a team of researchers working together in this four-year project which concludes in August 2026.

The effort brings together universities, research institutes and companies from Spain, France, Slovenia, Portugal, Germany, Belgium and the UK.

The international team is exploring how biosystems of combined bacteria, fungi and plants can help break down toxic chemicals in polluted soil.

The work is crucial because the EU has an estimated 2.8 million potentially contaminated sites, ranging from landfills and old mines to petrol stations and abandoned industrial zones.

All this land is technically out of use and hazardous to animal and human health.

“Many persistent organic pollutants are extremely hard to break down and can build up in the environment and in our bodies,” said Barros García.

# From lab to field

The BIOSYSMO team is testing a range of bioremediation strategies. They are using different combinations of bacteria, fungi and plants as bioelectrochemical systems in which microorganisms interact with electrodes to generate a small electric current while they break down pollutants.

This can help clean up contaminants in soil, groundwater, wastewater or estuary and coastal sediments more quickly.

Dr Sara Gil-Guerrero from IDENER, a research and engineering firm in Seville, explained that the goal is to identify natural allies in the soil and improve their cleaning activity by designing and optimising combinations of organisms that work well together.

“A huge phase of the project has been to identify the main players among the organisms already present in contaminated soils, so that we can uncover key ingredients for the development of new approaches.”

A computational framework developed by IDENER supports the experimental work by modelling how microbial communities break down pollutants. By analysing genetic data from contaminated soils, researchers can predict the best microbial combinations before field testing begins.

# Mapping microbes

The clean-up of Sabiñánigo is also being supported by another EU-funded research initiative called MIBIREM, which brings together researchers and companies from Austria, Belgium, France, Germany, Italy and the Netherlands.

The MIBIREM partners are working closely with the BIOSYSMO team to identify optimal combinations of microorganisms for clearing industrial soil pollution.

They are also creating a toolbox for microbial bioremediation. It will include methods, guidelines and resources that other scientists, remediation experts or governments can use to clean up similarly contaminated areas across Europe.

According to MIBIREM research, this kind of microbe-based cleanup could be 20–50% cheaper than traditional methods and produce 70–90% less $CO_2$ emissions.

“MIBIREM aims to help clean up contaminated sites in a more environmentally responsible way, with fewer greenhouse gas emissions and less energy consumption,” said David Donnerer, MIBIREM project manager at RTDS Group, the Austrian partner that coordinates the project’s research.

The MIBIREM team is working at two pilot sites in Germany: in Bitterfeld, where they are also tackling HCH contamination from Lindane; and in Stockach, at a former gasworks where they are working to remove cyanide pollution.

In France, they are focusing on reducing petroleum hydrocarbons at a former soap factory outside the town of Ploufragan, in Brittany.

They are also exploring how special bacteria discovered in the Griftpark in Utrecht, the Netherlands, could help break down the harmful petroleum hydrocarbons left over there from the park’s former life as a gasworks.

# Safeguarding our soil

Good quality soil is essential for life, but much of Europe’s land is in poor shape, with more than 60% of it currently considered unhealthy.

To tackle this wider challenge, the Mission A Soil Deal for Europe, one of the EU’s five major research missions, has set out to boost soil health across the continent.

While BIOSYSMO and MIBIREM are funded under Horizon Europe, their work complements the Mission’s goals by helping to develop cleaner, healthier soils across Europe.

# Slowly but surely

Against this broader push for healthier soils, both the BIOSYSMO and MIBIREM teams hope bioremediation will gain traction in the EU’s future biotechnology policies and overcome regulatory hurdles and other challenges.

These include legal constraints on field testing genetically modified organisms, which requires explicit permission from national authorities and the preparation of detailed technical dossiers and risk assessments.

Although bioremediation is not a quick fix – waiting for nature to take its course can take time – Barros García believes the approach can outperform chemical methods and gradually restore soil as nutrients return.

“Working with microorganisms is not always easy, but it is highly motivating knowing that this is a sustainable technology. And it works. We just need to figure out how to scale it up, worldwide.”

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# More info

- BIOSYSMO (CORDIS)
- BIOSYSMO project website
- MIBIREM (CORDIS)
- MIBIREM project website
- EU Mission: A Soil Deal for Europe