SOIL TECHNOLOGY FACT SHEET

Enhanced in situ bioremediation of soils contaminated

University of Bologna (UNIBO) and Eni Rewind technology
developed under the EU-funded NYMPHE project

PROBLEM

SOILS CONTAMINATED WITH COMPLEX HYDROCARBON AND CHLORINATED MIXTURES ARE DIFFICULT TO REMEDIATE, AS TOXICITY INHIBITS MICROBIAL ACTIVITY, RENDERING CONVENTIONAL SINGLE-STRAIN OR STANDARD BIOREMEDIATION APPROACHES INSUFFICIENT.

Target pollutants:

Mixture of benzene, toluene, ethylbenzene, xylenes (BTEX), total petroleum hydrocarbons (TPH), polycyclic aromatic hydrocarbons (PAH) and chlorinated aliphatic hydrocarbons (CAH).

TECHNOLOGY

System setup:

- Site-specific formulation of microbial inocula (bioaugmentation) and microbiome enhancers (biostimulation).
- Inocula sourced from the contaminated site (autochthonous) or other sites (allochthonous), selected for complementary biodegradation abilities.
- Application methods adapted to site hydrology/geology: direct injection, push-pull, or groundwater recirculation.
- Microbiome enhancers ("prebiotics") chosen via site microbiome characterization and digital simulations.

Operation:

- Microbial inocula and microbiome enhancers introduced into saturated soils and groundwater, either simultaneously or sequentially.
- Redox conditions modulated with commercial amendments (e.g., oxygen- or hydrogen-releasing compounds) to optimize microbial activity.
- Sequential or combined application ensures complementary degradation of hydrocarbons and chlorinated compounds.

Function:

- Microbial inocula degrade specific contaminant classes under tailored redox conditions.
- Microbiome enhancers stimulate indigenous microbes, altering microbiome composition and boosting pollutant biodegradation.
- Integrated bioaugmentation and biostimulation accelerate in situ remediation of complex hydrocarbon-chlorinated mixtures.

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INNOVATION

Ambition:
Rational, system-based design of bioaugmentation and biostimulation strategies for complex pollutant mixtures.

TRL:
4 (laboratory validation) → progressing to TRL 5 (field tests at the NYMPHE site).

Novelty:
The technology integrates multi-omics, metabolic network modelling, and microbiome engineering, enabling site-tailored interventions based on microbial ecology and pollutant interactions.

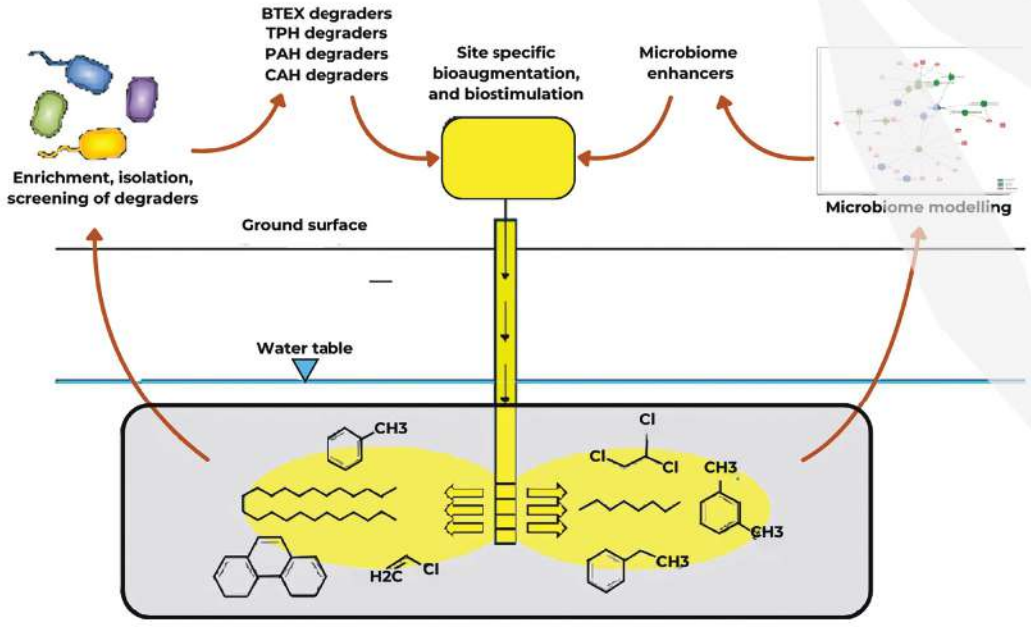
RESULTS

Isolated microbial consortia with strong degradation apacity for BTEX, TPH, PAH (≤3 rings).

Scale-up:
microbial "assembly"under production for field bioaugmentation.

Findings:
PAHs inhibit TPH degradation → resolved by sequential inoculation (PAH/BTEX degraders → TPH degraders).

Enhancers:
candidate microbiome stimulants identified via modelling.



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