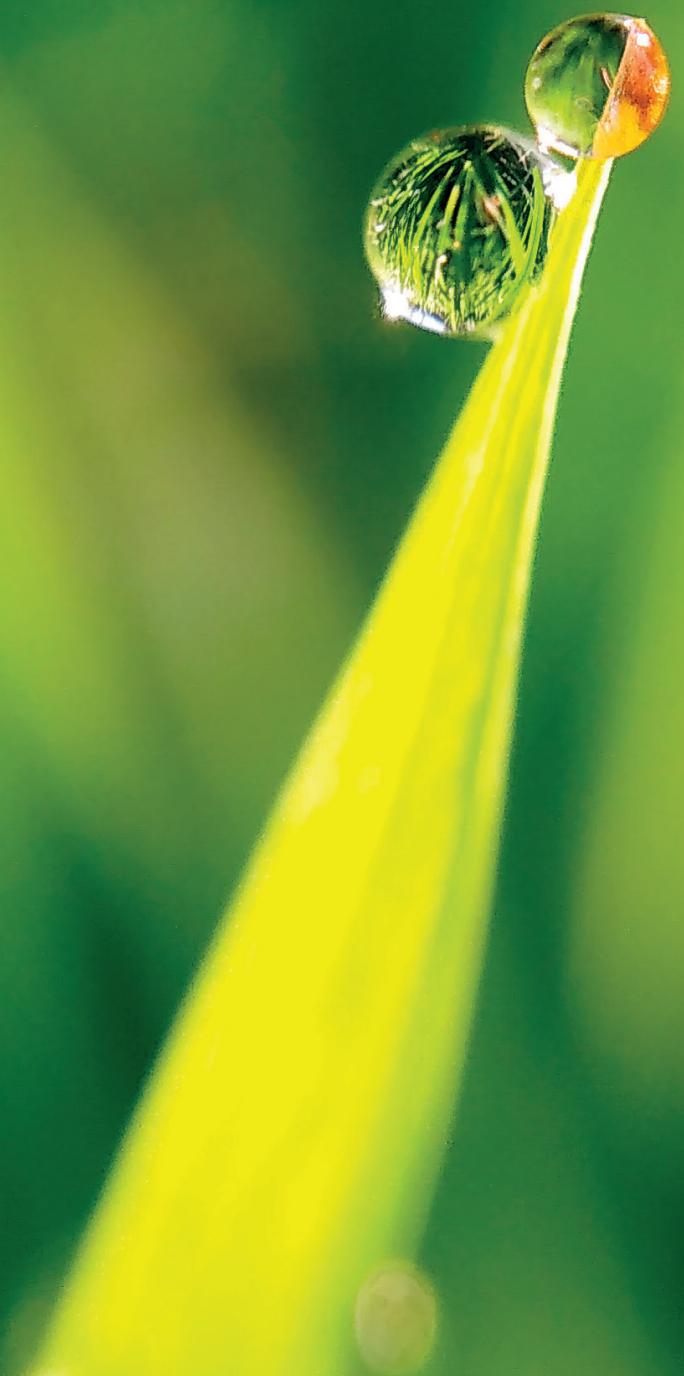




**Unlocking the power**  
of biotechnology  
for revitalizing  
environments



Contamination of the environment resulting from human activity affects climate change, food security and our well-being. **The EU-funded environmental biotechnology Nymphe project (New system-driven bioremediation of polluted habitats and environment)** explores innovative nature-based, low-energy and low-chemical bioremediation solutions to revitalize land and waters affected by deep environmental contamination.

## What is bioremediation?

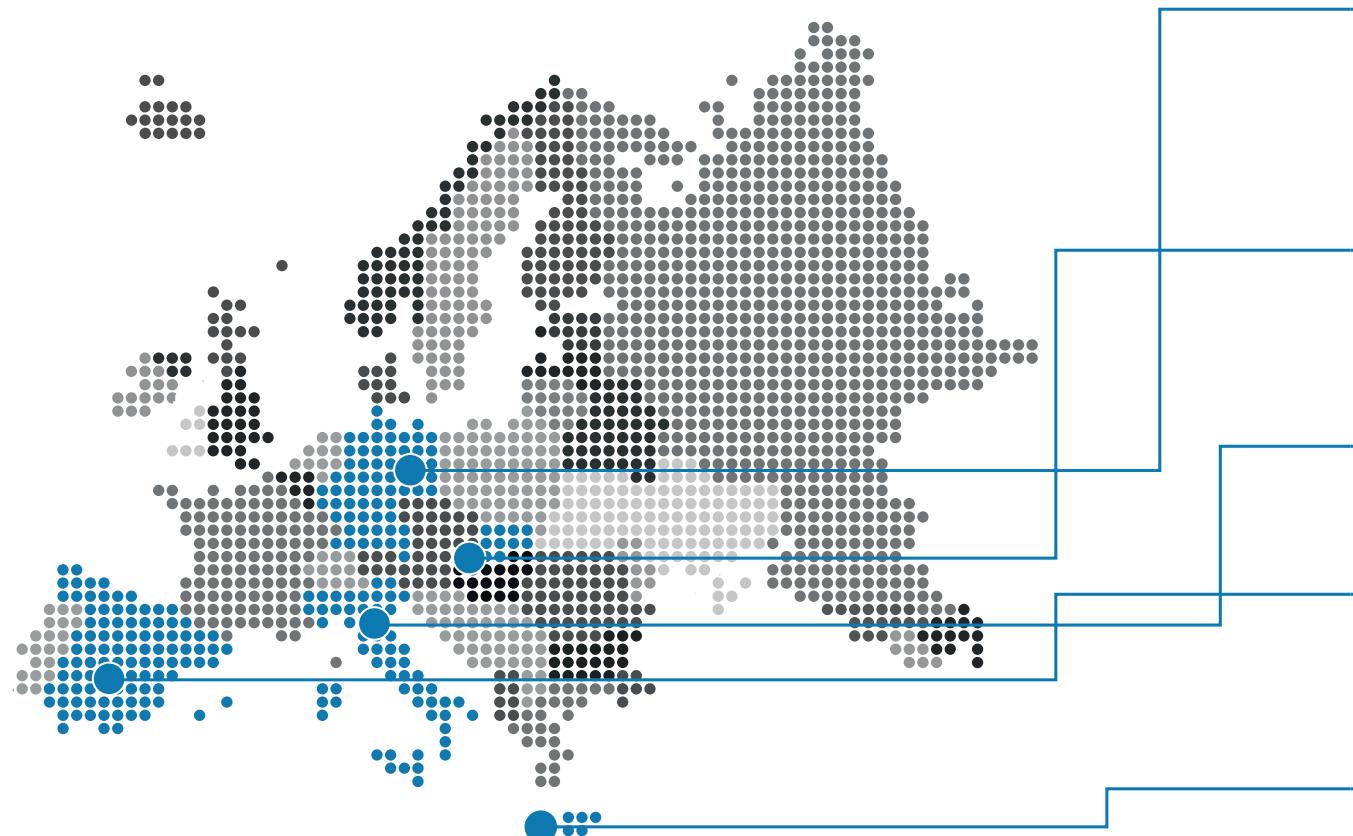
Bioremediation is a biotechnological method that exploits the natural abilities of microorganisms, plants and animals (biologics) and boosts their natural powers to degrade pollutants and toxins from soil, water, and other environments.

## The challenge

Nymphe aims to remove at least 90% of common pollutants like **pharmaceuticals, pesticides, microplastics, chlorinated solvents, petroleum hydrocarbon, and heavy metals** from different types of environments - soil, sediments, groundwater, wastewater and surface water. The pollutants will be removed from the matrices of four deeply contaminated European sites.

Nymphe will reimplement the assemblies of biologics in the sites and assess their efficiency of bioremediation, as well as restoration and revitalization of sites, from the environmental, ecological, economic, and societal points of views.

## Nymphe sites & target pollutants



## Nature-inspired biotechnological strategies

- » Construction of systems consisting of multiple biologics – **enzymes, microorganisms (bacteria, fungi, and microalgae), plants and their associated microorganisms, bivalves and earthworms** – suited for high-performance degradation of pollutants characteristic to the four sites.
- » Development of a toolbox for improving the efficiency of biologics at the individual and system-level, including modelling of microbiomes and design of microbiomes modulation strategies.
- » Reimplementation of the assembled systems of biologics in contaminated sites and one site enabling tests with genetically edited biologics under confined conditions.
- » Full assessment of Nymphe's bioremediation solutions: ecological, technological and econo-mic, along with biosafety & regulatory constraints analysis to ensure their safe and responsible implementation.

## Additional benefits

- » Extension of Natura 2000 network – after the process, the contaminated sites shall reach the highest environmental quality standards and their ecological status, with improved biodiversity, shall be closer to Natura 2000 specifications
- » Building social awareness – Nymphe will actively work on arising awareness for the beneficiary role of bioremediation solutions in environmental cleanup among local communities, environmental groups and regulatory agencies to increase public engagement related to bioremediation initiatives.

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### » **Hoppegarten, Germany**

Hyporheic zone (HZ) – Erpe river sediment and surface water contaminated with pharmaceuticals

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### » **Leopoldov, Slovak Republic**

Facility for „confined use“ of bioengineered biologics

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### » **Ferrara Province, Italy**

Industrial site

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### » **Alcalá, Spain**

Municipal WW contaminated with pharmaceuticals (antibiotics) and microplastics

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### » **Falassarna, Western Crete, Greece**

Agricultural field – soil contaminated with microplastics and pesticides

# Lab-scale Membrane Bioreactors (MBRs)

| **School of Life Sciences (FHNW) technology**  
developed under the EU-funded NYMPHE project

## PROBLEM

 **INEFFICIENT WASTEWATER TREATMENT FOR MULTI-COMPONENT POLLUTION.**

**Target pollutants:**

Municipal wastewater pharmaceutical pollutants: ibuprofen, diclofenac, enalapril, caffeine, atenolol, paracetamol.

## TECHNOLOGY

 **System setup:**

1 L MBRs operated with modified OECD medium (400 mL), continuous aeration and stirring.

 **Operation:**

Hydraulic Retention Time (HRT) = 38 h, infinite Sludge Retention Time (SRT) → prolonged microbial adaptation and evolutionary processes.

 **Function:**

Stable conditions allow microbial communities to adapt to stress from pharmaceutical pollutants and enhance degradation efficiency over time.



# Lab-scale Membrane Bioreactors (MBRs)

| **School of Life Sciences (FHNW) technology**  
developed under the EU-funded NYMPHE project

**TAILORED MICROBIAL CONSORIA = ADVANCED WASTEWATER TREATMENT & ENHANCED ECOLOGICAL SAFETY.**

## INNOVATION

 The technology goes beyond conventional systems that target single pollutants at low concentrations.



Application of infinite SRT enables microbial evolution within the system, enhancing degradation functions.

 Simultaneous biodegradation of multiple pharmaceuticals at both low and high concentrations (1–100 mg/l).

- 1** Bioreactor
- 2** Aeration
- 3** Membrane filtration tank



## RESULTS

REMOVAL EFFICIENCY:

**30–100%**  
UNDER FLUCTUATING LOADS

# METland® Microbial Electrochemical Technologies (METs)

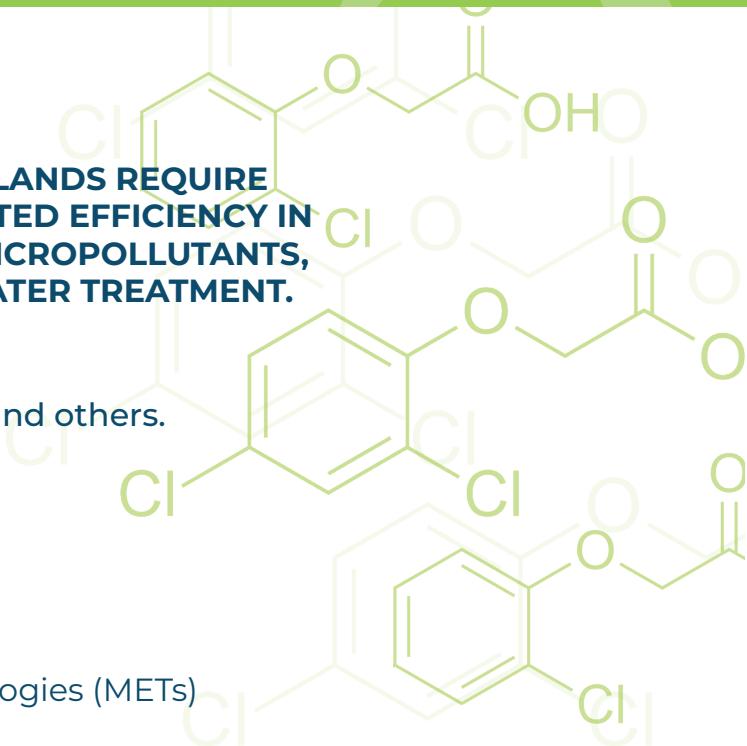
## | Metfilter technology

developed under the EU-funded NYMPHE project

## PROBLEM



**CONVENTIONAL CONSTRUCTED WETLANDS REQUIRE LARGE LAND AREAS AND SHOW LIMITED EFFICIENCY IN REMOVING ORGANIC MATTER AND MICROPOLLUTANTS, LEADING TO INSUFFICIENT WASTEWATER TREATMENT.**



### Target pollutants:

COD, nutrients, pharmaceuticals, herbicides, and others.

## TECHNOLOGY



### System setup:

- Combines Microbial Electrochemical Technologies (METs) with Constructed Wetlands (CWs).
- Replaces inert gravel with biocompatible electroconductive material ("microbial snorkel").
- Compact footprint ( $0.1 \text{ m}^2/\text{pe}$ ) compared to traditional CWs, monitored through electric potential sensors that track ionic and electron fluxes.



### Operation:

- No anode/cathode system; uses a single electroconductive bed in short-circuit mode.
- Boosts electroactive bacteria growth and interconnection between microbial communities.
- Electrical potentials (EP) measured with tailor-made sensors, allowing calculation of ionic current density (J).



### Function:

- Enhances pollutant removal (organic matter & micropollutants) beyond conventional CWs.
- Robust, low-maintenance, nature-based wastewater treatment.
- Prioritizes treatment efficiency over energy harvesting.

# METland® Microbial Electrochemical Technologies (METs)

## | Metfilter technology

developed under the EU-funded NYMPHE project

## INNOVATION

### **Infinite conductive bed:**

Microbes use DIET and CIET for electron transfer concentrations.



### **Key taxa:**

Geobacter spp. and other electroactive microorganisms.



### **Performance:**

Effective removal of recalcitrant micropollutants, including stereoselective biodegradation.



### **TRL:**

9 for urban wastewater & wineries;  
7 for complex matrices (e.g., polluted groundwater).

## RESULTS

### **METland Modular System can reduce footprint:**

Microbes use DIET and CIET for electron transfer concentrations.

### **Scalability:**

Modular, plug-and-play units allow flexible capacity expansion.

### **Demonstrated detoxification:**

Complete effluent safety verified with Daphnia magna and Raphidocelis subcapitata bioassays.

### **Industrial wastewater treatment:**

Handles high organic loads (3k–15k mg COD/L) with removal rates:

**2–10kg\***  
**COD/m<sup>2</sup>/DAY**

\*2 kg COD/m<sup>2</sup>/day (oil & gas),  
10 kg COD m<sup>2</sup>/day (winery).



# Electro-oxidation + biodegradation of microplastics

| **University of Girona (UdG) technology**  
developed under the EU-funded NYMPHE project

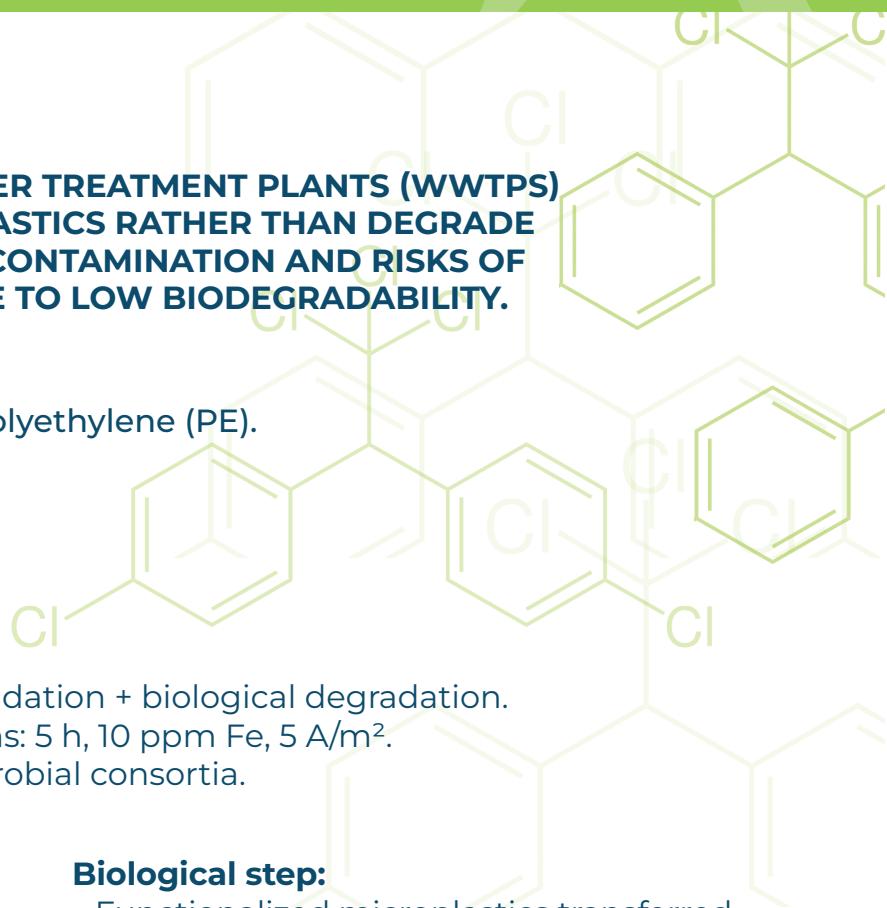
## PROBLEM



**CONVENTIONAL WASTEWATER TREATMENT PLANTS (WWTPS) MAINLY SEPARATE MICROPLASTICS RATHER THAN DEGRADE THEM, LEADING TO SLUDGE CONTAMINATION AND RISKS OF SECONDARY POLLUTION DUE TO LOW BIODEGRADABILITY.**

### Target pollutants:

Persistent microplastics, especially polyethylene (PE).



## TECHNOLOGY



### System setup:

- Two-step process: Electro-Fenton oxidation + biological degradation.
- Electro-Fenton under mild conditions: 5 h, 10 ppm Fe, 5 A/m<sup>2</sup>.
- Aerated bioreactor with specific microbial consortia.



### Operation:

#### Electro-Fenton step:

- In-situ generation of hydroxyl radicals ( $\cdot\text{OH}$ ) through reaction of hydrogen peroxide with Fe(II).
- Radicals attack microplastic surfaces, introducing oxygen-containing groups.
- Surface functionalization increases hydrophilicity and creates reactive binding sites.
- Partial solubilization of plastic fractions and additives improves bioavailability.
- Coupled electrochemical reactions enable continuous  $\text{H}_2\text{O}_2$  production and recycling of Fe(III)  $\rightarrow$  Fe(II), reducing chemical input.

#### Biological step:

- Functionalized microplastics transferred into an aerated bioreactor.
- Tailored microbial consortia colonize modified surfaces and utilize polymers as carbon sources.
- Accelerated breakdown of polymers into simpler compounds, progressing towards complete mineralization.



### Function:

- Significantly enhances biodegradability of microplastics.
- Allows microbes to achieve efficient degradation beyond conventional tertiary treatments.
- Prevents secondary pollution by reducing microplastic persistence in effluents.

# Electro-oxidation + biodegradation of microplastics

University of Girona (UdG) technology  
developed under the EU-funded NYMPHE project

## INNOVATION

The technology goes beyond physical separation by degrading microplastics through combined Electro-Fenton oxidation and microbial degradation, representing a breakthrough in quaternary wastewater treatment. The system enables true elimination of persistent microplastics (e.g., PE), preventing long-term environmental accumulation.

III TRL:  
3, the process has been validated with real microplastics and WWTP effluents.

## RESULTS

- Electro-Fenton pre-treatment increased PE **biodegradability 2-3x**.
- Surface functionalization confirmed by analytical methods.
- Over 80% of PE particles were removed after 21 days of biological treatment. Adding a microfiltration step at the bioreactor outlet could boost efficiency to nearly 100% while shortening treatment time.

### ELECTRO-FENTON OXIDATION:

**80%\***

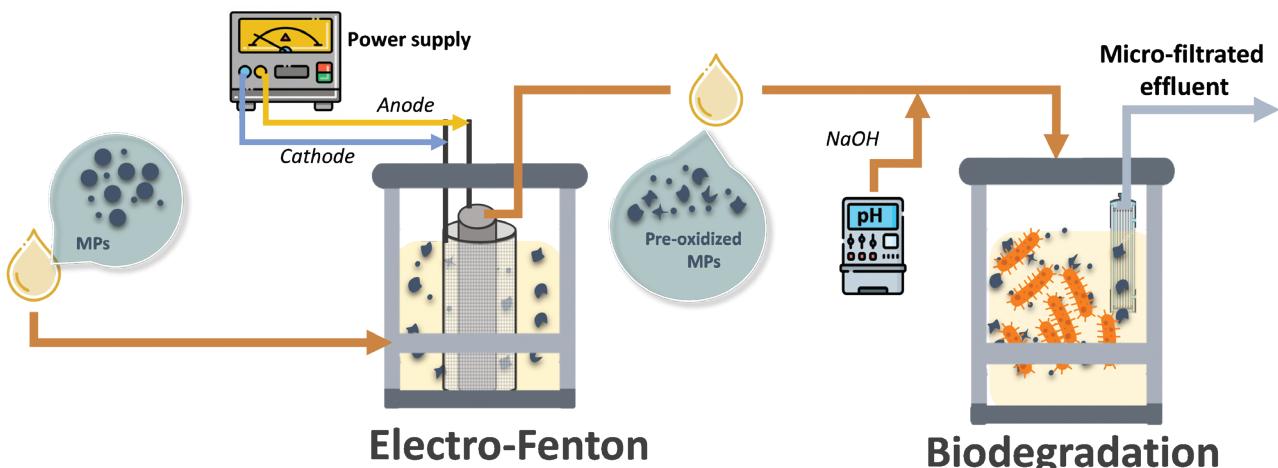
**PE REMOVAL**

\*21 days

### ELECTRO-FENTON OXIDATION + MICROFILTRATION:

**NEARLY 100%  
PE REMOVAL**

Figure 1: Scheme of the combined electro-oxidation-assisted biodegradation treatment of microplastics.



# Biofiltration and biosorption using bivalves and bivalve shells

| **University of Aveiro (UAVR) technology**  
developed under the EU-funded NYMPHE project

## PROBLEM



**LACK OF TECHNOLOGY THAT COMBINES ADVANCED WASTEWATER POLISHING WITH THE CIRCULAR USE OF AQUACULTURE BYPRODUCTS IN AN ECONOMICAL AND SUSTAINABLE WAY.**

## Degraded wastewater pollutants:

Persistent APIs, including antibiotics, after conventional treatment.

## TECHNOLOGY



### System setup:

- **Biofiltration:** Live bivalves naturally filter particles and organic contaminants, potentially reducing pharmaceutical concentrations.
- **Biosorption:** Natural and pyrolyzed bivalve shells demonstrated significant adsorption capacity for pharmaceuticals. Pyrolysis enhances shell properties, increasing biosorption potential.



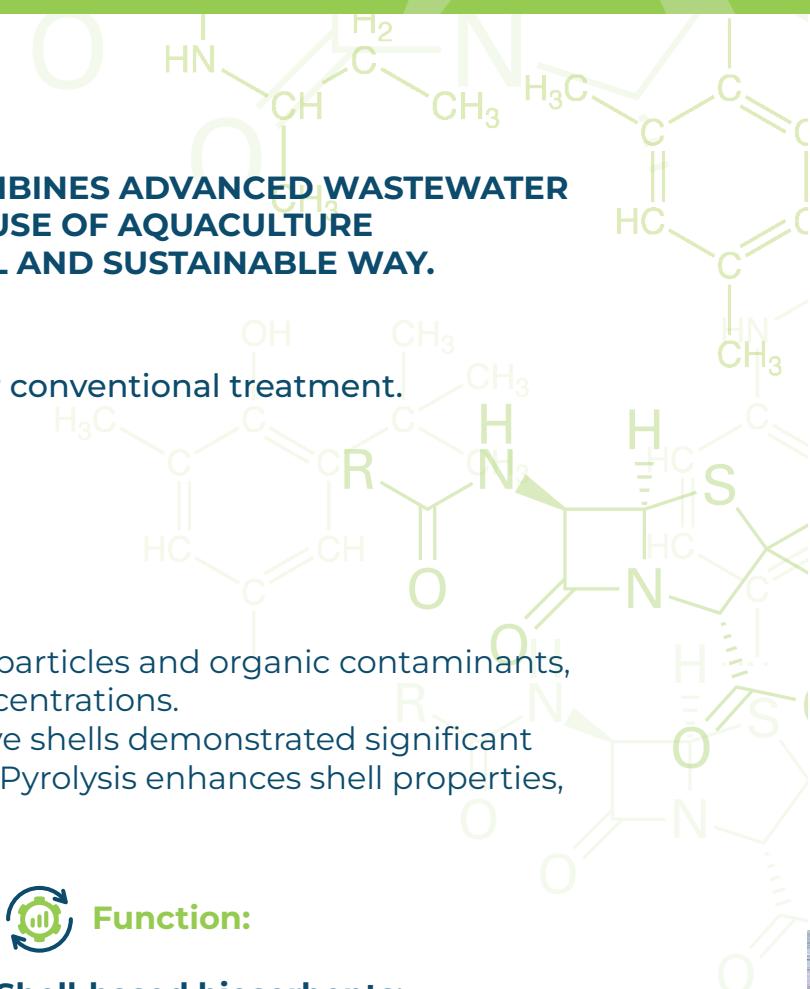
### Operation:

#### Biofiltration:

- bivalves filter suspended particles and organics but show limited removal of pharmaceuticals and low survival in raw wastewater.

#### Biosorption:

- shells, especially after pyrolysis, adsorb pharmaceuticals; efficiency depends on contaminant type and water conditions (e.g., pH).



### Function:

#### Shell-based biosorbents:

- Complement conventional wastewater treatment (polishing step).
- Enhance removal of residual pharmaceuticals.
- Repurpose waste → circular economy & pollution reduction.



# Biofiltration and biosorption using bivalves and bivalve shells

| **University of Aveiro (UAVR) technology**  
developed under the EU-funded NYMPHE project

## INNOVATION

Nature-based, circular bioremediation using biological (bivalves) and abiotic (shells) pathways.

Valorizes waste bivalve shells as biosorbents for pharmaceuticals.

Biosorption efficiency depends on water conditions (e.g., pH) and contaminant type.



4-5 (validated in laboratory and small pilot environments).

## RESULTS

- Live bivalves:**  
Limited survival and low pharmaceutical removal in untreated wastewater.
- Bivalve shells:**  
Pyrolyzed shells show strong biosorption; efficiency depends on surface properties and pH; optimal pyrolysis conditions identified.
- The shells' structure and surface properties were found to play a crucial role in their efficiency.**



## IMPACT

- Shell-derived biosorbents can be integrated into wastewater polishing, valorizing aquaculture waste and supporting circular economy.**
- Pilot-scale potential:**  
Significant reduction of pharmaceutical residues, lower ecotoxicity, and improved aquatic ecosystem health.

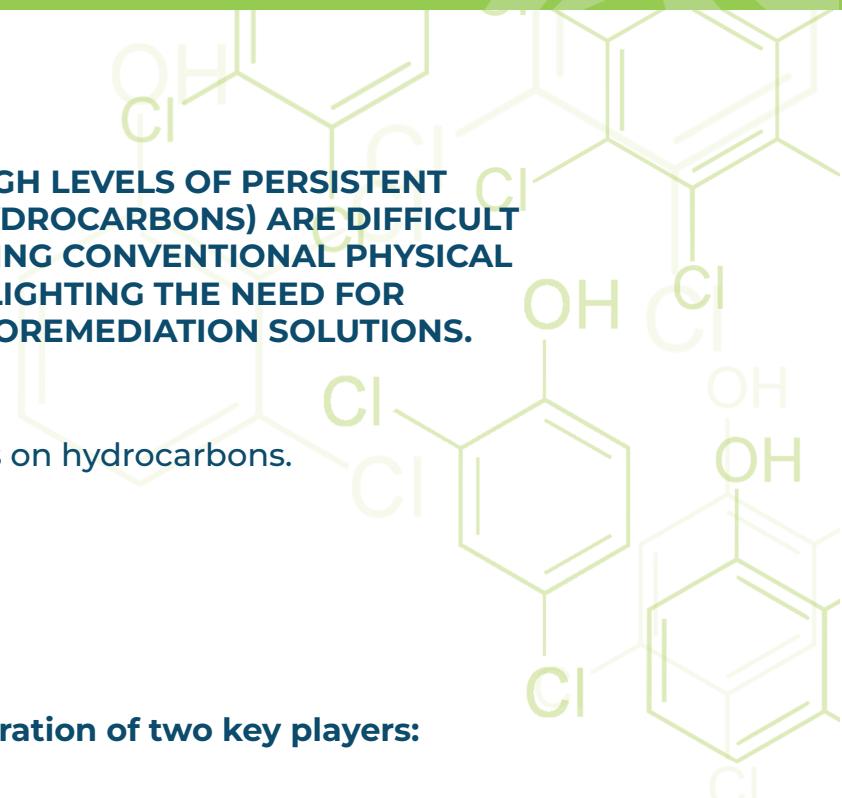
# Rhizoremediation

University of Milan (UMIL) technology  
developed under the EU-funded NYMPHE project

## PROBLEM



**SOILS CONTAMINATED WITH HIGH LEVELS OF PERSISTENT ORGANIC POLLUTANTS (E.G., HYDROCARBONS) ARE DIFFICULT AND COSTLY TO REMEDIATE USING CONVENTIONAL PHYSICAL OR CHEMICAL METHODS, HIGHLIGHTING THE NEED FOR SUSTAINABLE, LARGE-SCALE BIOREMEDIATION SOLUTIONS.**



## Target pollutants:

Persistent organic pollutants, with focus on hydrocarbons.

## TECHNOLOGY



### System setup:

- Rhizoremediation relies on the cooperation of two key players: plants and microbes.
- Sunflower plants selected for their tolerance to soil phytotoxicity.
- Native beneficial microbes isolated from the rhizosphere of sunflowers in contaminated soil.



### Operation:

- Sunflowers planted in hydrocarbon-contaminated soil.
- Plants recruit and enrich beneficial microbes through root exudates (the “cry-for-help” mechanism).
- Sunflowers combined with hydrocarbon-degrading microbes to enhance soil remediation.



### Function:

- Plants stimulate microbial activity and pollutant degradation via root exudates, including signal molecules, transcriptional inducers, and nutrients.
- Microbes degrade hydrocarbons and support plant growth through nutrient supply and phytohormone production.
- The integrated plant–microbe system accelerates bioremediation in polluted soils.

# Rhizoremediation

University of Milan (UMIL) technology  
developed under the EU-funded NYMPHE project

## INNOVATION



### Ambition:

Rationally designing rhizoremediation strategies by engineering plant microbiomes in heavily polluted soils.



### TRL:

4.



### Novelty:

Integrating multi-omic analyses, microbial ecology, and plant-microbe engineering to develop site-tailored rhizoremediation, advancing ecology-based soil cleanup.

## RESULTS

Bacterial collection characterized; strains with hydrocarbon-degrading ability identified.

- Microbial consortia tested with sunflowers → improved germination and growth in toxic soils.
- Enhanced hydrocarbon degradation observed in rhizosphere of inoculated plants vs. controls.
- Sunflower root metabolites under stress identified; potential future use as biostimulants for native microbiomes.



## IMPACT

Demonstrates feasibility of sunflower-microbe systems for hydrocarbon remediation, aligning with circular and ecological approaches.



# Enhanced *in situ* bioremediation of soils contaminated

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

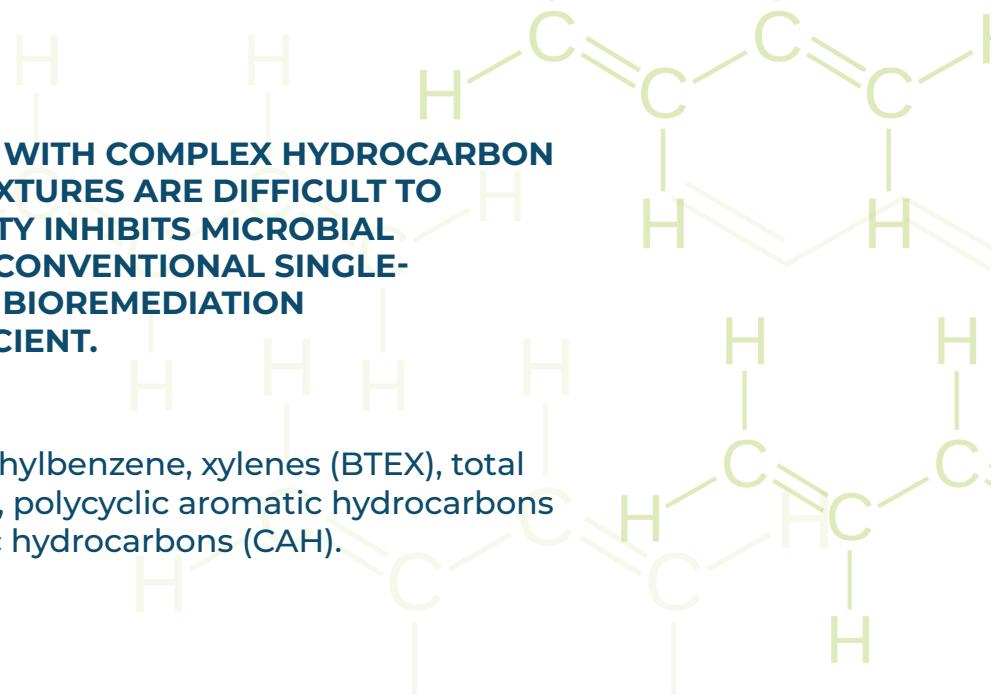
## PROBLEM



**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.

# Enhanced *in situ* bioremediation of soils contaminated

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

## 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.

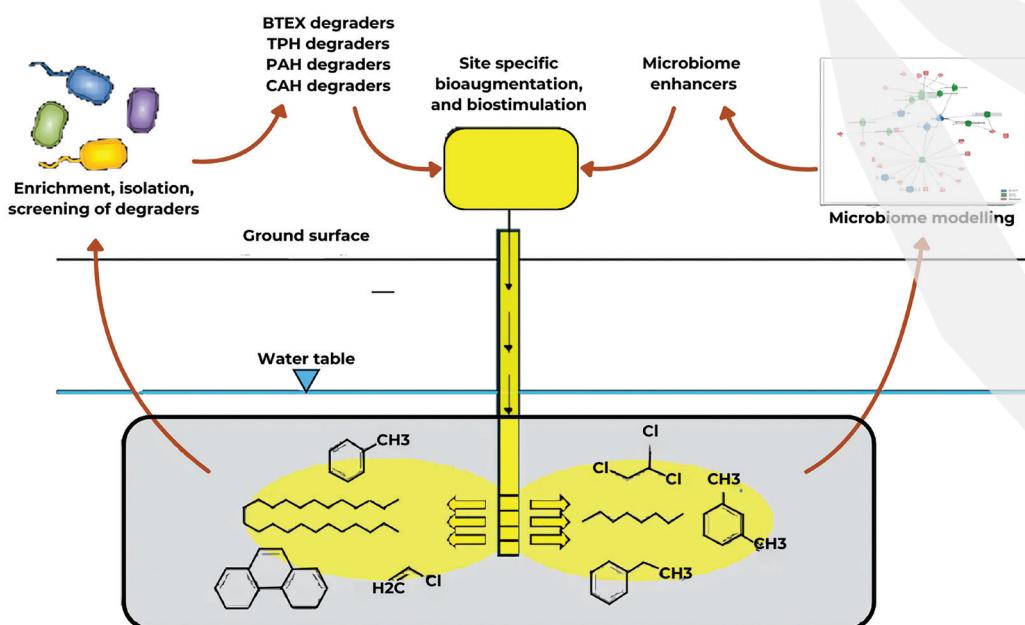
## RESULTS

 Isolated microbial consortia with strong degradation capacity for BTEX, TPH, PAH ( $\leq 3$  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.



# PhytoRhizoProm

University of Chemistry and Technology (vscht) technology  
developed under the EU-funded NYMPHE project

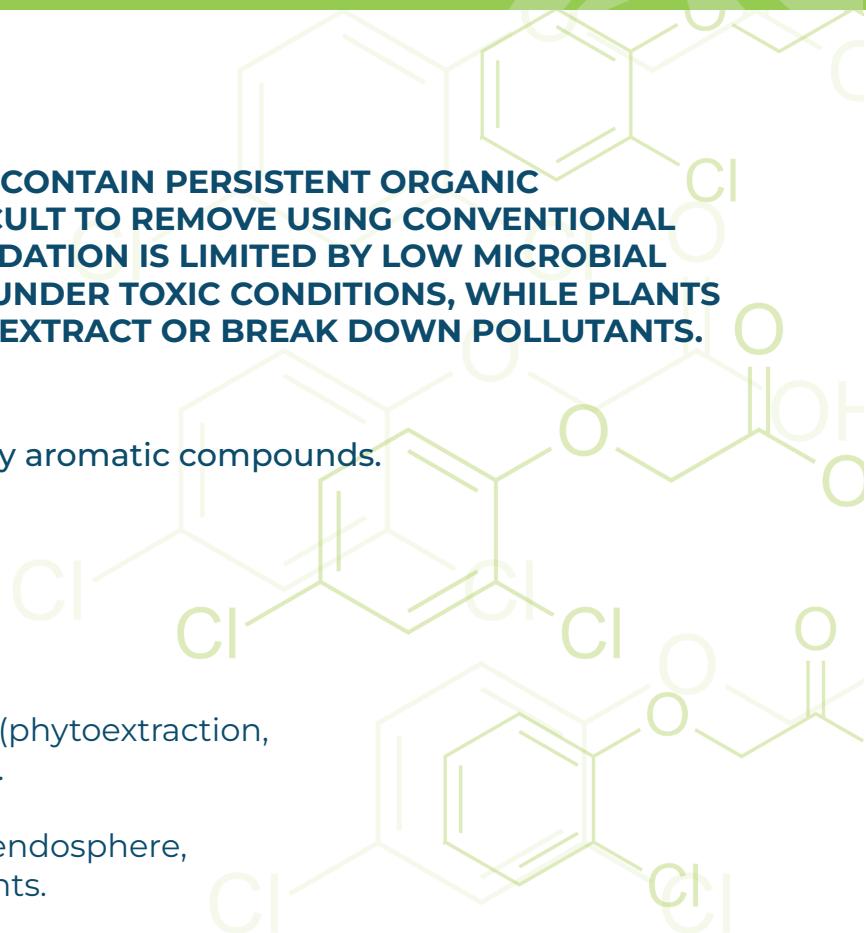
## PROBLEM



**CONTAMINATED SOILS OFTEN CONTAIN PERSISTENT ORGANIC POLLUTANTS THAT ARE DIFFICULT TO REMOVE USING CONVENTIONAL METHODS. MICROBIAL DEGRADATION IS LIMITED BY LOW MICROBIAL ACTIVITY AND PLANT STRESS UNDER TOXIC CONDITIONS, WHILE PLANTS ALONE MAY NOT EFFICIENTLY EXTRACT OR BREAK DOWN POLLUTANTS.**

### Target pollutants:

Persistent organic pollutants, especially aromatic compounds.



## TECHNOLOGY



### System setup:

- Plants selected for phytoremediation (phytoextraction, phytostabilization, phytodegradation).
- Microbial communities (rhizosphere, endosphere, phyllosphere) associated with the plants.



### Operation:

- Plants established in contaminated soil.
- Microbes colonize roots and surrounding soil, enhancing pollutant degradation.
- Plant–microbe interactions optimized for growth under polluted conditions.



### Mechanism:

- Plants + microbes form a holobiont for efficient pollutant breakdown and growth promotion.
- Synergistic interactions increase resilience and biomass for higher pollutant uptake.**



### Function:

- Phytoremediation:** plants extract, stabilize, and degrade pollutants.
- Rhizodegradation:** rhizosphere microbes degrade contaminants and support plant health.
- Genetic optimization:** bacterial genes in plants enhance aromatic ring degradation.

# PhytoRhizoProm

University of Chemistry and Technology (vscht) technology  
developed under the EU-funded NYMPHE project

## INNOVATION

This technology integrates phytoremediation, rhizodegradation, and plant growth promotion with genetic enhancement of pollutant-degrading traits.

Through genomic editing, specific bacterial genes are introduced into plants, enabling them to cleave aromatic rings — a key step in breaking down many persistent pollutants.

**The result is a plant–microbe holobiont**, a tightly integrated biological unit that provides a more efficient and environmentally sustainable approach to ecological restoration.



### TRL:

4–5 (lab validation → field tests planned).

## RESULTS

- Plants with integrated bacterial genes efficiently cleave aromatic rings, accelerating degradation of persistent organic pollutants.
- Synergistic interactions with plant growth-promoting rhizobacteria enhance plant growth under contaminated conditions.
- Higher biomass production boosts pollutant uptake and improves soil restoration potential.

**Initial results indicate a more efficient, eco-friendly remediation; field-scale validation will assess cost, scalability, and long-term sustainability.**



# Prebiotics intervention to enhance pollutant removal

| **Blossom Microbial Technologies (BLOM)**  
developed under the EU-funded NYMPHE project

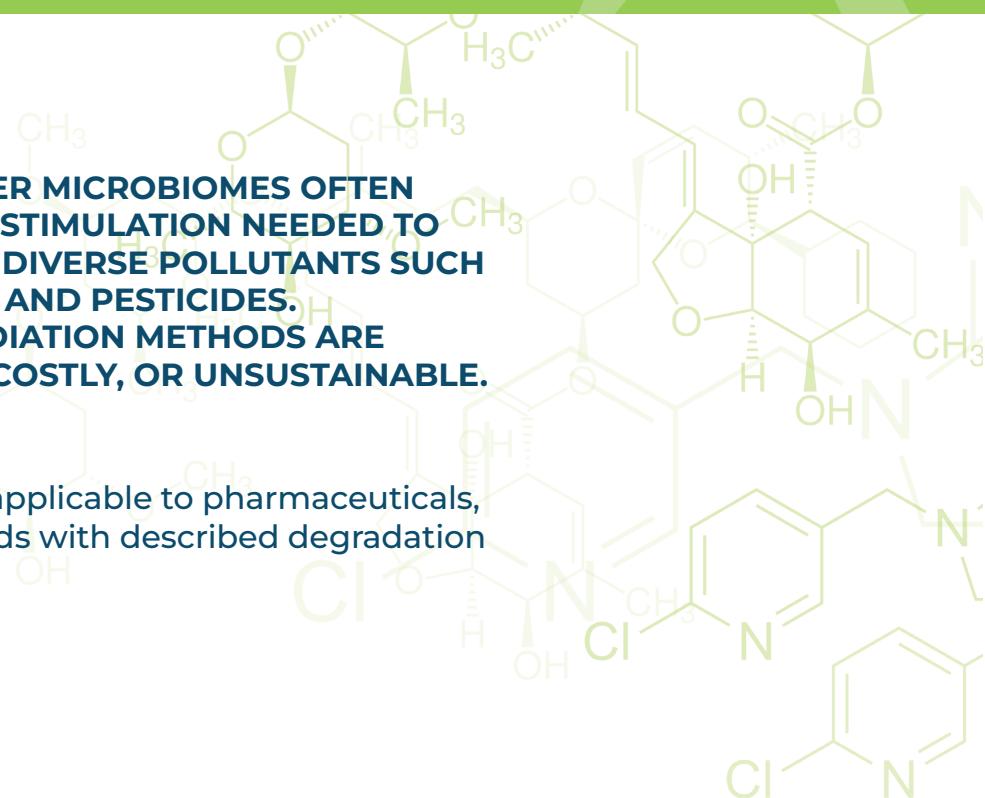
## PROBLEM



**NATIVE SOIL AND WATER MICROBIOMES OFTEN LACK THE ACTIVITY OR STIMULATION NEEDED TO EFFICIENTLY DEGRADE DIVERSE POLLUTANTS SUCH AS PHARMACEUTICALS AND PESTICIDES. CONVENTIONAL REMEDIATION METHODS ARE POLLUTANT-SPECIFIC, COSTLY, OR UNSUSTAINABLE.**

### Target pollutants:

Pollutant-agnostic approach – applicable to pharmaceuticals, pesticides, and other compounds with described degradation pathways.



## TECHNOLOGY



### System setup:

- Microbiome DNA (metagenome) scanned to identify key pollutant-degrading species.



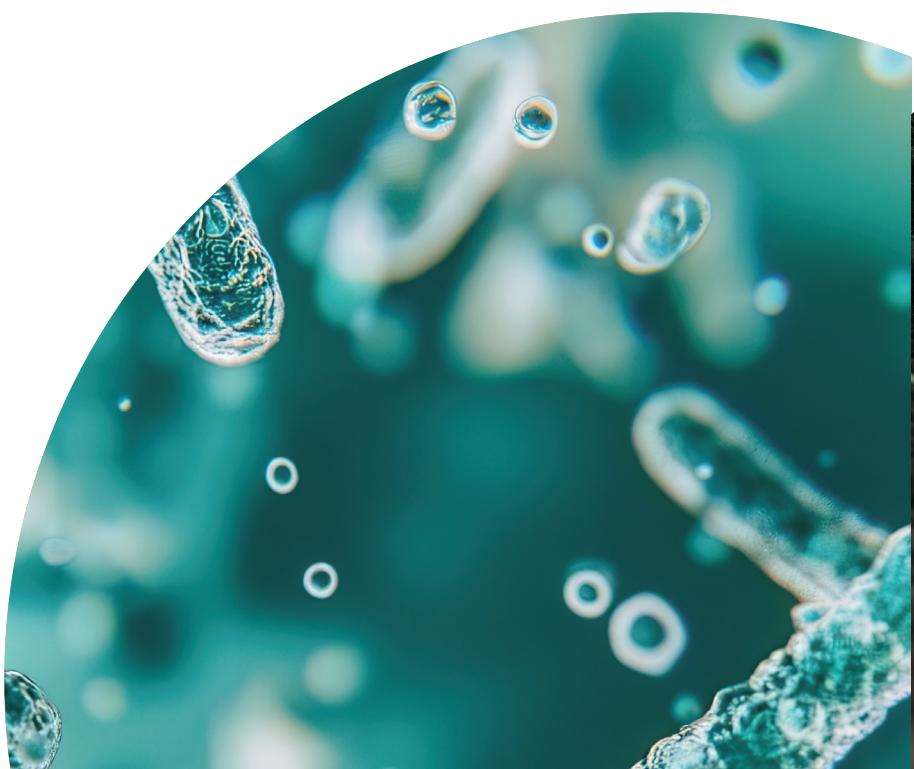
### Operation:

- Prebiotics designed as tailored “food” for target microbes.
- Applied to wastewater or soil to selectively feed and activate these microbes.



### Function:

- Boosts native microbiome capacity for pollutant degradation.
- Enables efficient, sustainable removal of pharmaceuticals, pesticides, and other contaminants.



# Prebiotics intervention to enhance pollutant removal

| **Blossom Microbial Technologies (BLOM)**  
developed under the EU-funded NYMPHE project

## INNOVATION

This is the first method to selectively boost native microbiomes for pollutant removal. Unlike bioaugmentation with external strains, it fosters hundreds of local species simultaneously, ensuring scalability, robustness, and long-term stability.

 **TRL:**  
4 (lab validation).

## RESULTS

-  Laboratory validation shows selective stimulation of pollutant-degrading microorganisms.
-  The approach demonstrates robustness across different microbial communities and pollutants.
-  Potential for broad application in wastewater and soil systems.
-  Currently seeking implementation partners for pilot-scale validation and distribution.



# Automated Synthetically-Primed Evolution of new biodegradative activities

Spanish National Research Council (CSIC) technology  
developed under the EU-funded NYMPHE project

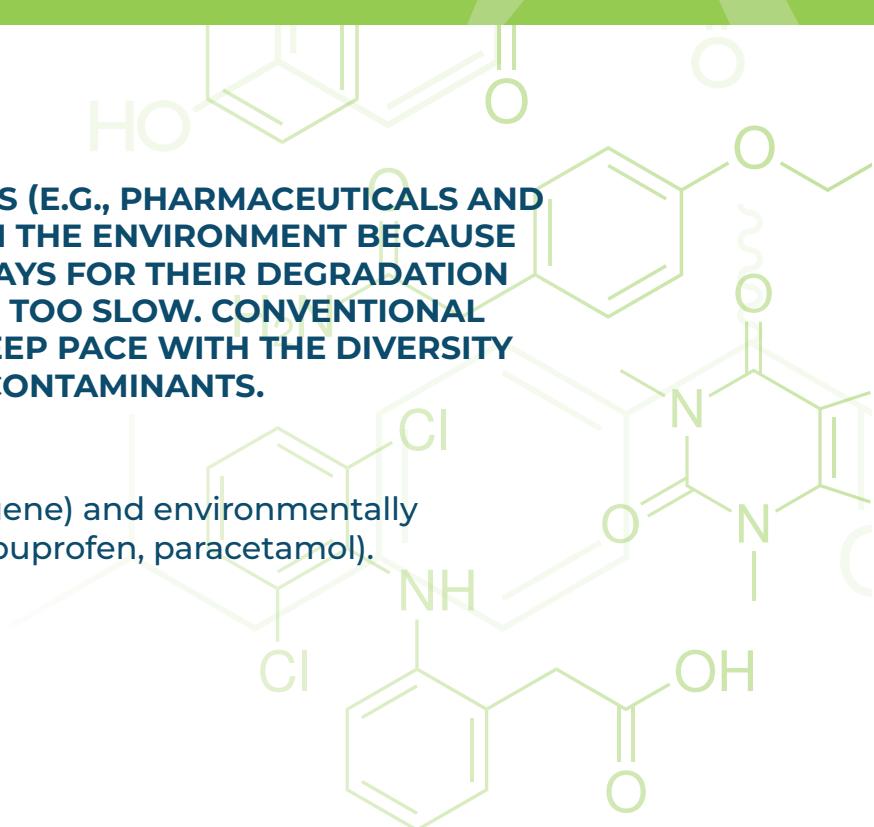
## PROBLEM



MANY EMERGING POLLUTANTS (E.G., PHARMACEUTICALS AND NITROAROMATICS) PERSIST IN THE ENVIRONMENT BECAUSE NATURAL MICROBIAL PATHWAYS FOR THEIR DEGRADATION ARE ABSENT, INEFFICIENT, OR TOO SLOW. CONVENTIONAL BIOREMEDIALATION CANNOT KEEP PACE WITH THE DIVERSITY AND COMPLEXITY OF THESE CONTAMINANTS.

### Target pollutants:

Model compounds (e.g., 2,4-dinitrotoluene) and environmentally relevant micropollutants (diclofenac, ibuprofen, paracetamol).



## TECHNOLOGY



### System setup:

- Bacterial chassis: *Pseudomonas putida* (recognized bioremediation host).
- Introduction of genes encoding new biotransformation activities.



### Operation:

- Initial genes are unoptimized for host's metabolic and genomic context.
- Recursive laboratory evolution applied, supported by an OpenTrons-type robotic platform.
- Iterative "molecular negotiation" between inserted genes and host regulatory/metabolic networks.



### Function:

- Generation of evolved bacterial strains with enhanced pollutant degradation capacity.
- Strains tailored for efficient bioremediation of complex or persistent contaminants.

# Automated Synthetically-Primed Evolution of new biodegradative activities

Spanish National Research Council (CSIC) technology  
developed under the EU-funded NYMPHE project

## INNOVATION



### Ambition:

Combine adaptive laboratory evolution with synthetic biology to create new biocatalysts.



### TRL:

Prototype stage.



### Novelty:

Integration of two traditionally separate approaches to generate entirely new microbial capabilities for pollutant degradation, beyond conventional bioremediation.

## RESULTS

- Preliminary results show potential for generating whole-cell catalysts capable of degrading compounds previously considered highly resistant.
- Enables faster development of efficient biodegradative strains for model and environmental pollutants.
- Provides a platform for rapid adaptation and optimization of biodegradative pathways in controlled conditions.



# Sediment-filled flow path tubes activities

| Leibniz-Institut für Gewässerökologie und Binnenfischerei (IGB) Berlin  
developed under the EU-funded NYMPHE project

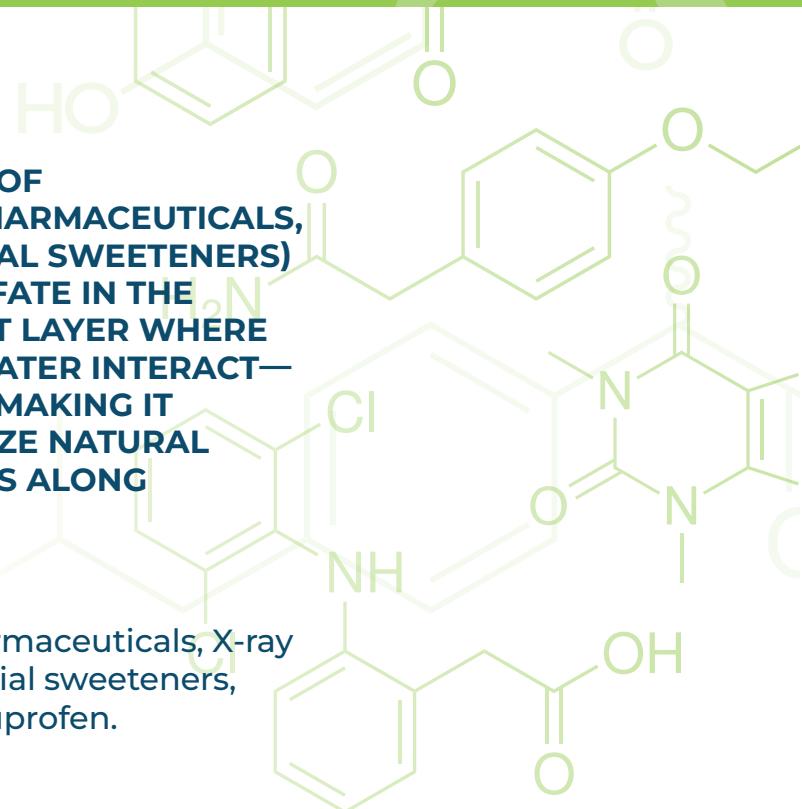
## PROBLEM



**TRACE ORGANIC CONTAMINANTS OF ANTHROPOGENIC ORIGIN (E.G., PHARMACEUTICALS, INDUSTRIAL CHEMICALS, ARTIFICIAL SWEETENERS) OFTEN PERSIST IN RIVERS. THEIR FATE IN THE HYDROHEIC ZONE—THE SEDIMENT LAYER WHERE SURFACE WATER AND GROUNDWATER INTERACT—REMAINS POORLY UNDERSTOOD, MAKING IT DIFFICULT TO PREDICT OR OPTIMIZE NATURAL IN-SITU DEGRADATION PROCESSES ALONG SPECIFIC FLOW PATHS.**

### Target pollutants:

Anthropogenic trace organics such as pharmaceuticals, X-ray contrast media, industrial chemicals, artificial sweeteners, specifically metformin, guanylurea, and ibuprofen.



## TECHNOLOGY



### System setup:

- Sediment-filled tubes with sampling ports and conductivity loggers.
- Sediment types: natural, artificially enriched with microbes, or synthetic.



### Operation:

- Monitoring water retention times via conductivity loggers.
- Tracking redox conditions along the subsurface flow path.



### Function:

- Assess how different sediments and redox states influence the attenuation and degradation of trace organic contaminants.

# Sediment-filled flow path tubes activities

| Leibniz-Institut für Gewässerökologie und Binnenfischerei (IGB) Berlin  
developed under the EU-funded NYMPHE project

## INNOVATION



### Ambition:

Provide a system to track contaminant fate along specific flow paths in natural rivers.



### TRL:

6 (system demonstration in relevant environment).

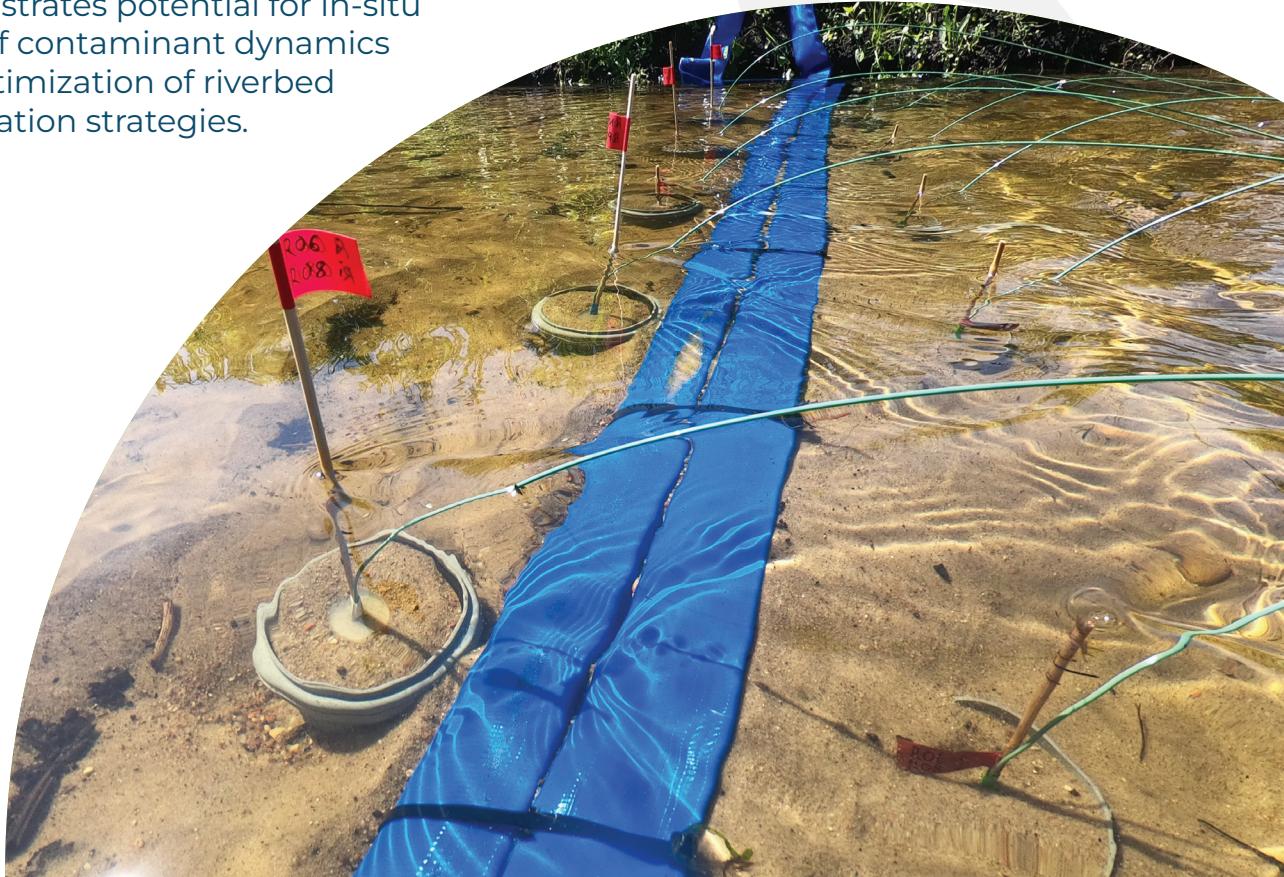


### Novelty:

No other system currently allows in-situ sampling along defined subsurface flow paths; enables manipulation of sediments and microbiomes to study degradation processes.

## RESULTS

- Natural microbial communities can attenuate trace organic contaminants.
- Best attenuation observed in **extensive oxic zones** with **intermediate residence times**.
- Demonstrates potential for in-situ study of contaminant dynamics and optimization of riverbed remediation strategies.





UNIVERSITÀ  
DEGLI STUDI  
DI MILANO



## Key figures

**Starting date:**

1 January 2023

**End date:**

December 2026

**Total cost:**

5.7 million €

**Funding:**

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18 partner organisations from 12 countries

9 universities & research institutions, 6 SMEs,

1 large chemical multi-company and 2 NGOs

## Contact us

<https://www.nymphaproject.eu/>



**Project Coordinator: Giulio Zanaroli:** [giulio.zanaroli@unibo.it](mailto:giulio.zanaroli@unibo.it)

**Communications: Agnieszka Sznyk:** [a.sznyk@innowo.org](mailto:a.sznyk@innowo.org)



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