TERRA-MED PhD PROGRAM - Marie Skłodowska-Curie Actions

Context on the program

TERRA-MED is an interregional doctoral program funded under the Marie Skłodowska-Curie COFUND Actions that will recruit and train a new generation of researchers to address the sustainability and resource stress (Water–Land–Energy nexus) in Mediterranean territories.



The Euroregion Pyrenees–Mediterranean, coordinator of the program, brings together the Regions of Occitanie (France), Catalonia and the Balearic Islands (Spain) forming a cross-border research ecosystem. Through this collaboration, TERRA-MED connects world-class universities, research centres and socio-economic actors committed to advancing resilience in the face of climate change. With more than 22,000 scientists across 10 universities and 2 research centers, encompassing 1000 research units, TERRA-MED provides a rich, interdisciplinary environment where doctoral candidates can excel and launch their research careers.

33 PhD positions will be offered to early-stage researchers with a unique interregional, interdisciplinary and intersectoral environment.

Fellows will benefit from having two supervisors (a principal supervisor and a co-supervisor) from two different regions and having a non-academic mentor. The fellows will undertake mandatory cross-border or international stays to the co-institution, as well as a secondment in a non-academic entity.

Moreover, doctoral candidates will receive a specifically designed training program related to their research topics, alongside modules on innovation, entrepreneurship, project management, ethics, open science, etc.

Benefits of TERRA-MED PhD program

- Top-tier PhD education and research training
- Access to world-class laboratories
- Interregional double supervision
- Double PhD degree (France / Spain) where applicable
- Interdisciplinary and cross-sector research experience
- Unique TERRA-MED's excellence training program on resources stress and climate change. See here
- Attractive salary in the frame of MSCA standards
- Extensive network of academic and non-academic partners
- 2 secondments: 1 in the co-supervisor's institution (9 to 12 months); 1 in a non-academic organization to gain extra academic experience and skills (3 to 6 months)

<table>
<tr><td>Reference of the thesis project:
(UdG3)</td><td colspan="2">Title of the thesis project
Electrochemical acceleration of microplastic aging and evaluation of biodegradation and/or bioelectrochemical degradation in Greywater and Wastewater Systems</td></tr>
<tr><td>Host institution:
Universitat de Girona (UdG)</td><td colspan="2">Co-supervision / co-host institutions:
1. Université de Toulouse (UT)
2. Universitat de les Illes Balears (UIB)</td></tr>
<tr><td>Country
Spain</td><td colspan="2">Country
1. France
2. Spain</td></tr>
<tr><td>Host Research Unit:
The Molecular Microbial Ecology Group (gEMM) at the University of Girona is a consolidated research team within the Institute of Aquatic Ecology. The group's work focuses on understanding the microbial processes that regulate the cycling of carbon, nitrogen, and sulfur, linking community composition with ecosystem-level transformations such as respiration, nitrification, denitrification, and the degradation of organic and inorganic compounds. The group makes extensive use of amplicon sequencing, metagenomics, and quantitative PCR complemented by physiological assays and bioinformatic modelling. This combination allows researchers to characterize both the taxonomic structure and the functional potential of microbial communities, as well as to quantify their activity in situ and under controlled experimental conditions.
gEMM integrates a strong and distinctive expertise in bioelectrochemistry and bioremediation, which complements its molecular ecology focus and positions the team at the interface between microbial physiology, electrochemical engineering, and environmental biotechnology. Their work demonstrates how mild</td><td colspan="2">Co-host Research Units:
UT
The Biofilm Engineering Group at the Laboratoire de Génie Chimique, University of Toulouse (UT), is an internationally recognized research team specializing in biofilm engineering, bioelectrochemistry, and environmental process engineering. The group investigates the interactions between microorganisms, electrochemical systems, and material surfaces, with particular emphasis on microbial electron transfer, biofilm development, and mass transport processes. It combines electrochemical techniques, microbial cultivation, physicochemical characterization, and numerical modelling to investigate the mechanisms governing microbial activity and biofilm–material interactions under controlled environmental conditions.
The group has developed strong expertise in coupling electrochemical processes with microbial transformations, providing fundamental insights into how electrochemical stimulation can modify surface properties, generate reactive species, and influence microbial colonization and biodegradation. This expertise is complemented by advanced multiphysics modelling integrating electrochemical reactions, reactive transport, and microbial processes to describe complex</td></tr>
</table>

electrochemical stimulation can activate oxidative pathways, generate reactive species, or modify substrates in ways that enhance downstream microbial degradation. The group's work shows how electrochemical tools can be used not only to degrade pollutants directly but also to condition substrates, steer microbial activity, and enhance biodegradability, creating new opportunities for circular and energy-efficient water-treatment technologies.	environmental systems. Within this project, the Biofilm Engineering Group will contribute to understanding how electrochemical aging modifies the physicochemical properties of microplastics, how these changes influence biofilm formation and biodegradation in greywater systems, and how modelling can support the mechanistic interpretation and optimization of these coupled electrochemical and biological processes.
1. UIB The Microbiology and Environmental Biotechnology Group (MICROBIAM) at the University of the Balearic Islands (UIB) is a multidisciplinary research team with extensive expertise in environmental microbiology, microbial ecology, and applied biotechnology. The group investigates the diversity, physiology, and ecological roles of microorganisms across natural and engineered environments, with particular strengths in microbial plastic biodegradation and pollutant degradation. MICROBIAM combines cutting-edge approaches in microbial physiological characterization, molecular biology, and multi-omics—including genomics, transcriptomics, proteomics, and metabolomics—to elucidate the mechanisms underlying microbial interactions with environmental substrates. This integrative expertise enables the group to bridge fundamental microbial ecology with innovative biotechnological applications aimed at advancing sustainable solutions for environmental challenges.	
Name of the first co-supervisor Luis Bañeras Vives **Email contact:** lluis.banyeras@udg.edu	**Name of the second co-supervisor** Benjamin Erable: benjamin.erable@ensiacet.fr **Name of the third co-supervisor** Joseph A. Christie-Oleza: joseph.christie@uib.eu
Doctoral School: Doctoral Programme in Water Science and Technology (https://www.udg.edu/en/estudia/oferta-formativa/programes-de-doctorat/doctorat?IDE=3556&ID=350130213)	**Doctoral School:** UT Doctoral School of Mechanics, Energetics, Civil & Process Engineering (https://adum.fr/as/ed/actu.pl?site=megep) **UIB** PhD in Environmental and Biomedical Microbiology (https://edoctorat.uib.eu/en/doctorat/TMAB/)
Research field(s) PE8_3 Environmental biotechnology / PE8_4 Bioprocess engineering /PE8_7 Electrochemical engineering / LS8_1 Microbial ecology /LS8_3 Environmental microbiology /SH7_4	

Environmental sustainability / SH7_6 Circular economy and resource efficiency /PE5_3 Polymers and plastics

Keywords
Microplastic degradation; Polyethylene ageing; Polypropylene ageing; Microbial electrochemical technologies; Greywater; Wastewater treatment polishing; Electro-biocatalysis

Description of the research project

Context and Rationale :

1. Scientific context

Current research on plastic degradation shows that most synthetic polymers remain highly recalcitrant, with biodegradation proceeding only after an initial abiotic oxidation steps. State-of-the-art (SoA) approaches rely on UV weathering, thermal oxidation, and chemical pretreatments to introduce oxygenated functional groups and promote random polymer scission resulting in chemically diverse mixture of oxidized aliphatic compounds spanning a broad range of chain lengths and oxidation states. This enables selected and optimized microbial consortia to metabolize the resulting fragments. Even with these advances, complete mineralization of plastic olefins (polyethylene and polypropylene as major components of plastic waste) is still a utopia: degradation rates are extremely low, and existing methods are energy intensive or poorly scalable, a situation that deserves further investigation. The field increasingly recognizes that hybrid strategies combining abiotic activation with extensive selection and optimization of microbial consortia, are essential to overcome the intrinsic resistance of micro- and nano-plastics to biological attack.

2. Progress beyond SoA

Bioelectrochemistry offers a promising route beyond the current state of the art by combining electrochemical pre-treatment with bioelectrochemical degradation under hybrid electrochemical–biological conditions. Electro-Fenton and related electrochemical oxidation processes can generate reactive oxygen species under mild operating conditions, enabling the controlled oxidation of recalcitrant polymers while minimizing adverse effects on microbial communities. This pre-treatment introduces oxygen-containing functional groups (e.g., carbonyl and hydroxyl groups), reduces polymer molecular weight, and generates soluble oligomers that are more amenable to microbial assimilation and biodegradation.

Building on this enhanced biodegradability, bioelectrochemical systems provide a unique platform to stimulate microbial oxidative pathways, enrich electroactive microorganisms, and precisely regulate redox conditions through electrode potential control. The coupling of electrochemical activation with microbial metabolism is expected to overcome the limitations of either process alone, creating synergistic electrochemical–microbiological interactions that accelerate the degradation of microplastics and other persistent organic contaminants while maintaining low energy requirements. Exploring and optimizing this integrated strategy constitutes the central scientific innovation of this thesis.

3. **Relevance to resource stress and climate change (Water-Land-Energy Nexus)**

Plastic persistence is tightly linked to resource stress in multiple ways. Accumulating plastics interfere with soil fertility, water quality, and waste management (in terms of energetic efficiency). The development of scalable strategies to transform recalcitrant polymers into biodegradable intermediates is essential for protecting both freshwater and marine ecosystems, reducing greenhouse-gas emissions from waste streams, and enabling circular resource flows. Bioelectrochemical approaches offer a particularly relevant solution because they operate under low-energy conditions, use water as the reaction medium, and generate biologically accessible substrates that can be mineralized down to CO_2 by microbial communities.

Objectives:

The project aims to address the persistent presence of microplastics (MPs) in greywater and wastewater treatment plant effluents, a resource that represents up to 75 % of domestic wastewater and yet remains under cleaned. Existing systems are designed for conventional pollutants and offer limited capacity to mitigate persistent plastic contaminants. This exciting project will explore how electromicrobial processes, combined with conductive nanostructured membranes, controlled redox environments and specialized microbial consortia (and pure microbial cultures), can accelerate MP biodegradation.

The research will investigate several questions, namely:

1. How do electrochemical conditions influence oxidative ageing of MPs, and how does this ageing enhance microbial accessibility and degradation kinetics?
2. Which microbial communities (populations) are the most effective and have the highest plastic degradation rate?
3. What metabolic pathways govern the transformation of MPs under combined electrochemical and biological action by studying genes (transcriptomics)and degradation intermediates (metabolomics)?
4. What are the environmental, regulatory and practical implications of integrating such systems into decentralized frameworks?

Expected Results:

The project is expected to deliver a mechanistic and technological improvement in the treatment of persistent plastic, and plastic derived contaminants in water. **First**, it will generate a quantitative understanding of how electrochemical (and bioelectrochemical) conditions accelerate oxidative ageing of MPs and plasticisers, identifying the specific redox regimes and reactor configurations that will maximize functionalization (promoting oxidative reactions) and fragmentation under low-energy conditions. **Second**, it will identify and characterize microbial communities and isolates capable of degrading electro-aged plastics (leachates), revealing their ecological traits and metabolic capacities, and enabling the construction of defined cultures (synthetic communities) promoting efficient mineralization. **Third**, a combined -omics approach will elucidate major metabolic

pathways and degradation intermediates involved in electrochemically stimulated plastic transformation, providing the first integrated map of gene expression and metabolite fluxes under hybrid electrochemical-biological conditions.
Technologically, the thesis will produce a validated hybrid reactor concept that demonstrates accelerated degradation of MPs compared with biological or electrochemical treatments alone. This system will serve as a prototype for decentralized greywater treatment and as a final polishing step of wastewater treatment plant effluents, offering a low-energy, water compatible solution aligned with circular resource management.

Work plan:
The thesis will develop a hybrid electrochemical–biological platform capable of accelerating the degradation and mineralization of microplastics (MPs) in greywater and as a polishing step for wastewater treatment plant effluents.
The work will be organized into **four research** phases that progressively build mechanistic understanding and environmental relevance of the process investigated.

The first phase will focus on studying the electrochemical ageing of representative MPs under controlled electrochemical conditions and different levels of electrical current. The work will be mainly carried out in **UT** under the supervision of Dr. B. Erable. Different electro-Fenton (EF) configurations will be investigated to generate mild oxidative conditions that selectively introduce oxygen-containing functional groups (e.g., carbonyl, hydroxyl, and carboxyl groups) onto polymer surfaces while promoting chain scission and the formation of lower-molecular-weight compounds from recalcitrant polymers. The resulting changes in polymer chemistry, crystallinity, hydrophilicity, particle size, and molecular weight distribution will be comprehensively characterized to establish quantitative relationships between electrochemical operating parameters and the extent of polymer ageing. In parallel, samples will be sent to UIB for advanced characterization of the low-molecular-weight compounds generated during the electrochemical pre-treatment. The aged microplastics and their transformation products will then serve as substrates for subsequent biodegradation and bioelectrochemical degradation experiments.

In the second phase, we will evaluate microbial accessibility and degradation kinetics of aged MPs using enriched consortia available at **UdG**, and isolated bacteria for PE and PP degradation provided by **UIB**. The use of pure isolated bacteria will enhance the full characterization of metabolic properties. High-throughput respirometry, oxygen consumption assays, and CO_2 evolution measurements will be used to quantify mineralization potential. MPs carbon incorporation into microbial cells will be assessed by $\partial^{13}C$ of biological carbon at **UIB** (under the supervision of Dr. J. Christie-Oleza). Community dynamics will be monitored through amplicon sequencing, enabling identification of taxa that respond positively to electrochemically aged substrates.

The third phase will integrate electrochemical stimulation and microbial activity within hybrid reactors, either using two-step processes or integrated column reactors with

immobilized biomass. The objective is to reduce the effect of EF conditions (low pH and production of ·OH radicals) on viability of cells. Transcriptomics will be used to identify genes and pathways activated during degradation after EF pretreatment. Metabolomics will track intermediates and reveal transformation routes. This mechanistic insight will clarify how electrochemical ageing and microbial metabolism interact to overcome the recalcitrance of PE and PP MPs.

The forth phase will assess environmental, regulatory, and practical implications of deploying electromicrobial systems in decentralized systems (house greywaters or WWTP effluents). This will include evaluating energy demand, operational stability, by-product formation, and compatibility with existing treatment units. Jointly, conceptual designs and models will be built for decentralized modules, supported by preliminary life-cycle analyses.

References of supervisors:

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- Bañeras L., Cabeza A., Perona-Vico E., Lopez-Abelarias M., Puig, S., De Wever, H. 2024. Microbial models for biocathodic electrochemical CO_2 transformation: A comprehensive review on pure cultures. Bioresource Technology Reports, 25: 101766

Required Skills and Competences:

Microbiology, Electrochemistry, Chemical Engineering, Environmental Engineering, Molecular Biology, -omics, Microbial Ecology

Master's degree(s) required or equivalent(s):

Master's degree in Chemical Engineering
Master's degree in Environmental Engineering
Master's degree in Chemical and Biochemical Processes
Master's degree in Water Science and Biotechnology
Master's degree in Advanced and Applied Microbiology
Master's degree in **Environmental Biotechnology**
Master's degree in Microbiology and Microbial Ecology
Master's degree in **Molecular biosciences** (and -omics, bioinformatics)

Co-supervision partnership framework

Co-supervision (3 supervisors): Yes
Dual degree PhD (France / Spain) where applicable and approved by the relevant institutions : Yes

Indicative mobility arrangements:
Hosting institution: 15 months (Universitat de Girona)
Co-hosting institution secondment 1: 9 to 12 months Université de Toulouse,
Co-hosting institution secondment 2: 6 to 9 months Universitat de les Illes Balears,
Non-Academic secondment: 3 months (to be defined)

Work conditions

Duration: 36 months
Indicative start date : September/ October 2027
Indicative gross salary:
~ €2,450/month + Statutory end-of-contract compensation in accordance with Spanish legislation estimated at ~ €80/months accrued during the contract and paid at the end of the contract. Estimated total annual gross salary: 30.600€
Eligible fellows with one or more dependent children may receive an additional family allowance of €50 per month**.**

Trainings: 2 ECTS equivalent of additional courses to be completed at the UdG. Offer available upon registration.

Mobility required : yes
Non-academic secondment : yes
Dual degree / Cotutelle possible : yes
Doctoral tuition fees and Visa fees: fully covered by TERRA-MED program
Social security: Full employer contributions covered by the recruiting entity.

Host institution	Co-host institution
The University of Girona (UdG) and the Molecular Microbial Ecology Group (gEMM) offer a solid, friendly, and well-equipped environment for PhD studies. UdG is a medium-sized university with strong research activity in environmental sciences, molecular microbiology, and biotechnology. The institute where gEMM is based provides modern laboratories, access to sequencing and analytical platforms, electrochemical equipment, and a collaborative atmosphere where microbial ecologists, chemists, and engineers work side by side. This makes it an ideal place for interdisciplinary projects. The Campus Montilivi (where gEMM is located) offer good student services	**The University of Toulouse** and the Laboratoire de Génie Chimique provide an outstanding environment for interdisciplinary doctoral research at the interface of environmental engineering, electrochemistry, microbiology, and process engineering. As one of France's leading research-intensive universities, the University of Toulouse offers access to a vibrant scientific community, advanced research infrastructures, and numerous opportunities for collaboration with academic, industrial, and international partners. The LGC is one of the largest French laboratories in chemical and environmental engineering, bringing together internationally recognised expertise in bioelectrochemical systems, biofilm engineering, environmental biotechnology, and process modelling. The Biofilm Engineering Group benefits from state-of-the-art electrochemical laboratories, microbial culture facilities, advanced analytical instrumentation, and numerical modelling tools, providing an ideal setting for experimental and mechanistic studies on electromicrobial processes.

and a welcoming international community. Girona itself is a very comfortable city for doctoral life: safe, walkable, and full of cultural activity. It offers a calm environment that helps maintain balance during intensive research periods. Moreover, Catalunya has a strong innovation ecosystem and many environmental and water-technology companies, creating opportunities for collaboration and applied research.	Located in the heart of Toulouse, the campus offers excellent research facilities, modern student services, and an active international community. Toulouse is one of Europe's major centres for science, engineering, and innovation, with a dynamic ecosystem connecting universities, research organisations, and high-technology industries. The city's high quality of life, rich cultural heritage, and proximity to both the Pyrenees and the Mediterranean coast make it an attractive destination for international doctoral candidates seeking an inspiring and stimulating research environment.
The University of the Balearic Islands (UIB) offers an outstanding environment for doctoral research in microbiology and environmental biotechnology. The Microbiology and Environmental Biotechnology Research Group (MICROBIAM) combines internationally recognised expertise in microbial ecology, biotechnology, and plastic biodegradation with access to state-of-the-art facilities for molecular biology, flow cytometry, advanced microscopy, genomics, proteomics, metabolomics, and isotope analyses. The group maintains a strong international network of collaborators, providing an excellent setting for multidisciplinary and high-impact research. Located on the Mediterranean island of Mallorca, UIB offers a modern campus, a vibrant international community, and immediate access to unique coastal and marine ecosystems. Combined with an exceptional quality of life and excellent international connectivity, UIB provides an inspiring environment in which to develop both scientifically and personally.	

Eligibility conditions

***Horizon Europe MSCA Mobility Rule*:** Researchers must not have resided or carried out their main activity (work, studies, etc.) in the country of the host organization (France or Spain depending on the employing institution) for more than 12 months in the 36 months immediately before the recruitment date – unless as part of a compulsory national service or a procedure for obtaining refugee status under the Geneva Convention.

***Horizon Europe MSCA Eligibility Criteria*:** Applicants must be eligible for enrolment in a doctoral programme at the employer institution and must not already hold a doctoral degree at the date of recruitment.

Applicants who do not fulfill the Mobility Rule and the Eligibility Criteria WILL NOT be considered for the research position.

***Language requirements*:** Applicants must demonstrate sufficient proficiency (B2) in English to successfully conduct doctoral research and participate in the TERRA-MED training programme.

For more information on this call for candidates see our website here and the guide for applicants here.

APPLY HERE BY Decembre 31st 2026

Administrative Contact

TERRA-MED Programme Office (only for general administrative questions and redress demands. Any research-related question must be addressed to the supervisors by email, see second page)

Email: terramed@euroregio-epm.eu