TERRA-MED PhD PROGRAM- Marie Skłodowska-Curie Action

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)

Reference of the thesis project: **UdG4**	**Title of the thesis project** **Microbes, Algae, Fungi and Membranes: Engineering the Next Generation of Net-Positive Water Reuse**
Host institution: University of Girona	**Co-supervision / co-host institution:** University of Montpellier
Country Spain	**Country** France
Host Research Unit: Laboratory of chemical and environmental engineering (Lequia). https://lequia-udg.com/	**Co-host Research Unit:** Institut Européen des membranes (IEM) IMemEau team: Intensification of membrane processes for water treatment
Name of the first co-supervisor Gaetan Blandin **:**gaetan.blandin@udg.edu	**Name of the second co-supervisor** Geoffroy lesage**:** geoffroy.lesage@umontpellier.fr
Doctoral School: Doctoral Programme in Water Science and Technology	**Doctoral School:** ED GAIA
Research field(s) Production technology, process engineering : Environmental engineering, e.g. sustainable design, waste and water treatment, recycling, regeneration or recovery of compounds, carbon capture & storage : Engineering of biomaterials, biomimetic, bioinspired and bio-enabled materials ; Environmental biotechnology and bioengineering : Biomass production and utilization, biofuels	
Keywords Membrane bioreactor; biological processes; water reuse; low energy; resource recovery	

Description of the research project

Context and Rationale

What if wastewater was no longer a waste, but a source of clean water, energy and valuable resources? In Mediterranean regions increasingly exposed to water scarcity, this question is particularly urgent. Agriculture consumes around two thirds of available water, while large volumes of urban wastewater are still treated through energy-intensive processes before being discharged. Transforming wastewater treatment from a "remove and discharge" approach into a circular system for water reuse, energy production and resource recovery could therefore become a key solution for a more resilient Mediterranean future.

Two main limiting factors are still to be overcome to ensure safe water reuse for irrigation:

- Safe water production free of main contaminants and allowing the elimination as well of contaminants of emerging concerns like micropollutants or microplastics.
- Low costs and low energy treatment chains to allow for affordable and sustainable use of water for irrigation

The proposed project aims at developing a new and integrated system allowing for low costs production of safe water through the combination of membrane systems and multiple biological processes. The objective is to produce water free of contaminants fitting with agriculture needs and transform pollutants (organic matter, nitrogen and phosphorous) into energy and biostimulants.

Existing schemes for water reuse are already existing and rely on biological and membrane processes for high quality water production. Biological processes like anaerobic digestion have emerged to produce biogas and move toward energy neutral systems but tackle only part of the pollution (organic matter mostly). A typical hybridization of membrane system and anaerobic digestion is the anaerobic membrane bioreactor (AnMBR) which allows in one step to produce high quality water and transform organic matter into biogas. Research already conducted in both research groups (Lequia and IEM) have demonstrated that with granular biomass incorporated into an AnMBR combined with various types of membranes could allow for sustainable operation of the system. However, state-of-the-art membrane processes remain energetically expensive for agriculture water reuse. Moving toward the implementation of low-cost membrane systems operated under minimal pressure (gravity driven) and/or using end-of-life membrane would promote the circularity of the integrated system.

AnMBRs efficiently convert organic matter into biogas, but they leave behind nutrients and emerging contaminants that still limit safe water reuse. This opens the door to a powerful biological complementarity: microalgae can capture residual nitrogen and phosphorus, while fungi offer promising pathways for the removal of more recalcitrant and emerging

contaminants. By combining bacteria, microalgae and fungi, wastewater treatment could evolve from a single-purpose process into a multifunctional biorefinery capable of simultaneously producing clean water, renewable energy and valuable bioproducts such as biostimulants. Surprisingly, this combination has never been fully explored. This PhD aims to make it happen.

Objectives:

The objective of this research is to integrate and optimize various potentially complementary biological processes (anaerobic digestion, microalgae, fungus) and membrane processes toward a net energy and safe water reuse integrated solution.

The following key research questions will be addressed:

- What would be the performance of multistage biological processes for pollution removal and energy/biostimulants production (removal and valorization of organic matter, nitrogen, phosphorus and emerging contaminants)?
- Could they be integrated in one step and are there any symbioses expected from these processes or better operate in multistage to avoid contamination and a more stable process?
- What would be the benefits/limitations from hybridizing and coupling various biological processes (synergies, biological preferential growth…)?
- Could recycled membranes operated in gravity-driven mode be integrated into membrane bioreactors to promote low cost and circular solutions?

Expected Results:

- Development of integrated process for production of high-quality safe water for reuse
- Development of a process with net-zero energy and sustainable valorization of side products
- Proof-of-concept of a new multifunctional wastewater biorefinery combining bacteria, microalgae, fungi and membranes to maximize water reuse, energy recovery and bioproduct generation
- Publication of 3 research articles in international high-impact (Q1) journals

Work plan:

The PhD will be structured into three complementary work packages, progressively moving from individual process development to biological integration, pilot-scale validation and sustainability assessment. The co-supervision between LEQUIA (University of Girona) and IEM (University of Montpellier) will be central to the project, allowing the doctoral candidate

to benefit from complementary expertise in biological wastewater treatment, membrane processes, anaerobic membrane bioreactors and process intensification.

Work Package 1 - Development of the individual building blocks and first integration steps - Year 1 - LEQUIA, University of Girona

Task 1.1 – State of the art, research framework and experimental strategy (Months 0–3)
A comprehensive literature review will be conducted on anaerobic membrane bioreactors, granular biomass systems, microalgae- and fungi-based wastewater treatment, membrane recycling and low-energy membrane operation. Particular attention will be paid to the respective transformation pathways of organic matter, nitrogen, phosphorus and emerging contaminants, as well as to possible synergies and incompatibilities between the different biological processes. This task will lead to the definition of the experimental strategy, analytical framework and key performance indicators for the whole PhD.

Task 1.2 – Development and optimization of microalgae- and fungi-based treatment processes (Months 3–12)
Laboratory-scale systems will be developed for the cultivation and stable operation of selected microalgae and fungi under wastewater treatment conditions. The candidate will assess their capacity for nutrient recovery, contaminant removal and production of potentially valuable biomass or bioproducts. Operating conditions such as hydraulic retention time, loading rate, light conditions, biomass concentration and wastewater composition will be investigated to identify robust operating windows for subsequent integration with AnMBR effluents.

Task 1.3 – Integration and evaluation of recycled membranes in anaerobic membrane bioreactors (Months 3–12)
Recycled or end-of-life membranes will be characterized and tested for their suitability in AnMBR applications. Their filtration performance, fouling behaviour, permeability, selectivity and long-term stability will be compared with conventional membranes. Particular attention will be paid to their potential use under low-pressure or gravity-driven operation in order to reduce membrane-related energy demand and improve the circularity of the overall treatment train.

Work Package 2 - Hybridization of biological processes and scale-up - Years 2-3 - Joint LEQUIA-IEM work, including an extended research stay at the University of Montpellier

Task 2.1 – Sequential integration of AnMBR, microalgae and fungi (Months 10–18, LEQUIA)
The first integrated treatment trains will be developed by combining the existing AnMBR platform with downstream microalgae- and/or fungi-based treatment units. The

performance of the different configurations will be assessed in terms of COD, nitrogen and phosphorus removal, emerging contaminant abatement, energy recovery and biomass or bioproduct generation. This task will identify the most promising process combinations and determine whether sequential treatment provides complementary removal mechanisms.

Task 2.2 – Pilot-scale validation at IEM Montpellier (Months 15–24)
During the research stay at IEM, the most promising configurations identified at LEQUIA will be transferred and validated using larger-scale AnMBR systems. This mobility period will enable the PhD candidate to move from proof-of-concept experiments to more representative operating conditions and to evaluate process robustness, membrane behaviour and treatment performance over extended operation.

Task 2.3 – Direct biological hybridization within the AnMBR (Months 20–24, IEM Montpellier)
Beyond sequential treatment, the feasibility of directly integrating fungi and/or microalgae within or in close coupling with the AnMBR will be investigated. The objective will be to determine whether biological synergies can emerge from co-existence or close interaction between anaerobic bacteria, microalgae and fungi, or whether competition and operational instability favour a multistage configuration. Microbial population dynamics, biomass distribution, contaminant removal, membrane fouling and overall process stability will be monitored.

Work Package 3 - Process consolidation, low-energy operation and sustainability assessment - Year 3 –LEQUIA, with IEM co-supervision

Task 3.1 – Integration of the optimized biological configuration with low-energy recycled membrane operation (Months 27–33)
The best biological configuration identified in WP2 will be combined with recycled membranes operated under gravity-driven or very low-pressure conditions. The objective will be to demonstrate an integrated treatment concept capable of simultaneously delivering high-quality water, contaminant removal, resource recovery and very low membrane energy demand.

Task 3.2 – Energy, resource recovery and sustainability assessment (Months 30–35)
A complete mass and energy balance of the integrated process will be established. Energy consumption will be compared with energy recovered through biogas production, while the recovery of nutrients, biomass and potential biostimulants will be quantified. Different process configurations will be compared using sustainability indicators in order to determine under which operating conditions the system can approach net-zero or potentially net-positive energy operation.

Task 3.3 – Process synthesis, publication and final PhD integration (Months 33–36)

The final task will consolidate the results obtained throughout the PhD into an integrated process concept for safe and circular water reuse. Scientific results will be synthesized into peer-reviewed publications, conference contributions and the doctoral manuscript. Particular attention will be given to defining the remaining scientific and technological barriers toward future pilot demonstration and implementation.

Role of the LEQUIA–IEM co-supervision

The co-supervision is designed to be more than a simple mobility requirement. LEQUIA will provide the main platform for developing and integrating microalgae-, fungi- and membrane-based treatment concepts, while IEM Montpellier will provide complementary expertise and larger-scale facilities for anaerobic and granular membrane bioreactors, membrane fouling, process intensification and scale-up. The approximately nine-month stay at Montpellier will therefore represent a major scientific milestone of the PhD, during which the candidate will transfer concepts developed at laboratory scale to larger systems, explore high-risk/high-gain biological hybridization strategies and work within a second internationally recognized research environment. This structure will give the candidate a genuinely international doctoral profile and strong expertise spanning environmental biotechnology, membrane engineering, process integration and resource recovery.

References of both supervisors:

Gaetan Blandin: Senior research, "Ramon y Cajal" fellow at University of Girona/Lequia

I completed a Joint PhD in chemical engineering at the University of New South Wales (Australia) and Ghent University (Belgium) in 2015. I have been working as researcher in private and public sector within the water field for more than 20 years. My research is dedicated to water processes associated with membrane technologies within the context of circular economy dealing for several applications (desalination, water reuse, nutrients recovery, membrane recycling) and topics (process validation and control, fouling and cleaning, module design /process modelling and optimization, fundamentals of mass transfer). I am also associate editor of Journal of Water process engineering.

Geoffroy Lesage: Associate Professor in Environmental and Chemical Engineering at University of Montpellier/IEM

I have been working at the interface of environmental and chemical engineering, biotechnology and membrane separation processes. I focus on the effective integration of these disciplines to develop innovative and sustainable solutions for achieving:

- High level removal of micropollutants and resource recovery for wastewater reuse application

- Energy production from anaerobic digestion of organic content of domestic wastewaters
- Insights into the complexity of dissolved and colloidal organic matter origin, fate and behavior in biological processes (aerobic and anaerobic) combined to membrane separation

The PhD will be developed closely in-between both supervisor and institution thanks to the proximity of both universities and existing shared work related to the topic:

- Olives, P.; Sanchez, L.; Lesage, G.; Héran, M.; Rodriguez-Roda, I.; Blandin, G. Impact of Integration of FO Membranes into a Granular Biomass AnMBR for Water Reuse. *Membranes* 2023, *13*, 265, doi:10.3390/membranes13030265.
- Vinardell, S.; Blandin, G.; Ferrari, F.; Lesage, G.; Mata-Alvarez, J.; Dosta, J.; Astals, S. Techno-Economic Analysis of Forward Osmosis Pre-Concentration before an Anaerobic Membrane Bioreactor: Impact of Draw Solute and Membrane Material. *Journal of Cleaner Production* 2022, 131776, doi:10.1016/j.jclepro.2022.131776.
- Sanchez, L.; Lesage, G.; Demiral, Y.O.; Rodriguez-Roda, I.; Heran, M.; Blandin, G. Revealing the Role of Supernatant and Granular Sludge Fractions on Granular Anaerobic Membrane Bioreactor Fouling. *Journal of Water Process Engineering* 2022, *49*, 103168, doi:10.1016/j.jwpe.2022.103168.
- Demiral, Y.O.; Ayol, A.; Lesage, G.; Le Beux, J.; Blandin, G. Forward Osmosis-Integrated Granular Anaerobic MBR: Enhancing Filterability and Reducing Mass Transfer Limitations. *Environ Sci Pollut Res* 2025, doi:10.1007/s11356-025-37324-0.

Required skills and competences:

Background in Process Engineering, Environment sciences, Membrane and water technologies
Outstanding track records during license/master degree and having completed 300 ECTS credits
Have not resided or carried out their main activity (work, studies, etc.) in Spain for more than 12 months in the 36 months immediately before their recruitment date (foreseen in September 2027)
Fulfill the requirements to enroll in UdG doctoral programme in water science and technology . Study > Access > Access to the doctoral programmes > Access requirements
Strong taste for research and lab work.
Critical and rigorous.
Strong communicational, sociable skills and taste for travelling
English skills (scientific English, work in an international team, exchange/mobility).

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

Master's degree in environmental science, environmental engineering, water technologies, applied biotechnologies or membrane science

Co-supervision partnership framework

Co-supervision (2 supervisors): Yes
Dual degree PhD (France / Spain) where applicable and approved by the relevant institutions : Yes/

Indicative mobility arrangements:
Hosting institution: 25 months (University of Girona, Spain)
Co-hosting institution secondment: 9 months (University of Montpellier, France)
Non-Academic secondment: 3 months (possibly at LBE Narbonne, France during last year of PhD)

Work conditions

Duration: 36 months
Indicative start date : September 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: -
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) is one of the main economic and cultural drivers of the province of Girona, located in the North East of Catalonia (Spain). With 15.800 students in last academic term, UdG has 3 university campuses, 13 research institutes and 1 doctorate school with 14 doctorate programmes (one focused on water resources). The selected candidate will join the Laboratory of Chemical and Environmental Engineering (LEQUIA), a multidisciplinary research group founded in 1993 and renowned for its work within the water sector. The group has a multidisciplinary team of 40 people, including chemists, biologists, biotechnologists, environmentalists, engineers, computer scientists, and political scientists. Current research lines include: 1) innovative processes of potabilization and (waste) water treatment; 2) gas treatment	The University of Montpellier offers a highly stimulating international research environment in one of Europe's most dynamic regions for water, environmental and membrane sciences. The PhD candidate will be hosted at the Institut Européen des Membranes (IEM), a leading research institute dedicated to membrane materials and processes, and will join the IMemEau team, which focuses on the intensification of membrane processes for water treatment. The research environment strongly promotes interdisciplinary work at the interface of process engineering, environmental biotechnology, membrane science and resource recovery. Beyond research, Montpellier offers an exceptional quality of life: a vibrant and international student city close to the Mediterranean Sea, combining a rich cultural

and carbon dioxide bioconversion, and 3) digitalisation and application of artificial intelligence to water cycle.	life, outdoor activities and an attractive Mediterranean lifestyle. This makes Montpellier an inspiring environment to conduct ambitious research while enjoying an excellent work–life balance.

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