UNIVERSIDAD DE ALMERÍA

Training in Microalgae Related Industrial Processes

JULY 06 - JULY 17 | 7,5 ECTS | 50 HOURS

A SEA OF KNOWLEDGE

STUDY ABROAD

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Introduction

Microalgae biotechnology has emerged as a strategic field at the intersection of chemical engineering, biotechnology, and environmental sciences, offering innovative solutions to some of today's most pressing global challenges, including climate change mitigation, sustainable food and feed production, wastewater treatment, and the development of bio-based products. Microalgae are highly efficient photosynthetic microorganisms capable of converting light, carbon dioxide, and nutrients into valuable biomass rich in proteins, lipids, carbohydrates, pigments, and bioactive compounds. Their versatility has positioned them as key building blocks of the circular bioeconomy, with applications ranging from biofuels and bioplastics to biostimulants, nutraceuticals, and environmental services.

The industrial deployment of microalgae, however, requires an integrated understanding of biological principles, reactor engineering, process control, and downstream processing. Key concepts include light capture and utilization, photosynthetic efficiency, mass and heat transfer, photobioreactor (PBR) design, monitoring and control strategies, harvesting technologies, and techno-economic and sustainability assessment. Bridging the gap between laboratory research and large-scale implementation remains one of the main challenges, demanding interdisciplinary training that combines theory, experimentation, modelling, and real industrial case studies.

In this context, the University of Almería (Universidad de Almería) offers a uniquely strong ecosystem for advanced training in microalgae-related industrial processes. Located in one of Europe's most favourable regions for solar-driven bioprocesses, the University hosts internationally recognised research groups and pilot-scale infrastructures dedicated to microalgae cultivation, photobioreactor engineering, and biorefinery concepts. Facilities

such as the CIESOL and SABANA platforms, together with close collaboration with industrial partners in water treatment, biotechnology, and agriculture, enable hands-on exposure to real operating systems.

This course builds on the University of Almería's long-standing leadership in microalgae research and technology transfer, providing participants with a comprehensive, application-oriented perspective that connects fundamental knowledge with industrial practice and prepares them to contribute effectively to the next generation of sustainable bioprocesses.

Coordinator

Francisco Gabriel Acién Fernández

Main Goals

- Provide a solid scientific and engineering foundation in microalgae-based processes, covering key concepts such as photosynthesis, light utilization, growth kinetics, strain selection, and the influence of environmental and operational variables on productivity
- Develop practical and analytical skills for the design, operation, and optimization of microalgae cultivation systems, including photobioreactors, monitoring and control strategies, and pilot-scale experimentation
- Train participants in downstream processing and biorefinery concepts, enabling the evaluation and selection of appropriate harvesting, processing, and valorization routes to obtain high-value products in a sustainable manner
- Enhance the capacity to assess techno-economic and environmental performance of microalgae-based industrial processes, integrating life cycle assessment, cost analysis, and scalability considerations to support decision-making in real industrial and environmental contexts

Contents

Module A: Biology and fundamentals of microalgae cultivation

Introduction to the biological, physiological, and biochemical principles governing microalgae growth. The module covers photosynthetic mechanisms, growth kinetics, nutrient uptake, and the influence of environmental factors such as light, temperature, pH, and dissolved gases on biomass productivity and composition.

Module B: Photobioreactor design and operation

Engineering fundamentals of microalgae cultivation systems, including open and closed photobioreactors. Topics include reactor configurations, hydrodynamics and mixing, light distribution, gas–liquid mass transfer, and thermal management, with examples from laboratory and pilot-scale installations.

Module C: Monitoring, modelling and process control

Principles and tools for monitoring and controlling microalgae production systems. This module introduces sensors, data acquisition, modelling approaches, and control strategies to optimize productivity, stability, and resource efficiency under variable operating conditions.

Module D: Harvesting and processing of microalgae biomass

Overview of downstream processing technologies, including harvesting, thickening, dewatering, and cell disruption. The module introduces biorefinery concepts for the extraction and fractionation of valuable compounds, with emphasis on efficiency, energy demand, and product quality.

Module E: Techno-economic and sustaniability assessment

Methods for evaluating the economic viability and environmental performance of microalgae-based processes. The module covers basic techno-economic analysis, life cycle assessment, and sustainability indicators, supporting the comparison of alternative process routes and scale-up scenarios.

Module F: Applications, commercialisation and marketing of microalgae-based products and services

Overview of current and emerging applications of microalgae, including food and feed ingredients, biostimulants and biopesticides, wastewater treatment and nutrient recovery, CO_2 capture, bio-based materials, and energy products. The module addresses market drivers, regulatory frameworks, certification, business models, and value-chain integration, highlighting pathways for commercial deployment and technology transfer.

Methodology

The course adopts an integrated and practice-oriented methodology designed to connect scientific fundamentals with real industrial and research applications in microalgae biotechnology. Lectures provide the conceptual framework, introducing key biological, engineering, and sustainability principles that underpin microalgae-based processes. These sessions are delivered by experienced academic staff and invited experts, ensuring exposure to both state-of-the-art research and industrial practice. In-lab sessions form a core component of the course, allowing participants to work directly with microalgae cultures, photobioreactors, and analytical tools. Students will carry out experimental measu-

rements related to light utilization, growth performance, harvesting, and processing, gaining hands-on experience in data collection, interpretation, and troubleshooting under realistic operating conditions. Academic visits to specialised research facilities enable participants to observe pilot-scale and demonstration systems in operation, complementing laboratory work and illustrating scale-up challenges. These visits highlight how fundamental concepts are translated into engineered systems. Company visits provide direct contact with industrial stakeholders involved in microalgae-based products and services, such as wastewater treatment, biostimulants, and bio-based materials. Through these visits, participants gain insight into market requirements, operational constraints, and innovation pathways. Talks and seminars by researchers, engineers, and industry professionals foster discussion on emerging trends, regulatory aspects, and future opportunities within the bioeconomy. Under "others", the course includes computer-based simulations, modelling exercises, and basic techno-economic and sustainability analyses. These activities help participants integrate experimental data with digital tools, strengthening their ability to evaluate, optimize, and design microalgae processes from a systems perspective.

Requirements

This course is primarily intended for graduate students, PhD candidates, and early-career professionals with a background in science or engineering. Applicants should hold, or be in the final stages of completing, a degree in disciplines such as Chemical Engineering, Biotechnology, Biochemistry, Biology, Microbiology, Environmental Engineering, or related fields. A basic understanding of mass balances, reaction kinetics, and biological processes is recommended, although advanced prior knowledge of microalgae is not mandatory. Participants are expected to have a personal laptop computer to take part in modelling, simulation, and data analysis activities. The working language of the course is English, and a good command of written and spoken English is required. Prior to the course, selected scientific articles and technical notes will be provided for preparatory reading to ensure a common baseline of knowledge among participants

Academic Visits & Networking

This course provides several professional visits to scenery and companies in the sector located in the province of Almeria. We will also carry out training workshops and professionals from the sector will be invited, who will share their experiences with students through informative talks. Scheduled academic and professional visits will give real opportunities to build contact networks.

Networking is promoted through expert talks, technical discussions, and informal meetings during visits, fostering interaction with researchers, engineers, and industry professionals and opening pathways for future collaboration.

SABANA Demonstration Platform

Operated in collaboration with the Universidad de Almería, where participants will explore pilot-scale raceway ponds, tubular and thin-layer photobioreactors under outdoor conditions. The visit focuses on scale-up strategies, monitoring and control, and operational challenges in microalgae production.

CIESOL Research Centre

A leading facility in solar energy and bioprocess integration, to understand how renewable energy, thermal management, and advanced monitoring are coupled with microalgae systems.

Biorizon Biotech

Dedicated to the industrial production of biostimulants and biopesticides from microalgae, where participants will learn about downstream processing, formulation, quality control, and regulatory aspects.

Aqualia

Will showcase wastewater treatment concepts based on microalgae, highlighting nutrient recovery, circular economy approaches, and integration with existing water infrastructure.

Chlydro

Focusing on innovative systems for CO_2 capture from air using microalgae.

Assessment

The evaluation of the course is based on a continuous and balanced assessment strategy, designed to reflect both the acquisition of theoretical knowledge and the development of practical and analytical skills.

- Final written exam (40%): An individual assessment covering the core concepts addressed in the lectures, including microalgae biology, photobioreactor engineering, process control, downstream processing, and sustainability analysis. The exam evaluates conceptual understanding and the ability to apply knowledge to practical scenarios.

- Laboratory and practical reports (40%): Participants will prepare short written reports based on laboratory sessions, pilot-scale activities, simulations, and technical visits. These reports will assess data analysis, interpretation of results, and the capacity to critically evaluate process performance and limitations.

- Attendance and active participation (20%): Regular attendance is mandatory. Active involvement in lectures, laboratory work, academic and company visits, discussions with experts, and group activities will be considered as part of the final grade.

This assessment structure ensures that students are evaluated not only on theoretical proficiency but also on practical competence, engagement, and critical thinking, in line with the applied and interdisciplinary nature of the course.

Lecturers

Francisco Gabriel Acién Fernández

Professor of Chemical Engineering at the Universidad de Almería and academic coordinator of the course. He is an internationally recognized expert in microalgae biotechnology, photobioreactor design, process control, and scale-up of microalgae-based systems. His research integrates biological fundamentals with advanced engineering, modelling, and techno-economic analysis. He has coordinated and participated in numerous national and European research projects and has extensive experience in industrial collaboration and technology transfer. He has authored a large number of high-impact scientific publications and has long-standing experience in postgraduate and doctoral training in microalgae-related processes.

José María Fernández

Professor at the Universidad de Almería with expertise in microalgae biology and cultivation fundamentals. His teaching and research focus on cellular physiology, photosynthesis, and the influence of environmental factors on microalgal growth and productivity. He contributes to the course by providing the biological foundations required to understand microalgae-based industrial processes, linking cellular behaviour with process performance.

José Luis Guzmán

Professor at the Universidad de Almería specialising in modelling, automatic control, and optimisation of bioprocesses. His research focuses on advanced control strategies, data-driven approaches, and artificial intelligence applied to microalgae cultivation systems. In the course, he addresses monitoring, modelling, and control of microalgae-related processes, highlighting the role of digital tools in improving productivity, stability, and resource efficiency.

Enrique Rodríguez Miranda

Professor at the Universidad de Almería with extensive experience in photobioreactor operation and pilot-scale experimentation. His work focuses on mass transfer, hydrodynamics, and performance analysis of outdoor microalgae cultivation systems. He contributes applied know-

ledge on reactor operation, scale-up challenges, and interpretation of experimental data from pilot and demonstration facilities.

Tomás Lafarga

Postdoctoral researcher at the Universidad de Almería, specializing in microalgae biorefineries and downstream processing. His research addresses the recovery and valorization of microalgae biomass into food, feed, and bio-based products. Within the course, he contributes to topics related to harvesting, processing, and sustainable valorization strategies.

Cintia Gómez

Postdoctoral researcher at the Universidad de Almería with expertise in microalgae harvesting, processing, and quality assessment. Her work focuses on improving efficiency and sustainability of downstream operations. She contributes to laboratory and applied sessions related to biomass recovery and processing technologies.

Ainoa Morillas

Postdoctoral researcher at the Universidad de Almería, working on microalgae cultivation, process optimization, and experimental evaluation at laboratory and pilot scale. Her contribution focuses on cultivation performance, experimental methodologies, and interpretation of operational data.

Martina Ciardi

Postdoctoral researcher at the Universidad de Almería with expertise in environmental biotechnology and microalgae-based wastewater treatment. Her work links microalgae cultivation with circular economy and environmental applications. She contributes applied perspectives on integrating microalgae systems into environmental and resource recovery processes.

Silvia Villaró

Postdoctoral researcher at the Universidad de Almería involved in applied microalgae research, including cultivation, processing, and integration with environmental and industrial systems. Her contribution supports practical training activities and applied case studies.

Zouhayr Arbib

R&D Manager at Aqualia, specialising in microalgae-based wastewater treatment and nutrient recovery technologies. His work focuses on the integration of microalgae systems into existing water treatment infrastructures and their operation at pilot and industrial scales. He contributes industrial case studies addressing operational constraints, scalability, and real-world implementation.

Joaquín Pozo

R&D Manager at Biorizon Biotech, with expertise in the industrial production of microalgae-based biostimulants and biopesticides. His experience covers scale-up, downstream processing, quality control, and regulatory aspects. He provides an industry-oriented perspective on market-driven process design and product development.

Jesús Ruiz

Professor at the Universidad de Cádiz, specializing in biochemical and environmental engineering. His research includes bioenergy, bioprocesses, and sustainable integration of biological systems. He contributes broader perspectives on bioprocess engineering and sustainability.

Vítor Verdelho

Secretary General of the European Algae Biomass Association (EABA) and internationally recognized expert in the algae sector. His professional activity focuses on market development, policy frameworks, and international coordination of algae-related initiatives. His lecture provides a global overview of the algae sector, addressing worldwide markets, value chains, regulatory trends, and future opportunities for microalgae and macroalgae.

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