# AQUAERA



Turning urban wastewater into clean water and renewable energy in an era of increasing water stress

Water4All
Water security for the planet

Coordinated by Early Career Researcher

## Abstract

Access to safe and clean water is a fundamental human right, recognised by the United Nations (UN) as a critical principle for the protection of human and environmental health. The increasing scarcity of safe drinking water, particularly in water-stressed regions, poses a significant threat to global water security. AQUAEra develops innovative solutions to improve water quality by addressing the growing presence of organic micropollutants (OMPs) in urban wastewater. These contaminants, including pharmaceuticals, personal care products, and industrial chemicals, are increasingly detected in aquatic environments and are often insufficiently removed by conventional urban wastewater treatment plants (UWWTPs). Their persistence in water systems raises concerns for ecosystem health, water reuse, and long-term environmental sustainability.

AQUAEra proposes an integrated treatment concept based on advanced oxidation processes and solar-driven photocatalysis capable of efficiently degrading OMPs in urban wastewater. By using visible-light-responsive photocatalysts, the system harnesses solar energy to drive pollutant degradation, enabling sustainable and energy-efficient water treatment. A key technological innovation is the development of a light-driven oscillatory flow reactor (Photo-OFR), designed to enhance mass transfer, light distribution, and reaction efficiency. This intensified reactor configuration allows photocatalysts to operate under continuous-flow conditions, improving scalability and facilitating future integration into wastewater treatment infrastructures. Immobilised photocatalysts on structured supports further enhance operational stability while eliminating complex catalyst recovery processes.

To improve the efficiency and reliability of the treatment process, AQUAEra integrates digital tools based on machine learning and hybrid modelling. These approaches analyse experimental data and identify optimal operating conditions for pollutant degradation under variable wastewater compositions. Data-driven optimisation enables improved process control, supporting the development of robust and adaptable treatment technologies.

In parallel, the project advances the monitoring of organic micropollutants and their transformation products. High-resolution analytical methods are applied to track contaminants before and after treatment, while ecotoxicological assessments evaluate the potential biological effects of treated wastewater. This integrated monitoring strategy ensures that treatment processes not only remove pollutants but also reduce potential environmental risks.

Beyond improving water treatment efficiency, AQUAEra explores the potential of wastewater as a resource within the circular economy. Organic compounds present in wastewater can act as electron donors in photocatalytic processes, enabling the simultaneous generation of renewable hydrogen as a clean energy carrier. This dual functionality contributes to energy-neutral wastewater treatment plants and supports the transition towards sustainable water-energy systems.

Through this multidisciplinary approach, AQUAEra contributes to safer water systems, improved pollutant monitoring, and innovative treatment technologies that support the circular use of water resources. By strengthening collaboration between research institutions across Europe, the project advances knowledge and solutions aligned with the objectives of the Water4All Partnership and contributes to the United Nations Sustainable Development Goals, particularly SDG 6 (Clean Water and Sanitation), while also supporting SDG 7 (Affordable and Clean Energy) and SDG 12 (Responsible Consumption and Production).

**KEYWORDS**

urban wastewater treatment, water quality protection, organic micropollutants, contaminants of emerging concern, advanced oxidation processes, solar-driven purification, water reuse, circular water systems, water-energy nexus, transformation products analysis, ecotoxicity assessment

## Project coordinator

**Maria José FERNANDES SAMPAIO** - FACULTY OF ENGINEERING OF UNIVERSITY OF PORTO - PORTUGAL

## Project partners

- KATHOLIEKE UNIVERSITEIT LEUVEN - BELGIUM
- SPANISH NATIONAL RESEARCH COUNCIL - SPAIN
- NATURE RESEARCH CENTRE - LITHUANIA
- NORWEGIAN UNIVERSITY OF SCIENCE AND TECHNOLOGY - NORWAY

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## Contact

**Maria José FERNANDES SAMPAIO**
mjsampaio@fe.up.pt