Water4All
Water security for the planet

FUNDED PROJECTS BOOKLET
WATER4ALL 2024 JOINT TRANSNATIONAL CALL

Water for Circular Economy

Co-funded by
the European Union

CONTENTS

INTRODUCTION

The Water4All partnership, launched in 2022 under the EU Horizon Europe programme for research and innovation, aims to strengthen research and innovation across the entire water value chain in Europe and beyond. Its vision is to boost systemic transformations across the research–innovation pipeline by fostering collaboration between problem owners and solution providers, thereby contributing to long-term water security for all.

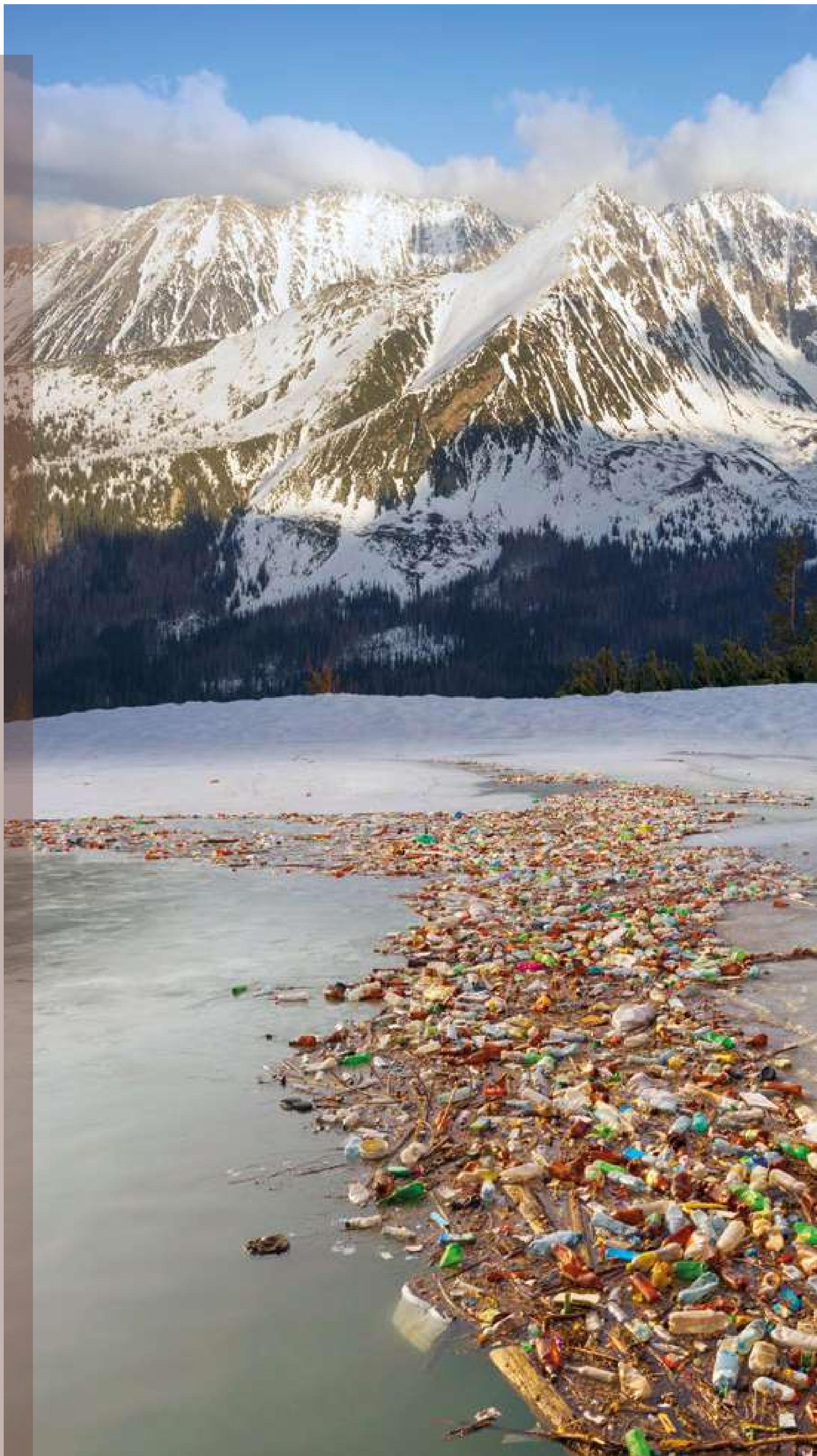
As part of its implementation, Water4All supports a series of annual Joint Transnational Calls (JTCs), pooling national and regional funding resources from ministries, authorities and funding organisations, with co-funding from the European Commission. These calls are designed to strengthen European and international collaboration in water-related research and innovation, and to generate and share high-quality knowledge, data, tools and solutions addressing key societal and environmental challenges related to water.

The 2024 Joint Transnational Call was implemented by 34 research and innovation funding organizations from 29 countries, with the financial support from the European Commission. At the end of the selection process, 27 excellent RD&I projects were selected for funding with total funding of around 28 million Euro.

OBJECTIVES OF THE 2024 JOINT TRANSNATIONAL CALL

The 2024 Joint Transnational Call focuses on the role of water in the transition towards a Circular Economy, recognising water as both a critical natural resource and a key enabler of sustainable economic and societal development. Within a Circular Economy framework, water management must move beyond linear use patterns towards approaches that avoid waste, improve efficiency, support reuse, and enable resource recovery while protecting ecosystems.

In alignment with the European Green Deal, the Circular Economy Action Plan and relevant EU and international water policies, the 2024 Joint Transnational Call aims to deliver innovative solutions that enhance water circularity, increase water resource efficiency, optimize allocation and use of water, and promote resilient and sustainable practices in water-dependent sectors. The call also seeks to address economic, social, regulatory and governance barriers that may hinder the adoption and deployment of circular water solutions.



THEMES OF THE JOINT TRANSNATIONAL CALL

The 2024 Joint Transnational Call is structured around the overarching theme “Water for Circular Economy”. The funded projects address one or more of the following thematic areas:

Topic 1 Enhancement of water circularity in industries

This theme focuses on innovative approaches to reduce water consumption in industrial processes, enhance wastewater reuse, enable resource recovery and support the transition of industrial sectors towards circular economy models. It includes the development of advanced treatment, monitoring and control solutions, as well as operating concepts and metrics that support efficient, compliant and economically viable water cycle management.

Topic 2 Urban water circularity

This theme addresses the transformation of urban water systems to improve efficiency, resilience and circularity. Topics include the integration of centralized and decentralized treatment systems, nature-based solutions, rainwater harvesting, reuse schemes and innovative monitoring and risk management approaches supporting safe and sustainable urban water reuse.

Topic 3 Resource recovery and valorization

This theme aims at the recovery and valorization of valuable resources from wastewater, sludges, brines and sediments. It covers integrated technological and management approaches targeting nutrients, critical raw materials, energy and high-value products, as well as the assessment of their applicability, life-cycle performance and contribution to circular value chains.

Topic 4 Economic, environmental and social implications of water reuse and recovered products

This theme focuses on assessing the broader impacts of circular water solutions, including environmental effects on water bodies, economic feasibility, social acceptance and governance aspects. It includes the development of policy options, management strategies and regulatory frameworks that facilitate the integration of water reuse and resource recovery into existing water management systems.

ACE-WATER

CombiSonoPlasma Electrolysis for simultaneous organic pollutants degradation, H2 production, desalination, and CRM recovery from wastewater

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Abstract

Cathodic Plasma-Driven Solution Electrolysis (CPDSE) is a highly efficient method for hydrogen production and is considered one of the advanced oxidation processes (AOPs), enabling simultaneous treatment of wastewater contaminated with a wide range of organic pollutants, including aromatic compounds, dyes, solvents, surfactants, pesticides, and pathogenic microorganisms.
Hydrogen production via CPDSE exhibits significantly higher Faradaic efficiency, often surpassing conventional water electrolysis, depending on the organic pollutant concentration.
Recent integration of ultrasonication with CPDSE has demonstrated a double synergistic effect, reducing overall energy consumption by nearly 50%.
This combined CPDSE-ultrasound (US) process, called as CombiSono-Plasma® (CSP), has been successfully tested for the degradation of oil in hypersaline produced water originated from the oil extraction industry, achieving over 80% reduction in total organic carbon (TOC).

In collaboration with researchers from Poland, Italy, Hungary, and Denmark, the CSP-based eco-innovation is proposed for the treatment of tannery and textile wastewater.
The primary aim of the project is to advance the CSP process as an AOP for textile and tannery wastewater treatment, focusing on organic pollutant degradation, hydrogen production, desalination, and the recovery of critical raw materials (CRMs) such as Ni, Mg, Mn, B, Cu, and Sb. Concurrently, the process aims to reduce heavy metal concentrations, including Cr and Cd.
The research will investigate the relationship between process parameters, hydrogen production efficiency, and the effectiveness of wastewater treatment, while leveraging the CSP process for desalination and CRM recovery.
The project will culminate in an upscaled CSP reactor capable of processing 300 L/h of real textile and tannery wastewater, achieving simultaneous hydrogen production, desalination, and CRM recovery effect. Feasibility of the upscaled wastewater treatment system will be validated by LCA and techno-economic analysis.

The proposed project aligns with topics 1.2 and 3.1 of the Water4All call, focusing on developing innovative processes for wastewater treatment and reuse, as well as integrated approaches for recovering valuable resources (CRMs) and energy from wastewater. This innovative approach to wastewater treatment, hydrogen production, desalination and material recovery is expected to support the energy transition, circular economy principles, and wastewater reuse strategies.

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- BULKAI LTD - HUNGARY
- AALBORG UNIVERSITY - DENMARK

▶ Funding organisations

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KEYWORDS

organic pollutants, plasma electrolysis, sonication, hydrogen production, recovery of critical raw materials, desalination, wastewater valorization

AQUA-CLEAR

Advanced Cavitation for PFAS Treatment and Circular Water Management

Water4All
Water security for the planet

Abstract

Per- and polyfluoroalkyl substances (PFAS) are synthetic chemicals with highly stable carbon-fluorine bonds, making them exceptionally persistent in the environment. Due to widespread use over decades, PFAS are now prevalent across various ecosystems.
Effective removal requires treatment across diverse water sources, such as drinking water, wastewater, and leachate. To ensure lasting impact, it is crucial that such treatment approaches are holistic, targeting the extraction of PFAS from the entire water cycle and preventing their recirculation back into the environment.
However, there are currently no resource-efficient removal technologies that are realistic from a socio-economic point of view. Current methods are limited by low efficiency, high energy demands, reliance on harsh chemicals, and significant costs while they do not provide an actual destruction or mineralization of PFAS but only a transformation of PFAS from water to other media such as adsorbents or concentrated retentate that require further treatment such as incineration to avoid PFAS-emissions.
To overcome these challenges, there is a pressing need for innovative solutions that combine energy efficiency, economic feasibility, environmental sustainability, and adaptability across diverse water matrices and implementation scales. Among emerging technologies, cavitation-based methods stand out as a promising, sustainable, and environmentally friendly approach for PFAS treatment.

With this project, we aim to address the questions around PFAS degradation with various radicals and develop a new generation of Hydrodynamic Cavitation reactor (HC) to remove PFAS from various water matrices, which will be validated in pilot scale and then adapted for installation in the facilities of a company participating as a partner in the consortium.
The consortium will develop and optimize a next-generation HC reactors at a scale for PFAS degradation in various wastewater (WW) matrices by investigating key mechanisms, including radical generation during cavitation bubble collapse. A prototype will be designed, validated at pilot scale and adapted for installation at the facilities of Borçelik, the consortium's end-user.
The goal will be to use a novel bottom-up strategy to remove persistent micropollutants, and specifically PFAS, from municipal and industrial WW, DW (discharging wastewater) and other relevant WW matrices such as LL. By integrating HC with selected reagents (oxidants/reductants), we seek to create effective conditions for PFAS breakdown, protecting natural water sources and preserving long-term water quality.

The practical results and impacts of this project can contribute to the creation of modern and innovative infrastructure for water treatment, including WWTPs (wastewater treatment plants).
As new regulations such as the recently adopted urban wastewater treatment directive (UWWTD) require enhanced removal of micropollutants (Urban wastewater treatment directive (recast)), HC-technology deployment will help to comply with new EU policies.
The environmentally friendly technology presented in this project can offer a cost-effective solution with minimal impact on energy consumption and CO_2 emissions for WWTPs.

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KEYWORDS

geen processes,
PFAS removal, cavitation ,
hydrodynamic cavitation reactor,
wastewater treatment

AQUAERA

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

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).

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- NORWEGIAN UNIVERSITY OF SCIENCE AND TECHNOLOGY - NORWAY

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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

AQUAWISE

Advanced Pollutant Tracking and Resource Circularity in Water Systems

Water4All
Water security for the planet

Abstract

About 58% of surface waters in Europe have not yet achieved good chemical and ecological status. In line with the European Green Deal and the zero-pollution ambition, improved monitoring of emerging pollutants and more harmonised monitoring and reporting approaches are urgently required. Systematic assessment of contaminants allows stakeholders to identify pollution sources, assess ecosystem health and implement targeted remediation strategies. Maintaining water quality is also a fundamental principle of the circular economy, supporting sustainable resource management and the regeneration of natural systems.

AQUAWISE aims to address these challenges and enhance the resilience and sustainability of freshwater resources through a holistic, innovative and scalable approach for monitoring, detection, analysis and management of pollutants in freshwater bodies such as rivers, lakes and reservoirs. The project integrates advanced technologies including unmanned vehicle platforms, remote sensing, artificial intelligence and geospatial analysis to improve the monitoring and understanding of pollution dynamics in aquatic environments.

A key component of AQUAWISE is the monitoring and detection of surface water pollutants using multi-modal uncrewed vehicles operating in aerial, surface and underwater environments. These platforms are equipped with advanced sensors and innovative sampling systems capable of collecting environmental and water quality data across large spatial areas and at multiple depths. Their deployment allows improved coverage of aquatic environments and supports the rapid identification and tracking of pollution events.

The project also integrates Earth observation data, meteorological information and in-situ measurements to analyse pollutant behaviour and dispersion patterns. Artificial intelligence and machine learning techniques will support the identification, monitoring and classification of pollutants, (e.g., heavy metals, nutrients, and plastics). Predictive models will be developed to map pollutant pathways and generate high-resolution spatio-temporal information on water quality conditions. These tools will support authorities and water managers in making data-driven decisions for pollution control and water resource protection.

In addition to monitoring and analysis, AQUAWISE investigates circular economy opportunities related to water pollution management. The project evaluates the feasibility of recovering valuable resources from polluted waters and examines the economic and environmental benefits of integrating resource recovery within water management strategies. This perspective contributes to more sustainable water systems and supports the transition toward circular water use.

The AQUAWISE framework will be demonstrated and validated in three pilot sites selected for their diversity in environmental conditions and water management challenges, including a natural lake, a reservoir and a transboundary river system. These pilot cases will enable the testing of the developed technologies under real operational conditions and will demonstrate their scalability and transferability to other regions

Stakeholder involvement is a key component of the project. Water management organisations, public authorities, industry representatives and local communities will participate in consultations, workshops and knowledge exchange activities. Their engagement will ensure that the developed solutions respond to real operational needs and can support improved water governance.

Through its interdisciplinary approach, AQUAWISE contributes to the development of advanced tools and methodologies for monitoring and managing water pollution. The project supports European policies related to water quality, environmental protection and circular economy while promoting sustainable and resilient water management practices for the future.

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KEYWORDS

water pollution monitoring, circular water economy, unmanned vehicles, earth observation, AI, remote sensing, resource recovery, hydrological modelling, sustainable water management

AQUICIRC

Managed Aquifer Recharge for a Circular Water Future

Water4All
Water security for the planet

Abstract

Groundwater is a cornerstone of global water security, yet increasing pressures from overextraction, climate change, and contamination threaten its longterm sustainability. Managed Aquifer Recharge (MAR) offers a powerful naturebased solution to enhance groundwater availability while supporting circular water economies through the reuse of unconventional water sources. However, the growing presence of highly persistent and mobile contaminants of emerging concern (CECs)—including PFAS, pharmaceuticals, pesticides, and industrial organics—poses significant risks to MAR operations. AQUICIRC addresses this challenge by developing innovative, safe, and optimized MAR strategies across six diverse case study sites in Europe and Africa.

AQUICIRC brings together leading institutions from Tunisia, Italy, Spain, the Netherlands, Belgium, and South Africa to advance the scientific, technological, and operational foundations of MAR. The project integrates field monitoring, analytical chemistry, laboratory experiments, and advanced hydrogeological and reactive transport modelling to evaluate the fate and transport of CECs in aquifers recharged with treated wastewater, industrial effluents, and harvested rainwater. By comparing MAR systems ranging from infiltration basins and check dams to subsurface irrigation and direct injection, AQUICIRC generates crossregional insights into how hydrogeological settings, climate conditions, and recharge strategies influence water quality outcomes.

A key innovation of AQUICIRC lies in enhancing MAR treatment performance through permeable reactive materials and naturebased pretreatment systems, alongside the deployment of lowcost Internet of Things (IoT) sensors for realtime groundwater quality and level monitoring. These technologies will feed into predictive modelling frameworks that optimize MAR design for improved contaminant attenuation, increased storage efficiency, and prevention of seawater intrusion in coastal aquifers. The project also evaluates longterm risks associated with persistent CECs, addressing critical knowledge gaps that currently limit regulatory guidance and operational decisionmaking.

Through strong engagement with water utilities, municipalities, environmental agencies, and industry partners, AQUICIRC ensures that scientific advances translate into practical improvements in MAR management. Expected outcomes include optimized recharge strategies, improved risk assessment frameworks for CECs, enhanced modelling tools for water quantity and quality, and evidencebased recommendations for integrating unconventional water sources into regional water cycles. These results will support safer and more efficient water reuse, contributing to climate resilience, reduced pressure on freshwater resources, and progress toward SDG 6 (Clean Water and Sanitation) and SDG 14 (Life Below Water).

By leveraging transnational collaboration and knowledge exchange between Africa and Europe, AQUICIRC delivers added value that extends beyond individual case studies. The project strengthens capacity in regions with limited resources, informs policy debates in countries where MAR with treated wastewater is not yet permitted, and provides scalable, adaptable solutions for sustainable groundwater management worldwide. Through its multidisciplinary approach, AQUICIRC advances the state of the art in MAR and positions circular water systems as a cornerstone of future water security.

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- NATIONAL AGRONOMIC INSTITUTE OF TUNISIA - TUNISIA
- STELLENBOSCH UNIVERSITY - SOUTH AFRICA
- UNIVERSITY OF THE WESTERN CAPE - SOUTH AFRICA
- IO-THINGS - BELGIUM

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NWO - (THE NETHERLANDS) / MUR (ITALY) / AEI (SPAIN) / MHESR (TUNISIA) / DSI (SOUTH AFRICA) / VLAIO (BELGIUM)

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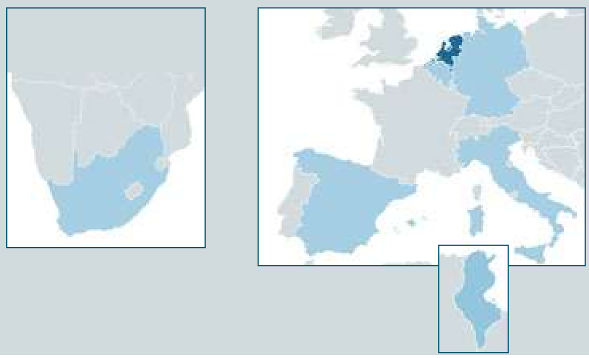

KEYWORDS

managed aquifer recharge (MAR), circular water economy, contaminants of emerging concern (CECs), PFAS, permeable reactive materials (PRM), groundwater quality, infiltration basins, direct injection, nature-based solutions (NBS), IoT groundwater monitoring, wastewater reuse, hydrogeological modelling, seawater intrusion prevention

AWARE

A water resource sustainability method

Abstract

The AWARE project will develop an innovative Life Cycle Sustainability Assessment (LCSA) methodology tailored specifically to Water Resource Recovery and Reuse (WRR&R) systems, aiming to improve the robustness, consistency, and comparability of sustainability assessments in the water sector. The project will establish clear and harmonized methodological rules aligned with existing international standards, while introducing targeted guidance to address the specific characteristics of circular water systems. Through this approach, AWARE will deliver a solid, knowledge-based tool to support policymakers and stakeholders in planning and implementing effective and sustainable water management strategies.

The proposed method will integrate the three dimensions of sustainability -environmental, economic, and social- by combining Life Cycle Assessment (LCA), Life Cycle Costing (LCC), and Social Life Cycle Assessment (S-LCA). Particular emphasis will be placed on the collection of primary data through interviews and questionnaires to capture diverse stakeholder perspectives. The economic analysis will include cost-benefit assessments to clarify treatment costs and improve user acceptance of WRR&R solutions, while the social assessment will examine impacts and benefits across the entire value chain, fostering more responsible and sustainable practices. This comprehensive approach will enable the identification and evaluation of key factors such as stakeholder awareness, market confidence, social acceptance, opportunities, drivers, and barriers influencing the uptake of WRR&R solutions.

The need for AWARE arises from the growing interest in the Water Circular Economy (WCE), which aims to mimic and restore the natural water cycle by transforming waste into resources. However, circularity alone does not necessarily lead to reduced environmental impacts, lower costs, or improved social outcomes compared to linear systems. Therefore, a holistic assessment of sustainability is essential. Although LCSA is a well-established methodology supported by international standards, its application in the WRR&R field remains limited and often produces non-comparable results due to inconsistent datasets, lack of transparency, and varying data quality.

AWARE addresses these challenges by tackling key sources of uncertainty, such as limited data availability for certain life cycle stages and the variability associated with local contexts and stakeholder-driven social data. By developing robust and sector-specific guidelines, the project will enhance the reliability, reproducibility, and practical relevance of LCSA studies.

Furthermore, AWARE is expected to foster wider adoption of LCSA in WRR&R, contributing to the achievement of the Sustainable Development Goals (SDGs) and the objectives of the Water4All partnership, and strengthening the role of integrated sustainability assessment as a key enabler of resilient and sustainable water resource management.

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- UNIVERSITY OF CAMPINAS - BRAZIL
- ISTANBUL TECHNICAL UNIVERSITY - TURKEY
- CATALAN WATER RESEARCH INSTITUTE - SPAIN

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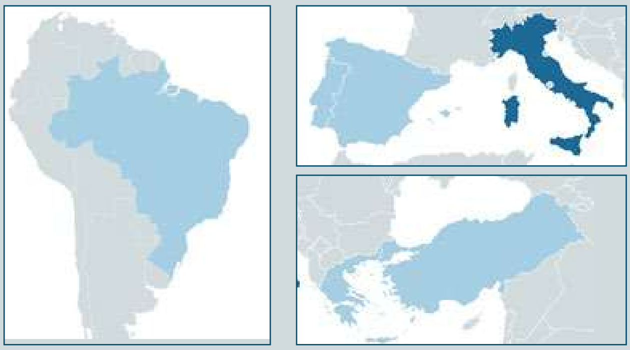

KEYWORDS

life cycle sustainability assessment,
water resource recovery and reuse,
life cycle assessment, life cycle costing,
social life cycle assessment,
circular water economy, water management.

C2C

From Contaminant to Commodity: Toward a Circular Economy for Arsenic in Groundwater

Water4All
Water security for the planet

Abstract

Millions of people in Europe rely on groundwater containing arsenic (As) levels above the WHO provisional drinking water guideline of 10 µg/L as their primary drinking water source. Groundwater treatment via As sorption to iron (Fe) oxides minimizes health impacts from As, but generates a concentrated As-loaded sludge by-product that is universally viewed as an environmental and economic burden. At the same time, As is experiencing a renaissance. The European Union classified As as a Critical Raw Material (CRM) in 2023 due to the role of metallic As(0) in materials needed for digital infrastructure and to transition to clean energy systems, such as high-speed electronics. The simultaneous requirements to remove As from groundwater, improve As-loaded waste management and create local sources of CRMs present a compelling opportunity to redefine carcinogenic As as a commodity.

The goal of this project, Contaminant to Commodity (C2C), is to develop a circular economy for As, thus maximizing the efficiency and sustainability of delivering low As drinking water, improving As-loaded waste management and recovering and valorizing CRMs. Eliminating the need for unsustainable As-loaded waste disposal practices, i.e., landfilling, sewer discharge or open disposal, ensures that improper management of waste from drinking water production does not perpetuate As contamination. Thus, this project contributes to water security in the long term and is consistent with multiple legislative goals adopted by the European Commission, including the 2020 Circular Economy Action Plan (CEAP) and the 2024 Critical Raw Materials Act (CRMA).

In C2C, we will apply an integrated approach to transform As in groundwater from an environmental burden to a valuable resource. To this end, we aim to:

- Characterize the structure and composition of As-loaded waste from different treatment plants across Europe;
- Identify structural properties of the waste that are most favorable for As extraction and recovery;
- Optimize reaction conditions to form As(0) from extracted aqueous As;
- Develop a novel method to create high-value As-bearing semi-conductors from upcycled As(0);
- Apply life cycle assessment to evaluate the human health and ecotoxicity impacts of As(0) upcycling; and
- Estimate the availability of groundwater resources with chemistry optimal for arsenic extraction and recovery based on project findings and continent-wide groundwater chemistry databases.

The knowledge and novel methods developed in this project will ensure a variety of outcomes across several sectors in Europe, namely: improved As-loaded waste handling at European waterworks, including identification of optimum sludge composition for As(0) production; the creation of sustainable sources of semiconductor raw materials, which will improve current semiconductor manufacturing practices in Europe; and more informed regulations regarding As-loaded waste disposal and management as well as new regulatory guidance to aid the Green Transition in Europe.

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KEYWORDS

groundwater chemistry,
arsenic treatment,
drinking water production,
critical raw materials, metallic arsenic,
advanced functional materials, semiconductors

CEPHAWA

PHA-cellulose composites with simultaneous water recovery to increase cellulose-processing circularity

Water4All
Water security for the planet

Coordinated by Early Career Researcher

Abstract

CEPHAWA develops a circular approach for cellulose-rich industrial wastewaters, with a particular focus on the pulp and paper sector. These streams are often costly to treat, yet they contain substantial amounts of cellulose and dissolved organic carbon that remain underused and represent a significant environmental challenge. Rather than viewing them as a disposal problem, CEPHAWA treats them as a resource for recovering both materials and water.

The project combines microbial process engineering, materials science, and water technology to convert cellulose-derived carbon into polyhydroxyalkanoates (PHAs), a family of biodegradable biopolymers.
In a first step, cellulose-rich streams are partially converted into carboxylates (C2-C8), which serve as substrates for PHA production. CEPHAWA explores two complementary biological routes for this step: aerobic heterotrophic microorganisms and purple non-sulfur bacteria. These routes offer different opportunities for carbon utilization, process robustness, and product formation, thereby broadening the design space for wastewater-based biopolymer production.
A second key innovation is the dual valorization of the cellulose fraction.

CEPHAWA uses them as a resource for carboxylates and as a structural component for the formation of PHA-cellulose composites. This opens a broader material design space, because the final properties depend on both the polymer and the fiber fraction. Cellulose fibers contribute structure, stiffness, and reinforcement, while PHAs provide the matrix and processability.

In addition, short-chain-length PHAs and medium-chain-length PHAs exhibit distinct material characteristics, ranging from stronger, more rigid to more flexible, more ductile behavior. By combining these dimensions, CEPHAWA aims to create in situ composites with tunable properties for various applications.

Beyond material production, CEPHAWA also addresses water circularity. By linking biopolymer synthesis with on-site water reuse, the project aims to reduce freshwater demand, lower wastewater loads, and decrease the overall environmental footprint of cellulose-processing industries. Techno-economic analysis, water-reuse scenarios, and application-oriented materials screening will identify the most promising implementation routes.

The project is closely linked to practice through industrial partners, which helps ensure that material development, application testing, and valorization routes remain relevant to real-world implementation. In this way, CEPHAWA bridges the gap between lab-scale innovation and industrial uptake, providing the evidence needed to support decision-making and policy discussions on circular water and materials strategies.

By bringing together expertise in microbial biotechnology, wastewater engineering, polymer science, and system assessment, CEPHAWA aims to deliver a practical platform for turning cellulose-rich wastewaters into valueadded biomaterials while supporting more circular water use in European industry.

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KEYWORDS

biopolymers, carboxylates, cellulose-rich wastewater, industrial wastewater valorization, PHA-cellulose composites, polyhydroxyalkanoates, pulp and paper industry, purple non-sulfur bacteria, water reuse

CIRC-WWTP

Increasing circularity of urban WWTP through valorisation of sewage sludge and advanced polishing of treated effluent

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Water security for the planet

Abstract

Urban wastewater treatment plants (WWTPs) are integral to modern cities, safeguarding public health and the environment by treating sewage before discharge.. Traditionally, WWTPs operate on linear models, focusing on wastewater purification and waste disposal rather than resource recovery.
However, with the growing emphasis on sustainable development and circular economy principles, there is a paradigm shift toward viewing wastewater and its by-products as valuable resources.

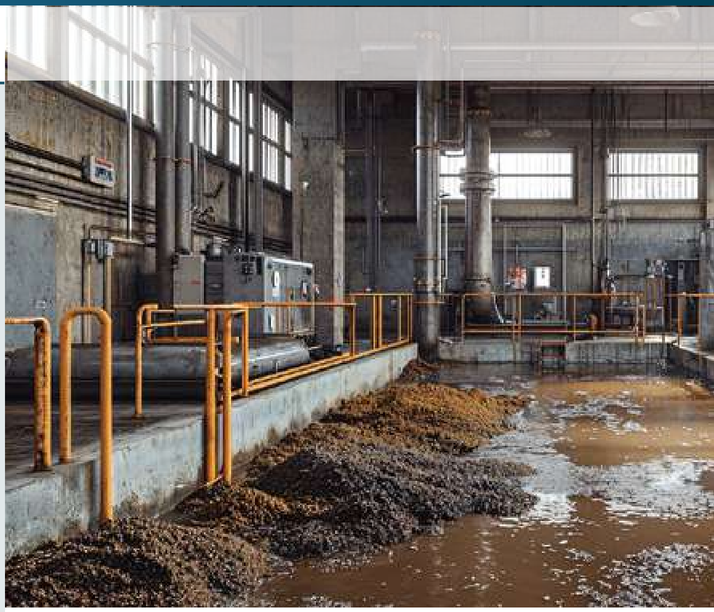
The CIRC-WWTP project aims to increase the circularity of urban WWTPs through two main strategies:

- (1) valorising sewage sludge to produce bioenergy, biofertilizers, medium-chain fatty acids (MCFAs), and biochar; and
- (2) facilitating the non-potable reuse of urban wastewater through advanced polishing of treated effluent.

This will be achieved through specific objectives, including:

- (1) demonstrating the use of electron beam technology for cost-effective sludge treatment, effluent disinfection, removal of emerging contaminants, and direct production of biofertilizer from sewage sludge;
- (2) achieving enhanced biogas production from sewage sludge using electron beam pretreatment;
- (3) enhancing MCFAs production and nutrient recovery from sewage sludge using electron beam pretreatment combined with electrodialysis technology;
- (4) producing biochar from residual solid sludge for use in soil amendments and effluent polishing;
- (5) developing integrated electron beam and biochar filter technology for advanced polishing of WWTP effluent for non-potable reuse; and
- (6) assessing the applicability of recovered materials for various uses through regulatory analysis, LCA assessment, and techno-economic analysis.

By integrating innovative technologies from each partner—such as electron beam technology, MCFAs production, bio-electrodialysis technology, biochar production, and advanced effluent polishing—this project addresses shared challenges in the partners' countries (Ireland, Poland, and Sweden).
These challenges include improving biogas yields, enhancing platform chemical production from waste sludge, producing biochar for soil enhancement, and enabling wastewater reuse. The collaborative approach facilitates the exchange of expertise, resources, and best practices, fostering innovation and accelerating the adoption of circular economy principles in urban wastewater treatment plants. This synergy not only advances each country's environmental goals but also contributes to the European Union's broader objectives of sustainable resource management and environmental protection.



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- UNIVERSITY OF BORÅS - SWEDEN

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EPA (IRELAND) / NCBR (POLAND) / FORMAS (SWEDEN)

▶ Duration

3 years

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KEYWORDS

WWTPs,
wastewater reuse,
sewage sludge,
salorisation

CURE - NBS

Circular water solutions for urban resilience with nature based solutions

Water4All
Water security for the planet

Abstract

Climate change and urbanisation contribute to urban water issues that have an impact on long-term sustainability and climate resilience. Nature-based Solutions (NbS) and Blue-Green Systems (BGS) mitigate the impact of extreme events, reduce pollution, enhance biodiversity and support water circularity through closed-loop water reuse measures aimed at maintaining adequate quantities of good quality water. Despite the benefits, several knowledge gaps impede implementation and long-term sustainability. This includes institutional resistance, lack of financial instruments, restrictive design regulations, uncertain operational performance (multifunctionality), limited stakeholder engagement and poor maintenance/monitoring functions.

This project will explore NbS-related challenges with the purpose of optimising the reuse of water and creating a sustainable water management approach that integrates surface drainage systems into existing urban planning strategies. The main objective of this project is to support the scientific framework for the successful deployment of water circularity principles by combining/upscaling NbS in the urban environment and facilitate wider implementation.

An interdisciplinary consortium of 5 universities from 5 European countries will execute 6 work packages. Each university maintains its own research infrastructure/technologies in the form of Urban Living Labs that will be used to conduct scientific analyses in support of a systematic, evidence-based approach to acquire scientific knowledge. Partners will monitor and collect data on the long-term performance of Urban Living Labs under simulated conditions of limited urban space and varying seasonal influences. Each system's performance will be monitored and assessed for risks, efficiency, durability and changes in physical, chemical and biological parameters which also impact on environmental aspects.
The goal is to advance water circularity through technologies and new frameworks that improve water quality, enhance infiltration, promote reuse of runoff, reduce reliance on conventional sources and strengthen urban resilience. Research activities will produce a comprehensive database demonstrating the reliability of NbS (to promote acceptance) and insights to guide future design, construction and maintenance practices that enhance the urban water cycle. The data will be used to develop models aimed at upscaling NbS from local to sub-catchment level, thereby supporting the building of resilient urban infrastructure worldwide. Stakeholder participation will be stimulated using interactive visualization tools (augmented reality) and initiatives for capacity building (ClimateCafé). The open-source knowledge sharing platform (ClimateScan.org) will facilitate stakeholder participation in planning and decision-making processes. The existing methods of ClimateCafé and ClimateScan platforms (with thousands international contributors) will be used rather than setting up new platforms for dissemination of Urban Living Lab activities and publishing results, following FAIR principles. Socio-economic aspects will be assessed to identify drivers/barriers for implementation. Guidelines, models, fact sheets and regulatory frameworks, developed throughout each work package, will facilitate the integration of circularity methodologies into existing water management frameworks while addressing economic and social concerns. This work also focuses on disseminating knowledge and connecting to relevant projects through channels such as social media and peerreviewed publications. Knowledge shared between partners, different platforms and project initiatives will encourage international cooperation in the water field. As such, several topics defined by the call are addressed, while strong focus on managing and monitoring project progress and deliverables are maintained. Finally, the project aims to deliver technical solutions that meet stakeholder needs and provide tangible results.

Project coordinator

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Project partners

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- VIA UNIVERSITY COLLEGE - DENMARK
- RIGA TECHNICAL UNIVERSITY - LATVIA
- UNIVERSIDADE DE COIMBRA - PORTUGAL

Funding organisations

NWO (NETHERLANDS) / NCBR (POLAND) / IFD (DENMARK) / LCS (LATVIA) / FCT (PORTUGAL)

Duration

3 years

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KEYWORDS

nature-based solutions,
blue-green systems,
water circularity,
stakeholder engagement,
urban planning

ELITRE

Electrochemical recovery of nitrogen vectors from wastewater

Water4All
Water security for the planet

Coordinated by Early Career Researcher

Abstract

A large fraction of European water suffers from eutrophication induced by high nitrate concentrations contained in agricultural runoff, while food production continues to heavily rely on ammonia-based fertilizers, a critical chemical with a large carbon footprint.
eLitre (Electrochemical Recovery of Nitrogen Vectors from Wastewater) proposes to develop integrated electrochemical and photobiological processes to address excess nitrate species in wastewater streams.

The technology developed in eLitre could actively help remediate nitrate-contaminated water bodies while upgrading nutrients back into raw materials for fertilizer applications. eLitre's direct path to impact lies in its contribution to water circularity and nutrient recovery and revalorization.
With the electrochemical processing pathway, eLitre pursues the direct conversion of nitrate species dissolved in wastewater into ammonia, at high nitrogen conversion rates, selectivity and rates.
In this context, eLitre will develop catalysts and systems that are tailored for the specific water streams enabling efficient anode operation to oxidize water and content, combined with cathodic valorization of nitrates into ammonia. Powered with renewable energy, this will enable the direct electrosynthesis of ammonia with minimum carbon footprint, as opposed to the widespread Haber Bosch, with the added value of water treatment and circularity.

eLitre will further develop advanced valorization pathways using the resulting ammonia and photobiological processes, seeking to realize high-value-added products such as biopolymers, carotenoids and Omega-3 fatty acids from otherwise carbon-nitrogen imbalanced nitrogen digestates.

eLitre will develop and assess these processes using wastewater streams from agricultural and urban environments. These recovery and valorization processes will be combined with novel rapid water monitoring technologies based on biophotonic probes. These will enable the quantification of nitrate and other biological species relevant to the application.
eLitre seeks to implement these into a small scale prototype using real wastewater streams enabling the treatment of water at litre-per-hour scales with minimum energy intensity and carbon footprint, targeting a TRL 5 at the end of the project.

With this, eLitre could contribute to the enhancement of water circularity in both agricultural industries and urban settings, including resource recovery and valorization and experimentally informed economic and environmental assessments. The consortium involves both early career and consolidated researchers from the public research and private sectors, and also includes stakeholders from policy making of different jurisdictions.

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- LODZ UNIVERSITY OF TECHNOLOGY - POLAND
- DELFT UNIVERSITY OF TECHNOLOGY - THE NETHERLANDS
- ACSA, OBRAS E INFRAESTRUCTURAS, S.A.U. - SPAIN

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AEI (SPAIN) / EPA (IRELAND) / NCBR (POLAND) / NWO - (THE NETHERLANDS) / CDTI (SPAIN)

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KEYWORDS

electrocatalysis,
nitrate electroreduction,
water electrolysis,
photobio reactors, Biopolymers,
water monitoring

EPHIC

Electrochemically assisted phosphorus and humics recovery via Ion exchange (EPHIC)

Water4All
Water security for the planet

Abstract

Wastewater treatment plants are being redefined. Their role as safeguards of human and environmental health expands to being a supplier of resources such as water and phosphorus. Achieving sufficient phosphorus removal and recovery is chemical-intensive and requires infrastructure that is largely absent today, such as sludge incineration facilities to produce phosphorus-rich ash. The emergence of smaller scale systems to locally enable water recovery also challenges recovery options. Surface waters used for process or drinking water production also exhibit phosphorus levels that are too high at intake, requiring chemical dosing. A new approach is needed.

The EPHIC concept is a revolutionary new approach that
(i) avoids the use of chemicals to remove phosphorus and organics (ii) minimises the need for major infrastructure
(iii) recovers the phosphorus as valuable phosphoric acid, and in parallel humics as valuable organics, both from wastewater and surface water
(iv) can be deployed both at small and large scales.

Our approach builds on a specific ion exchange process that sorbs phosphate to very low levels (<0.1 mg P/L). The resin is regenerated with an alkaline solution, after which the phosphate rich regenerant is treated in an electrochemical system. In this step, the phosphate is extracted as concentrated phosphoric acid while the alkaline solution is recovered for reuse. This enables near complete avoidance of chemical inputs. The phosphoric acid is an attractive product for fertiliser production, as it is already used by the fertiliser industry. This avoids the need for process adaptations. It is also an attractive chemical for non-agricultural applications. The ion exchange resin in time also accumulates organics, mainly humics that are present in wastewater and surface water. These can be removed with a second regeneration approach. We will subject this regenerant to a combination of membrane filtration and electrochemical pH swing recovering the regenerant as well as a concentrate of humics. EPHIC will thus create a second product, a humics concentrate, that is attractive as a soil improver, promoting plant growth and helping, for example, detoxify heavy metals in soils.

EPHIC builds on a team with complementary expertise from 4 countries. The ion exchange process will be developed to use electrochemically recovered regenerants at Cranfield University (The United Kingdom), whereas the electrochemical processing, both for phosphoric acid and humics, will be developed at Ghent University (Belgium, project coordinator). RWTH Aachen University (Germany) focuses on membrane filtration and separation of the humics. Finally, the BETA Technological Centre at the University of VIC (Spain) will investigate the use of the recovered phosphoric acid and humics towards agriculture.

We are supported by a wide group stakeholders across the value chain, from utilities to product offtakers and sector organisations, and invite others to join us over the course of the project. The scientific insights generated during EPHIC come at multiple levels, from operational aspects, technological designs and flowsheets to product specifications and verified use cases. Geared towards real-life impact this project will make an EPHIC contribution to a sustainable, future-proof phosphorus cycle.

▶ Project coordinator

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- CRANFIELD UNIVERSITY - UNITED KINGDOM
- RWTH AACHEN UNIVERSITY - GERMANY
- BALMES UNIVERSITY FOUNDATION - SPAIN

▶ Funding organisations

FWO (BELGIUM) / UKRI (UNITED KINGDOM) / BMFTR (GERMANY) / AEI (SPAIN)

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3 years

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KEYWORDS

phosphorus recovery, electrochemistry, ion exchange, membrane separation, nutrient recovery, fertilizer production, humics

GREEN4GREY

Urban green infrastructure for safe greywater treatment and reuse

Abstract

Water scarcity, climate variability and rapid urbanization are placing unprecedented pressure on urban water systems worldwide. While approximately 400 billion cubic metres of wastewater are treated globally each year, only around 11% is reused, largely due to regulatory barriers, monitoring challenges, public acceptance issues and concerns over environmental and health risks. Greywater, which constitutes roughly 65% of total household wastewater, and urban rainwater together represent vast untapped resources that could significantly ease the strain on conventional water supplies. Green4Grey aims to unlock this potential by advancing decentralized green infrastructure for the safe treatment and reuse of non-conventional water resources in urban settings.

Green4Grey will deliver an integrated, scalable and replicable framework that combines digital spatial planning, nature-based solutions, smart monitoring and social innovation. At its core is a spatially explicit City Information Model (CIM) that maps the quantity and quality of available non-conventional water sources – including rainwater, roof runoff, greywater and treated wastewater – alongside climate, population density and infrastructure data. This decision-support tool will enable urban stakeholders to identify optimal locations for decentralized systems and evaluate associated costs, benefits and environmental impacts.

Green4Grey will design, test and validate innovative decentralized treatment solutions, including nature-based and hybrid systems such as green roofs, constructed wetlands and subsurface flow systems, all adaptable to diverse climatic and urban conditions. A comprehensive risk assessment and mitigation framework will ensure compliance with EU, international and local standards, addressing both environmental and health dimensions and supporting safe reuse under variable operating scenarios. In parallel, an IoT-enabled dynamic monitoring and control system will integrate meteorological forecasts, real-time water quality and quantity data, predictive flow modelling and adaptive control functions. This will enable robust system operation, rapid response to changing environmental conditions and seamless interoperability between decentralized and centralized water infrastructures.

The project follows a dual approach: top-down development of transferable methodologies, best practices and planning tools, combined with bottom-up, multi-actor co-creation tailored to local needs and governance settings. Citizens, municipalities, water agencies and policymakers are engaged throughout all project phases, from planning and co-design to monitoring and dissemination, fostering public trust and ensuring that solutions are locally relevant and widely accepted.

These innovations will be demonstrated across five pilots in Haifa (IL), Heraklion (GR), Prague (CZ), Valencia (ES), and Florianópolis (BR), representing a wide spectrum of climates, urban forms, socioeconomic contexts and regulatory environments. The consortium brings together partners from Greece, Spain, Czechia, Israel, Sweden, the Netherlands, and Brazil, to contribute complementary expertise in hydrology, environmental engineering, urban design, AI-driven monitoring, constructed wetland systems and performance-based architectural design.

By combining city-scale digital planning, performance-based design, distributed low-cost sensing, machine learning, predictive maintenance, innovative water quality monitoring and meaningful stakeholder engagement, Green4Grey will move decisively beyond the current state of the art in decentralized urban water management. The project will deliver actionable knowledge, validated technologies and decision-support tools that strengthen urban resilience, reduce reliance on conventional water supplies, inform policy frameworks, and accelerate the transition towards circular, climate-adaptive and inclusive cities.

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- CZECH TECHNICAL UNIVERSITY IN PRAGUE - CZECHIA
- TECHNION - ISRAEL INSTITUTE OF TECHNOLOGY - ISRAEL
- HÖGSKOLAN KRISTIANSTAD - SWEDEN
- EINDHOVEN UNIVERSITY OF TECHNOLOGY - THE NETHERLANDS
- FEDERAL UNIVERSITY OF SANTA CATARINA -BRAZIL

▶ Funding organisations

GSRI (GREECE) / AEI (SPAIN) / TA CR (CZECHIA) / MOE (ISRAEL) / FORMAS (SWEDEN) / NWO (THE NETHERLANDS) / CONFAP (BRAZIL)

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KEYWORDS

urban water circularity,
decentralized nature-based treatment,
ity Information Model (CIM),
risk assessment framework,
IoT-enabled monitoring

GREENWATERTECH-2

Green remediation technologies to remove synthetic organofluorine chemical compounds from water

Water4All
Water security for the planet

Abstract

Per- and polyfluoroalkyl substances (PFAS) exposure has been linked to a range of adverse health effects. PFAS are ubiquitous in the environment, with over 14,700 unique compounds listed in the EPA's DSSTox database. These synthetic chemicals are highly water-soluble, enabling them to spread far from their sources, contaminating surface and groundwater and entering drinking water supplies globally. In the EU, 65% of drinking water is sourced from groundwater, and approximately 20 million people are directly exposed to PFAS through their water supply. These "forever chemicals" are designed to resist degradation, persist in the environment, and bioaccumulate in ecosystems, posing significant challenges for water quality and human health.

This project brings together a consortium of leading research institutions and industry partners from four EU countries to develop advanced modular hybrid technology (MHT) systems for the sustainable removal of PFAS from water. By leveraging cutting-edge chemical analysis techniques, we will assess the presence of PFAS in various water bodies and treatment processes. The project will focus on the evaluation of MHT systems using both model waters and real wastewater, with the aim of transforming polluted water into drinking water quality and enabling circular water use.

Building on the successful outcomes of a previous Horizon Europe "Aquatic Pollutant" Co-fund project, which demonstrated the feasibility of HMT technology in eliminating emerging pollutants, including pharmaceuticals from wastewater treatment plants, this project will expand and refine the MHT concept specifically for PFAS removal. We will investigate novel synergies within MHT modules, developing advanced nanoadsorbents and thermo-photocatalytic treatment units that integrate feedback regeneration for safe and efficient operation. New methods for synthesizing and dispersing pseudo-enzymatic adsorbents on natural carriers, alongside bio-based polymer matrices and functionalized silicates, will be explored. Additionally, an advanced oxidation process (AOP) using photocatalyst-coated glass fibers and luminous textiles will be developed, upscaled, and integrated into the MHT system to enhance PFAS degradation.

To address the critical need for sustainable and effective water treatment, we will also focus on developing innovative reactor designs to improve AOP efficiency and enable in-situ regeneration of saturated adsorbents through a unique refluxing process. This approach will minimize the need for external maintenance or disposal of spent materials. The project's results will provide valuable experimental data to guide sustainable water management practices and inform EU policies regarding PFAS regulation.

Current PFAS removal methods, including filters, membranes, and adsorbents like activated carbon and biochar, are costly, inefficient, and generate waste that requires further treatment. These methods also struggle to capture ultra-short PFAS compounds. Our proposed MHT approach could offer a cost-effective, sustainable alternative by directly eliminating PFAS without the need for additional treatment or disposal of the collected compounds. This approach has the potential to reduce the environmental spread of PFAS, lessen the burden on central wastewater treatment plants, and facilitate water reuse in industrial settings. Industry partners will be actively involved from the outset, contributing to the dissemination, exploitation, and commercialization of the project's results, ensuring that the technology reaches the market and has a significant impact on PFAS management and water treatment practices. Specifically, an ecological, technical and economic impact analysis of project results will be made.

▶ Project coordinator

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- TALLINN UNIVERSITY OF TECHNOLOGY - ESTONIA
- BROCHIER TECHNOLOGIES - FRANCE
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FORMAS (SWEDEN) / ETAG (ESTONIA) / ANR (FRANCE) / TA CR (CZECHIA)

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3 years

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KEYWORDS

PFAS, forever chemicals, water contamination, bioaccumulation, wastewater treatment, PFAS removal technologies, Nanoadsorbents, thermo-photocatalysis, advanced oxidation processes

HYDROSHIFT

Shifting mining waters from burden to resource

Water4All
Water security for the planet

Coordinated by Early Career Researcher

Abstract

Acid mine drainage (AMD) is one of the most persistent environmental legacies of mining. This acidic water, rich in toxic elements, contaminates ecosystems over extended periods, creating costly, long-term liabilities and requiring continuous treatment to protect ecosystems and human health. While widely implemented technologies such as lime neutralization effectively remove contaminants from water, they generate large volumes of treatment residues that accumulate on site and often contain significant concentrations of metals. At the same time, growing geopolitical tensions and the energy transition are increasing pressure on the supply of critical raw materials (CRMs).

HydroShift proposes to shift the paradigm in AMD management by transforming these long-term environmental liabilities into potential sources of valuable metals. The project focuses on two goals:
Metal Recovery Innovation from AMD and AMD residues: The project will develop and evaluate innovative technologies to extract valuable metals, including cobalt, nickel, copper, zinc and rare earth elements, from AMD with different compositions and site conditions. Based on the combination of biological processes, electro-driven technologies and innovative hydrometallurgical approaches, the objective is to produce marketable metal products, cleaned residue matrices suitable for safer storage or reuse, concentrated fractions of hazardous contaminants for secure disposal and finally output water that meets water quality compliance thresholds. By integrating process simulation with life cycle assessment (LCA), the project ensures these methods are economically viable, scalable, and environmentally optimized, supporting sustainable water management. During LCA assessment, the project aims at better defining the water footprint indicator in the mining sector, as this aspect is today poorly considered in the LCA of AMD prevention or remediation techniques.
Addressing economic and policy challenges: Through national inventories of CRM fluxes in AMD and stocks in treatment residues, HydroShift will quantify the potential resource base represented by these anthropogenic deposits. A decision-support flowchart will be developed to guide the selection of appropriate technologies depending on AMD characteristics, site conditions, and economic factors. A transnational stakeholder committee, bringing together industry, regulatory authorities, environmental and research organizations, will help identify barriers and opportunities for implementation.

The project's multidisciplinary consortium aims to demonstrate how AMD management can contribute to both environmental protection and the circular supply of critical raw materials. This project will serve as a model for other water-intensive sectors, demonstrating the potential to convert industrial waste into a valuable resource. Through outreach, open science practices, and dissemination, HydroShift aims to set new standards in AMD management and foster a long-term shift towards circular water use. The project will provide new tools and knowledge to help transform mining water treatment from a long-term burden into a strategic resource opportunity.

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- UNIVERSITY OF HUELVA - SPAIN
- TAMPERE UNIVERSITY - FINLAND
- USTAV GEOTECHNIKY SLOVENSKEJ AKADEMIE VIED - SLOVAK REPUBLIC
- NATURAL RESOURCES CANADA - CANADA

▶ Funding organisations

ANR (FRANCE) / AEI (SPAIN) / AKA (FINLAND) / SAS (SLOVAK REPUBLIC) / OTHER (SELF-FUNDED)

▶ Duration

3 years

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KEYWORDS

acid mine drainage, AMD sludge, resource recovery, critical raw materials, rare earth elements, cobalt, nickel, copper, zinc, mine water, mining residues, mining legacy, hydrometallurgy, biotechnologies

Water4All
Water security for the planet

IN.CYCLE

Closing the loop: an innovative treatment train for load-adaptive wastewater valorization and reuse in industries with highly polluted effluents

Coordinated by Early Career Researcher

Abstract

Industrial wastewater treatment must evolve to meet future environmental, regulatory, and resource management challenges. Wastewater treatment plants (WWTPs) are increasingly recognized not only as pollution control facilities but also as resource recovery hubs, in line with the European Green Deal and the UN Sustainable Development Goals.

Industrial effluents, particularly those rich in salts and organic matter, offer significant yet underexploited opportunities for water, energy, and material recovery. However, conventional treatment technologies severely limit valorization due to salinity impacts on biological processes and the presence of hazardous micropollutants that threaten compliance with the revised Urban Wastewater Treatment Directive (UWWTD) and the Water Framework Directive (WFD).

IN.CYCLE addresses these challenges by developing an innovative, modular treatment train combined with a digital twin (DT) framework for adaptive wastewater valorization. The project pursues four interconnected objectives:

- (1) electrochemical desalination to enable resource recovery and protect downstream biological treatment,
- (2) high-rate anaerobic treatment for enhanced energy recovery via methane production,
- (3) hybrid membrane and advanced oxidation processes for micropollutant removal to meet reuse standards, and
- (4) real-time, scenario-driven decision support through a predictive DT integrating process monitoring, modelling, and life cycle assessment.

The novel treatment technologies will be developed and validated in laboratory-scale experiments using wastewater from the Joint Water Treatment Plant GKW. Following optimization, pilot-scale units will be implemented and demonstrated under real operating conditions at GKW, treating complex industrial and municipal effluents. Real-time sensors, smart monitoring tools, and a modular DT architecture will support dynamic process management, predictive maintenance, and environmental performance evaluation.

Through the integration of advanced technologies with adaptive digital decision support, IN.CYCLE will significantly enhance resource efficiency, energy recovery, and industrial water reuse, contributing to sustainable water management and circular economy transitions in Europe.

Project coordinator

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Project partners

- STICHTING SAXION - THE NETHERLANDS
- GEMEINSCHAFTSKLÄRWERK BITTERFELD-WOLFEN GMBH - GERMANY
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Funding organisations

BMFTR (GERMANY) / NWO (THE NETHERLANDS) / FORMAS (SWEDEN)

Duration

3 years

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KEYWORDS

industrial wastewater treatment,
resource recovery,
digital twin,
energy recovery,
water reuse

MAINSTREAM

Upgrading water management in the industry by sustainable monitoring, treatment, and supportive governance mechanisms

Coordinated by Early Career Researcher

Water4All
Water security for the planet

Abstract

In a rapidly growing world, water security is increasingly at risk and may soon approach a point of no return. To overturn this dramatic trend, the path to a sustainable future demands urgent action to revolutionise wastewater treatment, cut pollution, and fully align with circular economy principles. In this project, we want to apply the paradigms of sustainability and circularity to upgrade industrial water management through a collaborative synergy among experts from research institutions and companies across Europe with transversal interdisciplinary and complementary competencies. The interlinked efforts provided by our Consortium will deliver holistic, sustainable solutions for water management in industrial sectors, e.g., chemical, pharmaceutical, and agricultural ones. The MAINSTREAM project is built on the idea that technological advances, governance strategies, and social awareness are entangled forces that must be harmonised to swiftly and effectively achieve circularity principles in water management.

Scientific/technological advances

- Surveillance of pollutants in industrial wastewater is fundamental to enable water reuse in a circular model. We will develop innovative and sustainable monitoring procedures for direct in-line tracing of critical pollutants in target wastewater based on high-performance sensor technology to overperform
- Current methods, combining newly green-synthesised molecules with customised sensors at low costs and low-energy consumption, relying on techniques that avoid toxic reagents and reduce liquid waste.
- Computational studies and modelling will provide scientific insights to develop advanced sensor technology. By assessing and deciphering the leading atomic interactions that govern the sensing molecule adhesion on the sensors, as well as their affinity towards the target pollutants, we will rationally control and optimise the sensor detection efficiency. Full ab-initio simulations will be adopted in the framework of molecular dynamics, delivering an in-depth understanding for the sensor design scale-up.
- The need for sustainable and affordable treatments for wastewater is decisive to unblock water reuse in industrial sectors. Innovative advanced oxidation processes will be explored, first in pilot plants and then validated in industrially relevant environments, by engaging industrial players and through real case studies. A full-around assessment of the process will be carried out to enhance sustainability. The goal will be to achieve zero liquid discharge and a full recovery of the water source, promoting circular management of water in industries across Europe and beyond.
- Integrated software and Machine Learning for automatic data management will ensure accurate data collection and real-time analysis of our innovative monitoring systems and treatment processes, achieving proactive decision-making, data-driven improvements, and prediction power.

Political-social aspects and dissemination

- Water-intensive industries are deeply influenced by political and economic frameworks. In MAINSTREAM, we will analyse “Systems of Governance” for water circularity, examining how multi-level, co-governance structures influence the adoption of water reuse and wastewater treatment technologies across industries, with a focus on legal, regulatory, and market-driven mechanisms. We will develop policy and corporate recommendations through case studies, global best practices, and intersectoral exchange of knowledge.
- Public engagement can significantly contribute to the circular revolution. Besides open science practices within the scientific community, new pathways will be explored to reach out to citizens, end-users, and stakeholders. Dissemination actions will be carried out through websites, social media, workshops, and public-open informative initiatives to raise awareness of water circularity in different contexts of society.

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- RO TECHNOLOGY SRL - ITALY
- OEKO-INSTITUT E.V. - INSTITUTE FOR APPLIED ECOLOGY - GERMANY
- DOKUZ EYLUL UNIVERSITY - TURKEY
- EARGE ENGINEERING DESIGN INDUSTRY E-ARGE. E TIC. LTD - TURKEY

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MUR (ITALY) / FORMAS (SWEDEN) / AEI (SPAIN) / BMFTR (GERMANY) / TUBITAK (TURKEY)

▶ Duration

3 years

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KEYWORDS

industrial wastewater treatment and reuse,
zero-liquid discharge,
In-line sensors data-driven monitoring,
computational modelling,
systems of Governance for water circularity,
life cycle analysis, social awareness

OXADIPR

Combining advanced oxidation processes with adsorption to recycle water for indirect potable reuse

Water4All
Water security for the planet

Abstract

The indirect reuse of water requires the careful control of the quality of the treated wastewater. More than 95% of the wastewater is undergone incomplete treatment prior to the discharge into surface water or reuse. New approaches are needed to mitigate the risks associated with non-biodegradable recalcitrant pollutants (pesticides, pharmaceuticals, personal-care products, perfluoroalkyl-substances / PFAS), and pathogens remaining in the effluents of the wastewater treatment plants, and produce potable water. In this manner, recycled water in accordance with European Union directives will be produced for multiple uses. The main contaminants remaining in the effluents of Sewage Treatment Plants (STP) are emerging pollutants, associated with long-term health effects, and pathogens that may cause diseases in short-term. Microfiltration, ultrafiltration, and reverse osmosis are commonly used for the direct reuse of potable water. However, the process efficiency decreases due to the fouling of membranes and the need for frequent module replacement. On the other hand, advanced oxidation process (AOPs) such as UV-treatment, photocatalysis, ozonation, electro-oxidation, photo-Fenton, or their combination (hybrid AOPs) are capable to dissociate recalcitrant pollutants and pathogens. However, in most cases, the complete mineralization of organic molecules is not attained very fast and a time-consuming and very expensive treatment of the water stream is required. On the other hand, during a fast AOP-treatment, the decomposition of pollutants leads to the generation of intermediate products which might be equally if not more toxic than the parent molecules. The removal of such compounds by other methods, such as the adsorption could accelerate the reduction of the factors controlling the water quality (e.g. COD, BOD, TOC, NO3-, PO43-).

In the context of OXADIPR project, a technology is proposed for improving the quality of water outflowing from STP units to make it suitable for indirect potable reuse. A synthetic contaminated water (SCW) containing recalcitrant contaminants representative of those encountered in typical effluents of STPs will be prepared. Three standalone and/or hybrid AOPs (e.g. photocatalysis, electrochemical oxidation, ozonation) will be selected and tested in batch/semi-batch experiments to quantify the degree of contaminant degradation and intermediates generated due to partial oxidation. One or two types of agricultural wastes will be selected to fabricate low-cost bio-sorbents (biochar/activated carbon), and tested as materials for the non-selective sorption of non-degraded species and intermediate byproducts. A method will be selected for the cost-effective and sustainable adsorbent regeneration. Based on the kinetic data of AOPs and sorption from lab-scale studies, alternative configurations coupling AOPs with adsorbents into an integrated continuous flow process will be suggested. Specific computational fluid dynamics (CFD) numerical models of the coupled processes will be developed. Setting the water treatment capacity to a fixed value (~10L/min), the alternative configurations of AOPs and adsorbents will be tested with the aid of CFD models, and the most efficient integrated process will be chosen to design, and manufacture a continuous flow pilot unit. The performance of pilot unit will be tested with real effluents of STP for water purification at levels satisfying the standards for indirect potable reuse. The results of pilot tests will be used for a life cycle analysis to assess the environmental impacts, and for calibrating the numerical model, which will further be used to design a large industrial unit. Simulations in the large-scale facility will be utilized for cost benefit analysis and benchmarking. Project results will be disseminated to academic society, stakeholders and public with scientific publications, conference presentations, workshops, website, leaflets, press releases, and social media.

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KEYWORDS

indirect potable reuse,
advanced oxidation processes,
adsorption, low-cost biosorbents,
recalcitrant contaminants,
numerical modeling, water recycle

RED-SUN

Sustainable nitrogen management under the revised directive on urban wastewater treatment

Water4All
Water security for the planet

Abstract

In November 2024, the European council definitively adopted the text for a revised directive on urban wastewater treatment, which will impose large wastewater treatment plants to lower their nitrogen discharge levels in the coming years. This represents an unprecedent opportunity to develop and evaluate new innovative solutions for nitrogen management, and to help closing the N-cycle.

The Red-SuN project aims at proposing and evaluating new routes to treat and/or recover nitrogen from wastewater within this revised directive without compromising the carbon-footprint of the plants. An in-depth evaluation of the current practice in terms of nitrogen treatment in the four countries participating to the project (France, Finland, Poland and Belgium) and of the required optimization/retrofitting of the existing plants to meet the revised European directive forms the starting point of the project. A full evaluation of innovative technologies to recover nitrogen from wastewater will also be carried out, as well as the impact assessment of the current and future N-related unit processes in terms of energy and chemical consumption and GHG emissions. The different scenarios will be assessed on a plant-wide level through simulation of full-scale installations, in order to propose and validate a methodology to select the best nitrogen management solutions to be implemented. Throughout the project, a close collaboration will be maintained with various stakeholders (water utilities in particular) who will share their data, their experiences and their vision towards the implementation of the new directive in a circular economy context.

The Red-SuN project targets the improvement of recovery technologies for nitrogen circularity between wastewater treatment, agriculture and industrial resource management sectors. This allows wastewater treatment utilities and industries to meet EU standards while reducing costs and keeping the carbon footprint low, providing agriculture with a sustainable alternative to synthetic fertilizers and supporting industrial circular economy practices.
The impact is expected to include reduced nitrogen pollution, operational savings, decreased fertilizer dependency, and contributions to EU goals in terms of circular economy, climate, environmental protection and public health.

Five academic partners will be associated in the Red-SuN project (INRAE and INSA Toulouse, France, Aalto, Finland, UGent, Belgium and Gdańsk-Tech, Poland). In addition to the competence required to develop the methodology and the models, the consortium partners are carrying out collaborative work with public end-users (water utilities, regulatory bodies...) and private end-users (water treatment companies, software developers, farming and agro-industry, fertilizer's companies...).
In particular, the partners will benefit from long-term collaborations with local water utilities, four of them having confirmed their participation in the project: Lyon Métropole (France), Helsinki Region Environmental Services (Finland), Aquafin (Belgium) and Chamber of commerce: Water Utilities (Poland). They will contribute to the definition of the evaluation criteria, give feedback on the assessed process schemes and commit to the sustainable implementation of successful project outcomes.

▶ Project coordinator

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KEYWORDS

nitrogen,
recovery, removal,
urban wastewater treatment directive,
valorisation,
multi-criteria evaluation,
sustainability

RENEW

Resource recovery of the future: water reuse for new bioplastics with tunable lifespan

Water4All
Water security for the planet

Abstract

Treated urban wastewater effluents may constitute a source of nutrients for the growth of bioplastic (polyhydroxyalkanoate, PHA) producing photosynthetic organisms. PHA are the only bioplastics that can fully biodegrade under all possible of environmental conditions. Currently, commercial PHA production process is undertaken by cultures of heterotrophic microorganisms with high demands of energy, substrates and clean high-quality water. While integrating PHA production into wastewater treatment has been suggested, this has not yet been achieved due to instability of the process.

In the present project, we propose a new approach to bioplastics production using cyanobacteria in the form of microbiomes which will be grown in treated urban wastewater taking the advantage of the residual nutrients contained within.
We will develop a production system by creating a new process engineering setup with intermediate separation and concentration step by using ultrafiltration membranes. Moreover, the system will be monitored with a fasttracking microbial community analysis tool based on flow cytometry to maintain cyanobacterial microbiomes stable in the highly variable treated wastewater environment. The treated wastewater, the culture's mixed liquor and the PHA will be analyzed and evaluated for micropollutants. Quantitative analytics (metabolomics and proteomics) and molecular biology methods (transcriptomics) will be applied to gain fundamental insight into PHA metabolic regulation mechanisms for the success of PHA production.
Different physical cell disruption techniques will be combined with environmental friendly solvents, such as natural deep eutectic solvents, for testing and developing a green PHA extraction and purification strategy.

This project is unique in that we aim to produce different PHA products with programmable biodegradability by embedding plastic-degrading bacteria within the bioplastic itself. We will assess the environmental, social, and economic impacts of the PHA production system to facilitate its upscaling and future implementation.

The stakeholders and end-users identified through the partners' networks will play an active role in shaping the project's challenges, problems and market uptake analysis. The process that we propose eliminates the need for aeration, high substrate and high-quality water demands of the commercial PHA production, and instead utilizes sunlight, captures CO_2 and produces O_2 . This process will contribute to recovery resources from water, will expand the current applications of water reuse and will allow to shift the existing paradigm of bioplastics manufacturing, rendering it inherently circular.

▶ Project coordinator

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- NOVA SCHOOL OF SCIENCE AND TECHNOLOGY - PORTUGAL
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KEYWORDS

water reuse,
bioplastics,
PHA,
cyanobacteria,
circular economy

RESET

Valorisation of non-conventional water resources in urban and peri-urban context

Water4All
Water security for the planet

Abstract

RESET (Valorisation of non-conventional water resources in urban and peri-urban contexts) aims to advance circular water management by developing innovative strategies to recover water, nutrients and energy from urban wastewater streams.

The project focuses on the valorisation of non-conventional water resources, including treated municipal wastewater, greywater and blackwater, to support sustainable water use in urban and peri-urban environments.

RESET combines advanced technical processes with nature-based solutions to create integrated treatment systems capable of producing high-quality reclaimed water for non-potable uses such as toilet flushing, irrigation, urban gardening and industrial applications. By integrating these complementary approaches, the project seeks to increase the availability of alternative water resources while reducing pollutant emissions and improving the efficiency of urban water systems.
In parallel, RESET investigates innovative approaches for recovering valuable resources from wastewater, including nutrients such as nitrogen and phosphorus for fertiliser production, as well as energy through biogas generation and algal biomass. By linking water reuse with resource recovery, the project aims to transform wastewater treatment plants and decentralised systems into resource hubs that contribute to closing material and energy loops within the urban water cycle.
A key element of the project is the development of decentralised and hybrid water reuse solutions that allow water to be treated and reused close to where it is generated, reducing pressure on conventional drinking water supplies and increasing the resilience of cities to water scarcity. Laboratory and pilot-scale experiments will be conducted in Europe and Brazil to test the performance, scalability and transferability of these technologies under different climatic, regulatory and infrastructural conditions.
To support the implementation of these solutions, RESET will develop an optimisation framework for designing reclaimed water distribution networks and integrating them with existing urban water infrastructure. In addition, the project will assess the environmental performance and sustainability of the proposed systems through Life Cycle Assessment and comparative scenario analysis.
RESET also adopts a participatory approach that involves key stakeholders such as policymakers, water utilities, industry representatives and civil society. Through co-design activities, workshops and stakeholder engagement processes, the project aims to ensure that the developed solutions are technically feasible, socially accepted and aligned with real implementation needs.
Ultimately, RESET seeks to contribute to the transition towards a circular urban water cycle by reducing freshwater demand, improving wastewater management and recovering valuable resources. The project will deliver scientific knowledge, technological innovations and decision-support tools that support cities, utilities and policymakers in implementing sustainable and resilient water management strategies aligned with European environmental policies and global sustainability goals.

▶ Project coordinator

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- UNIVERSITY OF LUXEMBOURG - LUXEMBURG
- UNIVERSITY OF CHEMISTRY AND TECHNOLOGY IN PRAGUE - CZECHIA
- UNIVERSITAET INNSBRUCK - AUSTRIA
- RHEINLAND-PFÄLZISCHE TECHNISCHE UNIVERSITÄT KAISERSLAUTERN-LANDAU - GERMANY
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KEYWORDS

circular water management, water reuse, wastewater valorisation, resource recovery, nature-based solutions, advanced oxidation processes, nutrient recovery, decentralised systems, urban water cycle, life cycle assessment

REUSE

Recovery of added value compounds from coffee and olive oil wastewaters

Water4All
Water security for the planet

Abstract

The REUSE project focuses on the circular economy approach addressing the recovery of valuable polyphenolic compounds from wastewaters taken as case studies from the processing of coffee and olive oil. Olive oil and coffee production generate large amounts of wastewater with high Biochemical Oxygen Demand (BOD5) and Chemical Oxygen Demand (COD), causing toxicity to plants and microorganisms, soil acidification, and pollution in rivers if untreated.
Traditional wastewater treatments, such as aerobic/anaerobic digestion and activated carbon filtration, are often costly, time-intensive, and lack the specificity needed to selectively recover valuable organic compounds, such as polyphenols. Polyphenols have strong antioxidant properties and, once recovered, could be used in industries like pharmaceuticals, food, and cosmetics, giving agricultural waste new commercial value. Furthermore, filtered water could potentially be recycled for agricultural use, reducing both waste and the environmental impact of water release. To tackle these issues, REUSE aims to develop advanced filtering systems that can selectively recover valuable polyphenolic compounds, and at the same time reducing the environmental impact. This project involves collaboration among three partner institutions with expertise in porphyrins, Metal-Organic Frameworks (MOFs), and selective filtration materials: the Institut de Chimie Moléculaire de l'Université Bourgogne Europe (France), Embrapa Instrumentação (Brazil), and the University of Rome Tor Vergata (Italy). Together, these teams will leverage their combined knowledge in chemistry, materials science, and engineering to create innovative filtration systems and sensors.
One key approach in REUSE's methodology is the development of advanced filtration materials, such as zeolite with porphyrin-based coatings, and MOFs. Zeolites, low-cost and widely available porous materials with high adsorption capabilities, will be functionalized with ad hoc porphyrins to selectively capture polyphenols from wastewater. Similarly, porphyrin-based MOFs will be tested as potential novel adsorbents. The presence of porphyrins as binding units also exploits their dual use as sensing elements, foreseeing the possibility of incorporating real-time monitoring technology using colorimetric, fluorometric, or electrochemical sensors that allow continuous assessment of filtration effectiveness and detect when filters need replacement.

The project aligns with the Water4all call's objectives of resource recovery and pollution reduction, specifically targeting sustainable solutions in wastewater treatment. REUSE's focus on polyphenol recovery meets the call's theme of resource valorization while promising significant environmental and economic benefits. Expected project outcomes include high-impact research publications, the development of efficient filtration technologies for industry use, and a sustainable approach to managing agricultural wastewater. By establishing a multidisciplinary and transnational team, REUSE leverages each partner's expertise to enhance the scalability and applicability of novel solutions, directly in major coffee- and olive oil-producing countries like Brazil and Italy.

▶ Project coordinator

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KEYWORDS

coffee, olive oil, porphyrins, MOFs, zeolite, wastewaters, polyphenols, filtering systems

REWADD

Resource recovery from wastewater based on photo-bio-electrochemical and membrane processes with minimal chemical addition to obtain added value goods

Abstract

The project ReWAdd aims at developing process schemes to recover, concentrate and upcycle nutrients, especially Nitrogen and Phosphorus, from wastewater streams, while addressing the removal of Contaminants of Emerging Concern (CECs). The global aim of the project is to change the traditional conception of wastewater treatment plants as waste management facilities into a new paradigm where wastewater is seen as a resource pool, where treatment plants evolve into factories for producing added-value goods while ensuring water security for all. The production of high added-value products from different water sources (urban and industrial effluents) is explored in ReWAdd.

The process schemes investigated in ReWAdd are based on electro-membrane and pressure-driven membrane processes, and hybrid bio- and photoelectrochemical systems. Such processes, coupled in an efficient way, can lead to synergies between their respective outlet streams, which can be used as feedstocks in other process units. The added-value products obtained from the different process schemes include N-P fertiliser, single cell protein product, acid and alkali solutions and clean water for reuse purposes. As an example, the generation of alkali and N-P rich streams by bipolar membrane electrodialysis can be fed to crystallisation systems for the production of fertiliser, whereas acidic solutions can be used in the cleaning of nanofiltration or reverse osmosis membranes.

In contrast with state-of-the-art methods for nutrient removal, these technologies involve minimal addition of chemicals and thus, enabling a reduction of the volume of sludge generated in wastewater treatment plants. The technologies proposed work at room temperature, are modular and easily scalable and can be easily powered by an electrified network or by renewable energy sources. The Project involves activities for testing the operation units at laboratory scale, reassessment and optimization of their coupling in different process schemes, and life cycle assessment, technoeconomic and scalability studies to ensure the further implementation of the process at larger scale. Moreover, pilot tests will be conducted with effluents generated in the food industry and with urban wastewaters.

Aligned with Water4All's 2024 Joint Transnational Call, ReWAdd contributes primarily to:

- Topic 1. Enhancement of water circularity in industries. In ReWAdd, different process units are coupled to generate added-value products from food industry wastewater, remove N/P and CECs enabling water reuse and minimise the addition of reagents that would result in increased sludge generation.
- Topic 3. Resource recovery and valorisation. ReWAdd integrates approaches for nutrient extraction, concentration and upcycling, as well as CEC elimination.
- Topic 4. Economic, environmental and social implications of water reuse and recovered products. Pilot tests with effluents of the food and urban sectors and technoeconomic and feasibility analysis will be conducted, which is a fundamental step for the subsequent transfer of the research to real-time application on larger scale.

▶ Project coordinator

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- TECHNICAL UNIVERSITY OF DENMARK - DENMARK
- NATIONAL LABORATORY OF CIVIL ENGINEERING - PORTUGAL
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KEYWORDS

nutrient recovery, membrane processes, bipolar electrodialysis, micropollutant removal, single cell protein

SALTREC

Integrated resource recovery from saline wastewaters in a circular context

Water4All
Water security for the planet

Coordinated by Early Career Researcher

Abstract

Saline wastewaters are common in many industries, such as fish processing, agro-food, aquaculture, oil and gas, pulp and paper, chlor-alkali, and leather industries. Freshwater scarcity and industrial water recycling are expected to increase the abundance of saline wastewaters. Such wastewaters require adequate treatment to prevent environmental damage from their discharge in surface water bodies. Both physicochemical and biological treatment processes are severely hampered by the saline content of these wastewaters, which implies the need for a novel saline wastewater treatment system.

In this project, we will develop a novel value chain for integrated valorisation of water, organic matter and minerals from saline wastewaters towards the recovery of energy, clean process water and the production of high-value products in a holistic approach. Such an integrated, circular approach, in contrast to the current dissipative and limited treatment of saline wastewaters, will open novel routes towards maximal resource recovery in a circular economy.

First, we will develop a robust anaerobic digestion system that relies on salt-resistant microbial granular entities for the removal of organics and concomitant production of biogas as renewable energy source.
Next, a microbial consortium consisting of methane oxidizing bacteria and microalgae will be used for the production of high-value ectoine from the residual nutrients in the effluent from the anaerobic digestion process. Both biogas valorisation and biogas cleaning will be targeted by selectively promoting either methane oxidizing bacteria or microalgae in the methalgae consortium.
Next, a pilot desalination unit will be operated towards target-oriented and, thus, energy-efficient desalination, with specific focus towards reducing the brine discharge.
Finally, the different unit technologies will be virtually integrated into the novel value chain. The environmental and circularity impacts and societal readiness and acceptance of this value chain will be evaluated, ensuring innovations are sustainable, policy-compliant, and aligned with public interest.

Overall, this project will be an important step towards the sustainable management of saline wastewaters.

▶ Project coordinator

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▶ Project partners

- WAGENINGEN UNIVERSITY & RESEARCH - THE NETHERLANDS
- UNIVERSITY OF GABES - TUNISIA
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KEYWORDS

anaerobic digestion, brine, biogas upgrading, desalination, life cycle assessment, methalgae, methanogenesis, methanotrophs, resource recovery, responsible research and innovation, saline wastewater, water circularity, zero-liquid discharge

ULTRABUBBLES

Nanobubble technology for sustainable wastewater treatments: micro-algae recovery and simultaneous micro-pollutant and microplastics removal

Water4All
Water security for the planet

Abstract

The concentration of Micro- and Nano-Plastic particles (MNPs) and Micro-Pollutants (MPs), such as antibiotics and cosmetics, in urban and industrial wastewaters is substantially high, and the inefficiency of traditional wastewater treatment processes poses a significant risk of their discharge into natural environments. Once wastewaters reach the oceans, the possibility of successfully detecting and removing these undesired elements drastically decreases. Currently, suspended MNPs and MPs are detected in all treated waters in the EU, with some posing hazards to public health and the environment even at very low concentrations. Therefore, MNPs and MPs must be removed by upgrading wastewater treatment plants with new technologies. Advanced treatment techniques must be developed to meet the European "zero pollution action plan" target for 2045. These techniques should be sustainable, preferably avoiding the use of chemical additives, and applicable to both large and small urban communities.

ULTRABUBBLES is a basic-research project aimed at developing and demonstrating the efficiency of an innovative advanced wastewater treatment technology, hereinafter referred to as ULTRABUBBLES technology. This technology aims to remove MNPs and MPs by combining flotation, adsorption, and oxidation of emerging contaminants using NanoBubbles (NBs) and MicroAlgae (MAe), which are harvested, reused, and ultimately separated from the effluent.

Two processes will be explored.

The first integrates multiple treatment mechanisms within a single reactor system. This approach combines aggregation of dispersed microplastic particles, NB-enhanced flotation for their separation, and advanced oxidation processes for the degradation of recalcitrant pollutants, offering both environmental and economic benefits, with removal efficiencies exceeding 96%.

MAe have shown remarkable ability to adsorb MNPs from wastewater, forming the basis of the second process. This approach relies on the bioadsorption of MNPs by suspended microalgal biomass, followed by NB flotation as a sustainable alternative to conventional MAe recovery methods, thereby reducing the typically high operational costs. The project will also investigate the use of CO_2 NBs - potentially extracted from activated sludge and biological filters in the secondary treatment stage - to provide MAe with a carbon source. This CO_2 supply would enhance the diurnal photosynthesis of green algae while simultaneously contributing to CO_2 reuse and valorisation (carbon sink). A final treatment with ozone NBs will inactivate residual MAe before the effluent is discharged into the natural environment.

ULTRABUBBLES technology will contribute to shift wastewater treatment plants from a linear "treat and discharge" model to a circular "capture–reuse–restore" loop. In fact, secondary waste generation is minimised by relying on clean physical–biological mechanisms, MAe enriched with microplastics and other adsorbed contaminants are recovered, while CO_2 from wastewater treatment residues is reused turning a greenhouse gas into a productive input.

To enable the development of the ULTRABUBBLES technology, a model describing the physical and chemical processes responsible for the aggregation of MNPs and MAe, as well as the oxidation of MPs, will be developed and validated against a unique series of multi-scale laboratory and numerical experiments. The high removal efficiency will be supported by innovative hybrid NB generators developed by Nanobubbles Europe, a rapidly growing European leader in NB technologies. The scalability of the ULTRABUBBLES technology will be assessed using a pilot-scale prototype reactor and tested according to the requirements of the project stakeholders.

Project coordinator

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Project partners

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- UNIVERSITY OF UDINE - ITALY
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Funding organisations

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Duration

3 years

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KEYWORDS

sustainable wastewater treatment, micropollutant removal, nanobubble flotation, microalgae harvesting, CO_2 reduction, advanced oxidation processes,

VALORBIO

Valorizing agrifood wastewater through advanced biorefining techniques for sustainable packaging solutions

Water4All
Water security for the planet

Abstract

Traditionally regarded as waste streams requiring treatment and disposal, wastewaters are increasingly recognized as valuable resources within the framework of the circular economy. Wastewater treatment plants can evolve into resource recovery facilities capable of simultaneously producing clean water, renewable energy, and valuable bioproducts. Among these resources, biodegradable biopolymers produced by microorganisms represent a promising alternative to conventional petroleum-based plastics. As global plastic production exceeds 400 million tonnes annually and plastic waste continues to accumulate in terrestrial and marine environments, developing sustainable bioplastic production platforms based on waste-derived feedstocks offers an important opportunity to reduce environmental impacts while creating value from wastewater streams.

VALORBIO proposes an integrated approach to convert agri-food wastewater into high-value biodegradable bioplastics while assessing opportunities for water reuse. The project focuses on recovering microbial biomass rich in polyhydroxyalkanoates (PHAs) and extracellular polymeric substances (EPS), two natural biopolymers produced during biological wastewater treatment. PHAs are widely recognized as promising alternatives to conventional plastics due to their biodegradability in diverse environments. However, their large-scale production remains limited by high costs and low recovery yields. A major factor contributing to these limitations is the simultaneous production of EPS during microbial growth, which is typically discarded during conventional PHA extraction processes.

VALORBIO addresses this challenge by developing a strategy for the simultaneous recovery and valorisation of both PHAs and EPS. By treating these biopolymers as complementary resources, the project aims to increase overall biopolymer recovery and improve the economic feasibility of wastewater-based bioplastic production. To achieve this, VALORBIO will develop an innovative co-extraction method based on sustainable ionic liquids, enabling the recovery and blending of PHA and EPS directly from microbial biomass without the use of toxic solvents. The recovered biopolymers will be then used to produce transparent films and coatings for food packaging. In addition, the project will explore the biodegradation of these materials through co-fermentation processes that generate volatile fatty acids (VFAs), which can be recycled as carbon sources for further biopolymer production, creating a circular production system.

VALORBIO brings together a multidisciplinary consortium of six research groups with expertise in environmental engineering, microbiology, polymer chemistry, materials science, and environmental and socioeconomic assessment. The agri-food sector will serve as the main case study due to its high water consumption, generation of biodegradable wastewater, and extensive use of packaging materials.

The project aligns with the objectives of the Water4All 2024 Joint Transnational Call on "Water for Circular Economy", contributing to innovative solutions for resource recovery from wastewater and sustainable water management. By transforming agri-food wastewater into biodegradable packaging materials while evaluating water reuse opportunities, VALORBIO supports the development of circular water-based value chains and reduces environmental pressures associated with wastewater management and plastic production.

Project coordinator

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- KTH ROYAL INSTITUTE OF TECHNOLOGY - SWEDEN
- INSTITUT POLYTECHNIQUE GRENOBLE - FRANCE
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Funding organisations

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Duration

3 years

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KEYWORDS

biopolymer production, bioplastics, biodegradability, circular bioeconomy, sustainable packaging, wastewater valorisation

WAVE

Microbial-based bioprocesses towards dairy wastewater reuse and conversion into new bioplastics

Water4All
Water security for the planet

Abstract

The scarcity of freshwater is expected to have significant economic global impacts. Revalorizing and reusing all wastewater are a must to decrease the burden on freshwater demand. Application of treated or recovered water for different purposes instead of freshwater can be help mediating worldwide water stress.

Huge volumes of dairy wastewater are generated globally and dairies and cheese producers may invest in specialized treatment systems of challenging wastewater and whey. Based on this fact, this project proposes an innovative approach that maximizes the value of the entire wastewater matrix, aiming to recover clean water for irrigation and to produce bioplastics. This integrated solution contributes to reducing water stress and promotes circularity in both water and the economy.

The primary objective of this project is to develop an integrated process that incorporates microbial-based biotechnologies for the reuse and conversion of dairy wastewater into new bioplastics. To achieve this aim:

I. Dairy wastewater containing whey is used as feedstock to produce short-chain fatty acids (SCFAs) in an anaerobic fermentation.
II. SCFAs are converted into single cell proteins (SCP) by non-conventional yeasts.
III. A water effluent with low salinity for landscaping is obtained by increasing salt uptake and intracellular compartmentalization in D. hansenii.
IV. Bio-based and degradable plastics are produced from Debaryomyces-derived SCP
V. The sustainability of the proposed technology and demonstrating its contribution to a Circular Economy is evaluated.

WAVE is envisaged as a promising method for treating wastewater while generating two key outputs: treated water with low salinity suitable for irrigating urban green spaces, and bioplastics.

The success of WAVE is guaranteed by a multidisciplinary consortium with high expertise for setting cutting-edge and innovative solutions from complementary fields including Chemistry, Material Science, Biotechnology, Engineering and Economics. The expected outcomes of WAVE include technological advances that will open new venues of research. Dissemination efforts will target these groups using tailored materials and tools. The project aims to foster market and policy changes by establishing an international network of researchers, innovators, stakeholders, and policymakers to promote sustainable economic growth and protect vital water resources.

WAVE will deliver new knowledge on wastewater treatment and re-use of treated water while creating new tools for SCP production and conversion into bioplastics. WAVE expected results will clearly impact on increasing water resource efficiency and optimizing water use in water-dependent sectors and developing new materials more sustainable than products offered on the market and enabling new applications fostering industrial sustainability and competitiveness in Europe. Technological developments will put in place wastewater as a new circular feedstock. Furthermore, outcomes on bioplastics derived from yeast-based SCP will represent an important contribution to the scientific knowledge in the field of plastics.

WAVE will mitigate potential environmental and operational risks associated with water reuse practices. Environmental impact will also be reinforced by the replacement of highly polluting plastic wastes and the production of more environmentally friendly bio-based plastics building blocks. Additionally, the application of advanced technologies for bioplastics generation can boost the development of technology-based companies, as well as add value to the wastewater management sector.

There is no doubt about the social impact of WAVE. Environmental protection (water bodies) and economic growth will have a direct impact in social well-being.

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- UNIVERSIDAD DE VALLADOLID - SPAIN
- KTH ROYAL INSTITUTE OF TECHNOLOGY - SWEDEN
- INTERNATIONAL HELLENIC UNIVERSITY - GREECE
- 21ST BIO A/S - DENMARK

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DISCLAIMER

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