iMERMAID

KEY EXPLOITABLE RESULTS

BOOKLET

Funded by the European Union

PART OF THE EU MISSIONS
RESTORE OUR OCEAN & WATERS

CONTENT

This booklet was compiled by the iMERMAID project partner Armengaud Innovate GmbH on the basis of input received from the corresponding project partner. We would herewith like to heartfully thank all project partners for the excellent collaboration not only for this content but throughout the entire project.
Enjoy reading and if you need any more information do not hesitate to contact us!

FIND iMERMAID

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KEY EXPLOITABLE RESULTS

BOOKLET INTRODUCTION

iMERMAID (imermaid.eu) is an EU-funded project focused on protecting the Mediterranean Sea and its basin from Contaminants of Emerging Concern (CoEC)—newly emerging chemical pollutants like pharmaceuticals, herbicides, pesticides, PFAS, heavy metals, and oils that pose significant risks to ecosystems and human health but lack specific regulations.

Within the scope of the iMERMAID project eleven innovative solutions for CoEC monitoring, remediation and digitalization, as well as for social impact and capacity building were developed. These enable key stakeholders—such as water treatment plants, industries, municipalities, research organisations and NGOs—to identify and scale methods for monitoring and remediating of CoECs and to create large-scale awareness on the topic of CoEC across the Mediterranean basin.

This booklet briefly introduces the main benefits of each of the solutions along with the major takeaways from their pilots and scale-up and exploitation strategies.

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LOW-COST ELECTROCHEMICAL SENSOR BOX TO DETECT ORGANIC MICROPOLLUTANTS

UNIVERSITÉ D'ANGERS

University of Angers introduces a monitoring electrochemical sensor box enabling low-cost, near-real-time quantitative assessment of non-degradable and persistent chemicals such as pharmaceuticals, nitrites, plastic additives and Perfluoroalkyl substances (PFAS) in sweet water.

Unlike other solutions on the market, UA's sensor implements electrodes modified with molecularly imprinted polymers (MIPs) and gold nanoparticles to achieve higher selectivity and sensitivity to organic micropollutants. Combined with the on-site measurement capability and option to detect multiple contaminants simultaneously, the sensor is a steppingstone in the Common Implementation Strategy (CIS) of the Water Framework Directive (WFD) towards improved water quality surveillance and decision-making.

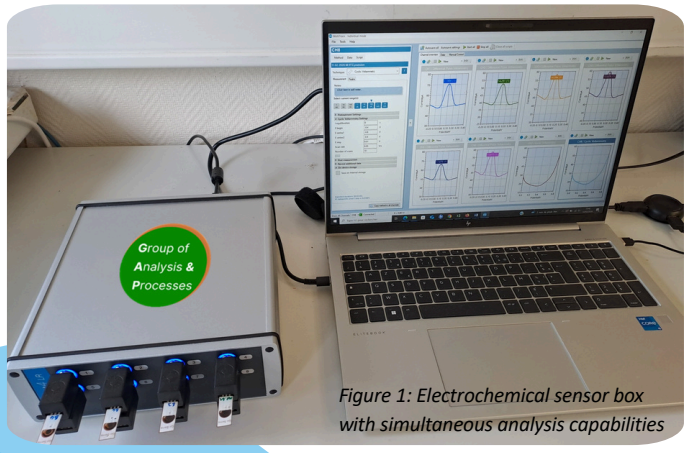

Figure 1: Electrochemical sensor box with simultaneous analysis capabilities

The wide applicability of the sensor has been proven during the iMERMAID's use case implementations at diverse wastewater treatment plants. The sensors demonstrated sensibility and selectivity far beyond limits required by national laws.


Figure 2: On-site analysis using single channel mode

In the long term, the monitoring box can be implemented by environmenal authorities for early detection of organic micropollutants in wastewater treatment plants to comply with the revised urban wastewater treatment directive, by municipal or regional water utilies and researchers to perform rapid on-site screening supplementary to acredited lab analyses and by industrial operators to continuously monitor pharmaceutical effluents and landfill leachates. Rapid on-site monitoring supports fast mitigation of pollution events very close to the source and may potentially prevent them altogether. Importantly, low-cost monitoring sensors help determine the remediation processes efficiencies.

Key Benefits

- **Sensitive:** High sensitivity to persistent chemicals (e.g. pharmaceuticals, pesticides, PFAS)
- **Affordable:** Low-cost electrodes enable widespread and frequent use
- **Simultaneous analysis:** Multichannel system to monitor multiple contaminant compounds
- **Portable and rapid:** Rapide response time (<2min), and on-site monitoring

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MICROFLUIDIC REMEDIATION SYSTEM FOR WASTEWATER TREATMENT

EDEN

To support the quaternary remediation step in water treatment plants, EDEN brings to the market a biomimetic (nature inspired) microfluidic system to remove organic pollutants, such as pharmaceuticals, plastic additives and pesticides, from wastewater.

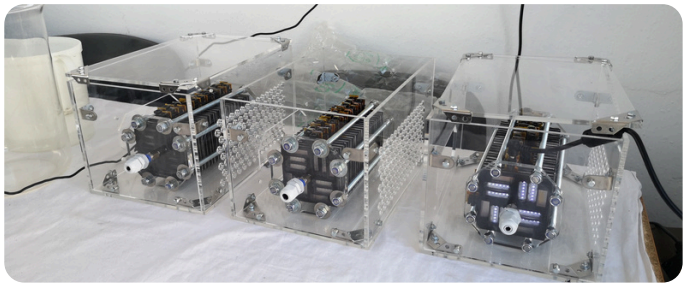

Figure 1:Scalable AKVO modules with stacks of microfluidic discs for increased water treatment capacity.

The revolutionary system draws inspiration from the human circulatory system. Just as the human circulatory system efficiently transports fluids and removes waste with minimal energy, AKVO's network of microchannels optimizes fluid flow and pollutant removal at low operating pressures and treats wastewater volume of up to 10 m^3 per day while consuming less energy than other conventional technologies. The device comprises microfluidic discs approximately the size of a CD. These are engraved with networks of microchannels and stacked into smart energy microfluidic grids.

Compact and sustainable design minimizes the prototype-to-product cycle and allows for a quick transition to industrialization.

The system's performance was validated during the iMERMAID's use case implementations at Opalia pharmaceutical company in Tunisia, where it was deployed to treat water heavily saturated with exceptionally high concentrations of pharmaceutical compounds such as ibuprofen, ketoprofen, and diclofenac.

Figure 2: A Single AKVO demonstration prototype module consisting of 20 discs.

In the long term, the solution will be able to treat volumes required by small municipalities and will offer the option for seamless integration to the existing plants. EDEN's microfluidic solution thus provides an adequate solution for the wastewater treatment plants with >100 000 and >10 000 p.e. load who are, according to the revised EU Urban Wastewater Treatment Directive, required to include the quaternary treatment stages by 2035 and 2040, respectively.

Key Benefits

- Efficient: Removes organic pollutants with efficiency >80%
- Sustainable: Low energy use and carbon impact, chemical-free, water reuse
- Modular: Scalable, flexible, easy to adjust to treatment needs
- Compact: Seamless integration in urban settings, easy maintenance

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OIL SENSOR BOX

BIOSENSE

BIOSENSE brings to the market a portable device for in-situ identification of toxic hydrocarbons from crude oil and its derivatives in fresh and salt water.

As maritime transport and related industrial activities increase, the contamination of waters with crude oil and its derivatives remains a recognised European problem. Oil industry as well as regional environmental and governmental organisations rely on state-of-the-art techniques such as fluorescence spectroscopy. However, these technologies are slow, lab-based and costly.

The robust portable solution provided by BIOSENSE (based on membrane inlet mass spectrometry) offers high resolution for the target compounds and sensitivity (to low ppb) in water, ensuring reliable detection of up to 64 elements simultaneously. The device is designed to be three times cheaper when compared to the well-known portable GC/MS systems. Not forgetting that the timely detection of oil leaks may save millions of euros on environmental fines & cleaning.

Figure 1: Analysis in the Larnaca marina

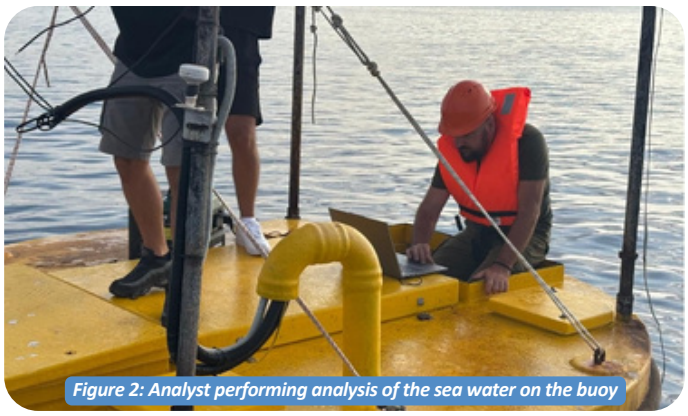

Figure 2: Analyst performing analysis of the sea water on the buoy

The sensor has been successfully deployed at several locations in Cyprus, including St. Raphael Marina near Limassol, a buoy located 2 km offshore from Limassol, and Larnaca Marina. These test deployments demonstrate that oil sensors are a viable option for effective pollution monitoring.

The next steps include finalizing the product and completing the data-processing software to make the instrument as user-friendly as possible. The goal is to develop a commercially available real-time VOC's monitoring system that can be deployed across various types of surface waters, fully compliant with EU regulations.

Key Benefits

- High stability allowing for continuous monitoring and trend detection
- Cheaper than lab
- Detection of concentration of individual oil compounds
- Real-time monitoring, no sample preparation

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WEEEFINER 4D SCAVENGER

WEEEFINER

WEEEFINER introduces to the market a 3D-printed, chemically functional porous filter system designed to selectively remove and recover heavy metal contaminants, such as Cu, Ni and Zn, from wastewater.

At EU level, there are alarming levels of some heavy metals in the environment that are harmful to human health and the environment. Recent policies and directives such as EU Sewage Sludge Directive or Industrial Emissions Directive are designed to lower these numbers if consequantly controlled.

WEEEFINER's 4D Scavenger® solution supports the mining, metallurgy and semiconductor industries in complying with existing and upcoming EU regulations. It provides a customisable remediation system with low energy requirements and high reaction kinetics that can be adapted to a range of applications.

Figure 1: The team of WEEEFINER, UNIFI and SMAT during the deployment of the remediation and monitoring technologies at the SMAT's wastewater treatment plant

The applicability of the 4D Scavenger® has been demonstrated at a wastewater treatment plants in Italy and Finland demonstrating the 4D Scavenger's potential to remove > 95% of the heavy metals present in the wastewater. The removed metals could be reused in the form of metal concentrates.

Figure 2: Picture of a 4D Scavenger unit designed for heavy metal removal from industrial wastewater. Picture shows the 4D Scavengers modules (8 pieces) as well as process piping and equipment.

The WEEEFINER's solution supports EU industries in adopting a closed-loop production model by reducing pollution and the need for virgin raw materials. At the same time, it generates additional revenue from the recycled materials and water. The long-term goal is to demonstrate the capabilities of 4D Scavenger in additional tests covering a range of sectors. Meanwhile, the product will be offered to selected market segments within the industrial wastewater treatment sector.

Key Benefits

- Easy scalability in moderate wastewater flows (< 250 m^3/h)
- Low chemical consumption compared to conventional approaches
- High metal recovery rate (>95%)
- Selective recovery of target elements

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PFAS SENSING EC BOX DEVICE

ZENTRIXLAB

Persistent Per- and Polyfluoroalkyl Substances (PFAS) are increasingly recognised as one of the most pressing environmental and public health challenges in Europe. Due to their persistence, bioaccumulation potential, and presence in drinking water and wastewater streams, regulatory pressure has intensified. Since January 2026, EU Member States are required to monitor and report PFAS levels under the recast Drinking Water Directive.

Zentrix Lab has developed a compact PFAS Monitoring EC Box designed to support continuous, on-site environmental screening. The system enables rapid quantitative indication of PFAS presence and supports remote data transmission, allowing operators to track trends and react early.

While accredited laboratory analysis remains the reference standard, the PFAS Monitoring EC Box serves as a complementary field-deployable monitoring tool. Its design allows distributed deployment across multiple sites, enabling long-term monitoring strategies at wastewater treatment plants, industrial discharge points, and drinking water facilities.

The solution focuses on affordability, ease of use, and scalable deployment — making proactive PFAS monitoring accessible beyond central laboratory infrastructure.

Field validation has demonstrated reliable operational performance in real wastewater environments. The solution supports utilities, regulators, and industrial operators in strengthening compliance readiness and risk management.

Zentrix Lab is currently preparing for broader market introduction across the Balkan and Central European regions, with further application expansion into industrial effluent monitoring and environmental remediation projects.

Commercial partnerships, regulatory pilots, and strategic distribution agreements are underway to accelerate market adoption.

Key Benefits

- Low-cost distributed monitoring
- Portable and rapid deployment
- Remote data transmission capability
- Supports regulatory compliance readiness

ZENTRIX LAB
Research&Innovation

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WATER INFORMATION AND REMEDIATION PLATFORM (iWIRE)

SOFTWATER

Environmental monitoring and wastewater treatment facilities are increasingly required to manage large volumes of heterogeneous data in order to comply with existing and emerging EU regulations, demonstrate treatment performance, and support data-driven decision-making. However, operational data are often fragmented across multiple systems and difficult to interpret by non-technical users.

iWIRE is a multi-stakeholder digital platform developed within the iMERMAID project to address this challenge. iWIRE integrates and visualises heterogeneous environmental datasets – including laboratory analyses, in situ and sensor data, climate information and contextual data – into a unified, user-friendly web interface. Through interactive dashboards and analytics, iWIRE enables transparent monitoring of water quality, assessment of remediation technologies, and comparison across sites and solutions.

The platform has been demonstrated across five Mediterranean use cases (Spain, Tunisia, Italy, Cyprus and Greece), covering industrial wastewater, municipal treatment plants, marine monitoring and landfill leachate. iWIRE supports different user profiles, from plant operators and technology providers to environmental agencies, policy makers and the general public, through differentiated access levels.

iWIRE establishes a robust digital infrastructure for environmental monitoring and remediation assessment at regional scale. Beyond iMERMAID, the platform is designed as an open, modular and reusable solution, with strong potential for adoption by water utilities, service operators, environmental consultancies, regulatory bodies, and future European projects. iWIRE will remain operational after the project and is positioned as a transferable digital asset for long-term exploitation.

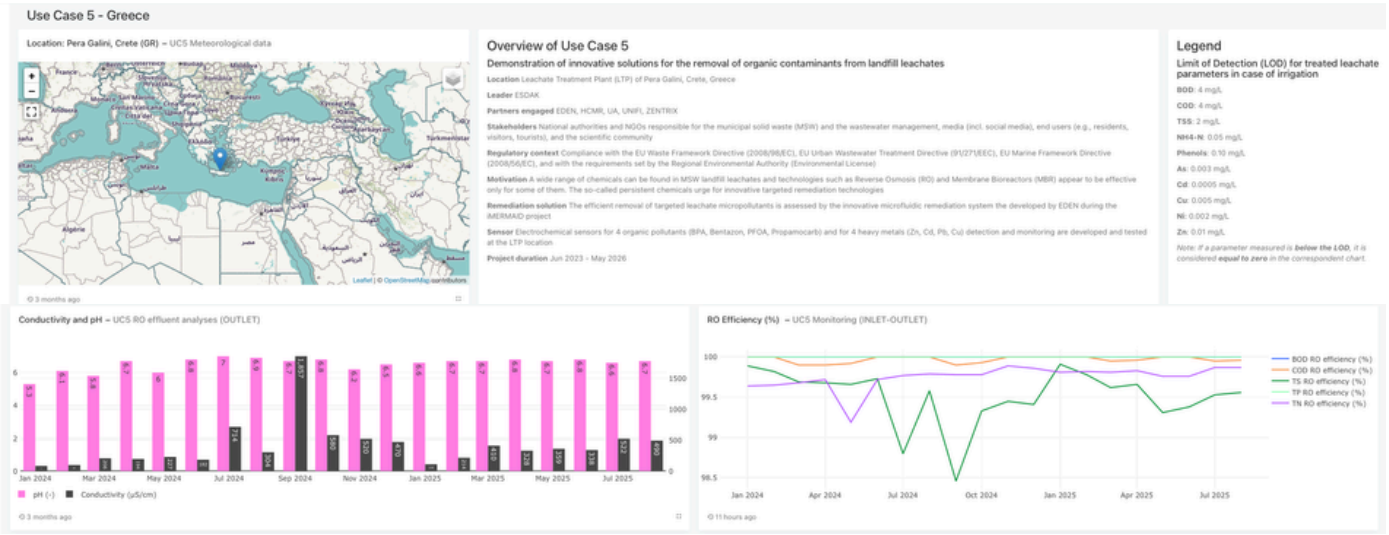

Figure 1: Screenshot of dashboard created for Use Case 5 in Pera Galini, Crete (Greece) on the platform https://iwire.soft-water.it/.

Key Benefits

- Integrated environmental data in one platform
- Interactive dashboards for decision support
- Reusable, open-source and scalable architecture

SoftWater

iWire platform
https://iwire.soft-water.it/

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IMMERSIVE DIGITAL TWIN OF SAN ESTEBAN DE LITERA WWTP - ITCL

Small wastewater treatment plants often lack advanced digitalisation tools. In many rural facilities, limited instrumentation and fragmented documentation make it difficult to visualise processes, train operators, or communicate plant operation to stakeholders.

Within the iMERMAID project, ITCL developed an immersive Digital Twin (DT) of the San Esteban de Litera Wastewater Treatment Plant, located in San Esteban de Litera.

Figure 1: A snapshot of the immersive Digital Twin - biological reactor at the San Esteban de Litera Wastewater Treatment Plant.

A detailed 3D model of the facility was created on Unity and deployed on Meta Quest 3 virtual reality glasses. The solution allows users to walk through the plant in an immersive environment, explore each treatment stage, and understand the layout and operation of the infrastructure in an intuitive way.

Due to limited on-site sensorisation, the DT is currently focused on spatial, structural and educational value rather than real-time data integration. However, the platform is designed to be scalable and ready for future integration of monitoring systems.

This immersive DT enhances communication, training and dissemination capacities, transforming a small rural WWTP into an innovative demonstrator of digitalisation in the water sector.

Figure 2: A snapshot of the immersive Digital Twin - San Esteban de Litera Wastewater Treatment Plant.

Furthermore, it forms a reference case for immersive digitalisation of small wastewater treatment plants. Future steps include the integration of process models and real-time data once additional sensorisation is implemented, enabling advanced monitoring, simulation and decision-support functionalities.

Key Benefits

- Immersive exploration of wastewater treatment processes
- Enhanced training and stakeholder engagement
- Low cost digitalisation for small rural WWTPs
- scalable platform ready for data integration

ITCL TECHNOLOGY CENTRE

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HEAVY METALS SENSOR BOX (HM BOX)

UNIFI

Due to their toxicity, persistence and potential for bioaccumulation, heavy metals are among the priority pollutants in European waters. The policies and directives such as EU Water Framework Directive and Industrial Emissions Directive are designed to support EU countries on their way to reduce the contamination of waters by heavy metals if consequently controlled. The state-of-the-art monitoring technologies such as spectroscopy are highly accurate and sensitive but, at the same time, highly expensive and operatable only off-side, in labs with experienced personnel.

UNIFI's portable heavy metal sensor box (HM Box) answers the need for an affordable alternative enabling real time quantitative monitoring of heavy metals directly on site. Equipped with miniaturised screen-printed sensors and relying on low power consumption, modularity, possibility of remote control and sharing results in the cloud, the HM box is capable to detect in few minutes Cd(II), Pb(II), Cu(II) and Zn(II) up to ppb levels in different types of waters. The ad-hoc designed device is equipped with a user-friendly software which supports by all steps users, including unskilled personnel.

Figure 1: The HMBox working at the WWTP in Brandizzo (Turin, Italy).

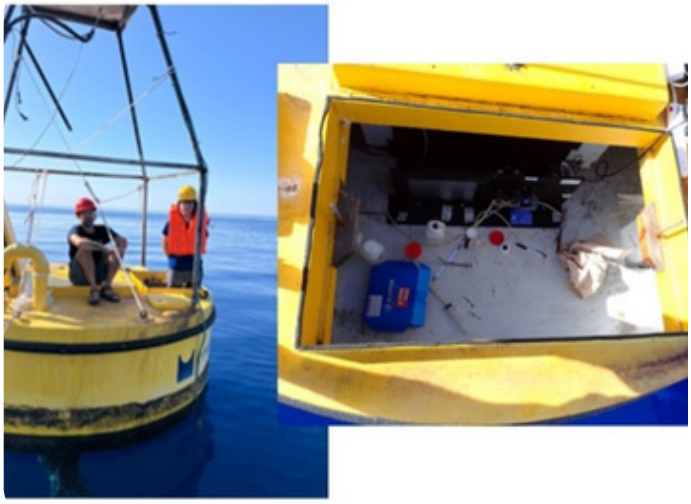

Figure 2: The HMBox installed in the marine buoy in the sea near to Limassol (Cyprus).

The solution has been tested on two use cases including a wastewater treatment plant in Brandizzo (Turin, Italy) and a marine buoy in Limassol (Cyprus) with results demonstrating that the HM Box being a valuable solution for real time monitoring and support for fast decision making. Unifi's HM Box is expected to support a wide range of stakeholders and safety regulators as a screening tool during field inspections or to quickly assess situation during contamination events.

Key Benefits

- Portable, remote controllable
- applicable to different type of waters
- Ability to measure Cd(II), Pb(II), Cu(II) and Zn(II) at ppb levels
- suitable for real time monitoring and as support for fast decision making

UNIVERSITÀ DEGLI STUDI FIRENZE

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H2O PEOPLE BLUE EDUCATION ACTION BOX (BE-AB)

H2O PEOPLE

Schools and youth organisations face a lack of ready-to-use, high-quality materials to teach complex water and pollution topics. Teachers often lack time or confidence to develop engaging activities, and existing education remains too passive to inspire real behavioural change and form the basis for a long-lasting societal change.

The **Blue Education – Action Box (BE-AB)** solves this by offering a complete, facilitator-friendly set of interactive tools that translate the latest iMERMAID knowledge on the mitigation of the water pollution caused by contaminants of emerging concern (CoEC) into creative, hands-on youth challenges. The Action Box can be delivered directly by H2O People or implemented autonomously by educators using the respective workbook – based on missions- and the educator handbook, offering a structured guide for each of the missions.

Figure 1: Banja Luka teachers using schooling

The BE-AB empowers young people to understand water challenges and recognise their own role in creating a cleaner, healthier environment within their own context. Through missions, experiments, and reflection tools, students connect real-world issues to their daily behaviours—building insight, agency, and motivation. Educators benefit from time-saving, high-quality materials backed by scientific expertise. Municipalities, NGOs, and project partners gain an accessible outreach product that can be replicated across Europe.

Next steps include scaling the workbook and respective handbook for educators in other languages, integrating it into partner outreach programmes, and expanding the model to future EU projects and youth-led initiatives focused on water, sustainability, and behavioural change.

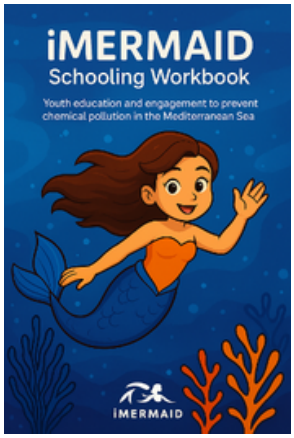

Figure 2: iMERMAID Schooling Workbook

Key Benefits

- Ready-to-use, high-quality educational materials
- Saves teacher preparation time and effort
- Engaging youth challenges driving behaviour change
- Scalable and contextualised outreach tool for partners

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H2O PEOPLE HUMAN-CENTRIC IMPACT FRAMEWORK (HCIF)

H2O PEOPLE

The notion of *impact* is increasingly required in EU projects, public programmes, and organisational strategies — yet most teams involved in these projects lack **impact literacy**, time, and practical tools to design meaningful strategies for impact that would lead to lasting change, within and beyond the project boundaries. Stakeholders often feel disconnected from impact processes, leading to low engagement and reduced uptake of project outcomes.

The **H2O People Human-Centric Impact Framework (HCIF)** provides a structured, accessible, and people-focused approach for defining, assessing, and communicating impact. The framework combines science-based methods with human-centred design, enabling organisations to understand behavioural drivers, co-create interventions, and measure real-world change.

Delivered as a ready-to-use toolkit supported by H2O People consultants, the HCIF helps teams break silos, align around shared goals, and create impact pathways that resonate with professionals and project partners, as well as with key external stakeholders, such as citizens.

The HCIF strengthens impact literacy, builds internal capacity, and increases engagement by making impact visible, actionable, and meaningful for all stakeholders. It enables organisations to move from compliance-driven reporting to true value creation.

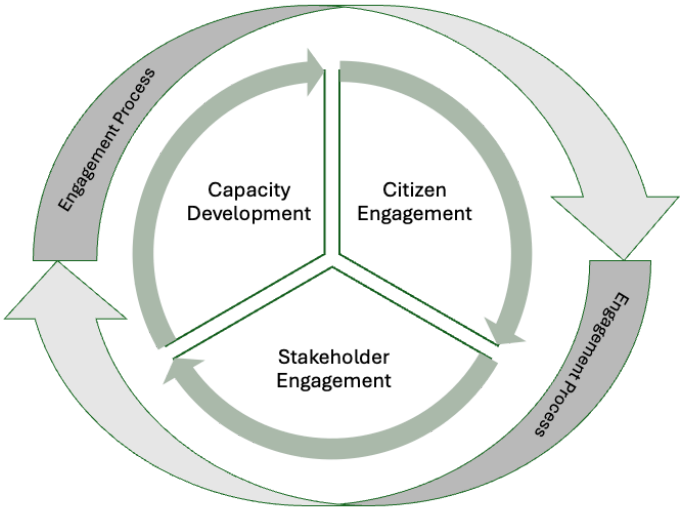

Figure 1: The H2O People Toolkit for Social Impact can be utilized throughout the engagement process

Next steps include scaling the digital version of the toolkit embedded in the framework, integrating it into training programmes, and expanding its use across EU projects, municipalities, research institutions, and the water sector for validation and further valorisation purposes The HCIF will serve as a long-term asset for partners aiming to embed human-centric design into their everyday work and behavioural understanding into their impact strategies.

Key Benefits

- Human-centric design for real impact
- Ready-to-use framework strengthening impact literacy
- Engages stakeholders and breaks organizational silos
- Clear pathways for behavioural change

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PDP TECHNOLOGY DEPLOYED AT THE WASTEWATER TREATMENT PLANT - IRIS

Industrial and municipal wastewater increasingly contains persistent organic micropollutants, including dyes, pharmaceuticals, pesticides and PFAS-related substances, that are poorly removed by conventional biological treatment. IRIS has developed HiNaPEF, a modular Pulsed Discharge Plasma (PDP) remediation system designed as an advanced polishing step for difficult wastewaters. The process creates short, high-energy electrical discharges directly in water, generating reactive species such as hydroxyl radicals without dosing oxidants or producing chemical sludge.

This makes HiNaPEF attractive for textile, pharmaceuticals, and many other industries, as well as wastewater treatment operators, that need to reduce Contaminants of Emerging Concern and prepare for stricter requirements under the revised Urban Waste Water Treatment Directive and Industrial Emission Directive. The system can be installed as a compact add-on to existing treatment lines, treating selected sidestreams or final effluents where conventional solutions such as activated carbon or ozonation may be consumable-intensive or create secondary concerns.

Impact and next steps:

The technology has been demonstrated on real wastewater from San Esteban de Litera, validating PDP as a robust option for reducing recalcitrant organics under relevant operating conditions. The next step is scale-up and field validation with industrial end-users, focusing on performance, energy efficiency, operational stability and integration into reuse-oriented water loops.

Overall impact

HiNaPEF helps EU industries move towards safer discharge and water reuse by reducing micropollutant loads without additional chemicals. By enabling modular, on-demand advanced oxidation, IRIS supports circular water management, regulatory readiness and reduced dependence on scarce freshwater resources.

The long-term goal is to extend PDP applications to industrial wastewater sectors where persistent organic pollutants limit reuse or discharge compliance.

Figure 1: PDP technology deployed in San Esteban de Litera

Key Benefits

- Chemical-free advanced oxidation
- Targets recalcitrant micropollutants and CoECs
- Compact retrofit for existing treatment lines
- Modular scale-up for industrial reuse

IRIS PLAYGROUND FOR NEW IDEAS

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