Yearly Water Innovation

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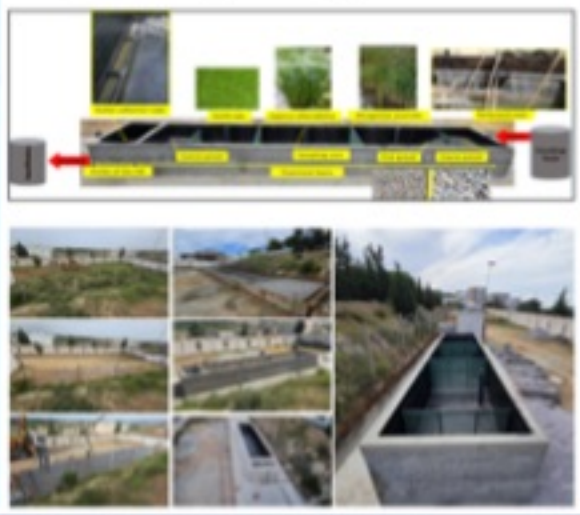
CIRQUA - NEWSLETTER

4 Pilot Sites | 4 Countries | 140 m² Total CW Area | Pathogen Removal

DUTH's CW prototype

ABC's CW prototype



CIIMAR's upgraded CW

ASU's CW prototype

Figure 1: CIRQUA's four Constructed Wetland pilot sites across the Mediterranean.

Waterwise Futures: Integrated Approaches at Local Scale for Enhancing Water Reuse Efficiency and Sustainable Soil Fertilization from Wastewater's Recovered Nutrients

Our Four Pilot Sites:
CIRQUA has designed, constructed, and is operating four CW demonstration systems across Greece, Tunisia, Portugal, and Egypt — each integrating horizontal subsurface flow wetlands with nanofilter units and photocatalytic modules.

About CIRQUA: The CIRQUA project (Integrated Approaches at Local Scale for Enhancing Water Reuse Efficiency and Sustainable Soil Fertilization from Wastewater's Recovered Nutrients) is a PRIMA-funded initiative developing nature-based, decentralized wastewater treatment solutions across the Mediterranean. Through innovative Constructed Wetland (CW) prototypes enhanced with nanofilter units and photocatalytic modules, CIRQUA demonstrates that treated wastewater can be safely reused for agriculture while recovering nutrients for soil fertilization.

CIRQUA Waterwise Futures

PRIMA PARTNERSHIP FOR RESEARCH AND INNOVATION IN THE MEDITERRANEAN AREA

This project is part of the PRIMA programme supported by the European Union

PILOT SITE PROFILES

❶ DUTH Pilot Site — Xanthi, Greece

Democritus University of Thrace • 20 m²

Horizontal subsurface flow fully-automated with PLC CW with four stainless steel compartments planted with *Typha* and *Caltha*. Equipped with nanofilter and photocatalytic module (TiO_2-coated glass tubes). Achieved complete removal of *enterococci/coliforms*, high DNA reduction, and zebrafish toxicity eliminated.

❷ ABC Pilot Site — Sidi Thabet, Tunisia

Higher Institute of Biotechnology • 20 m²

Concrete-based CW with *Phragmites australis*, *Cyperus alternifolius*, and *Azolla* spp. Sand filter with nanofilter material and 400 L photocatalytic module. Results: Almost complete pathogen removal; *Vibrio cholerae* eliminated. Managed by Raspberry Pi/Arduino-based Smart Industrial Control Unit (SICU-1).

❸ CIIMAR Pilot Site — Ponte de Lima, Portugal

Paço de Calheiros • 40 m²

Upgraded existing gravity-fed CW (15 years operational, zero energy). Features *Canna flaccida*, *Zantedeschia aethiopica*, and *C. indica*. CIRQUA added MOF-based nanofilter and photocatalytic module. Automated via PLC with HMI. Ecotoxicity testing confirmed significant toxicity reduction.

❹ ASU Pilot Site — Giza, Egypt

Zenin Wastewater Treatment Plant • 60 m² (3 cells × 20)

Largest CIRQUA pilot: three parallel CW cells (10×2 m) with graded gravel substrates. Nanofilter unit and UV photocatalytic module PLC automation. Enhanced protozoan cyst reduction (*Giardia*, *Cryptosporidium*, *Entamoeba*).

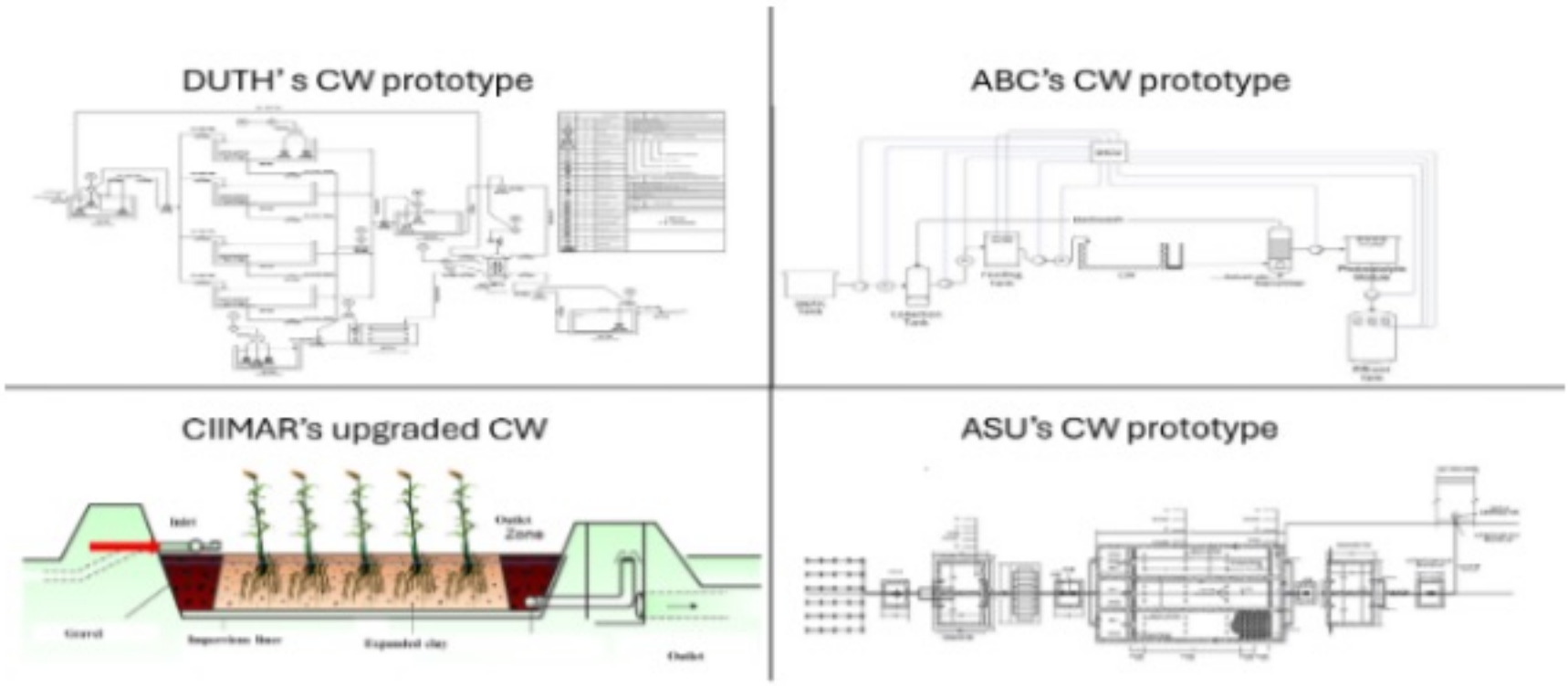


Figure 2: Automation system designs for all four CIRQUA CW prototypes.

KEY RESULTS & INNOVATIONS

Treatment Performance Highlights

Parameter	Performance	Significance
Orthophosphate Removal	**Up to 99%**	High performance for CW prototypes
Heavy Metals	**Below EU Directive**	Meets Drinking Water Directive 2020/2184
Pathogen Removal	**Almost complete pathogen removal**	Below national threshold limits for water reuse
Residual DNA Reduction	**Multiple-fold DNA Reduction**	Marked Decrease in DNA Levels
Micropollutants	**Effective removal**	Including pesticides and antibiotics
Zebrafish Toxicity	**Up to no effect**	From influent to PhC outflow (DUTH)

Advanced Nanofilter Units:

Each pilot integrates a nanofilter loaded with Metal-Organic Framework composites (MOFCs). Synthesized from bamboo biochar, bentonite clay, and calcium alginate, these materials effectively reduce suspended solids, orthophosphates, total phosphorus, and heavy metals.

Photocatalytic Modules

The final treatment stage employs TiO_2-based photocatalytic modules under UV irradiation. The modules reduce residual DNA, eliminate pathogens, and remove micropollutants including pesticides and antibiotics — ensuring treated water meets quality standards for agricultural reuse.

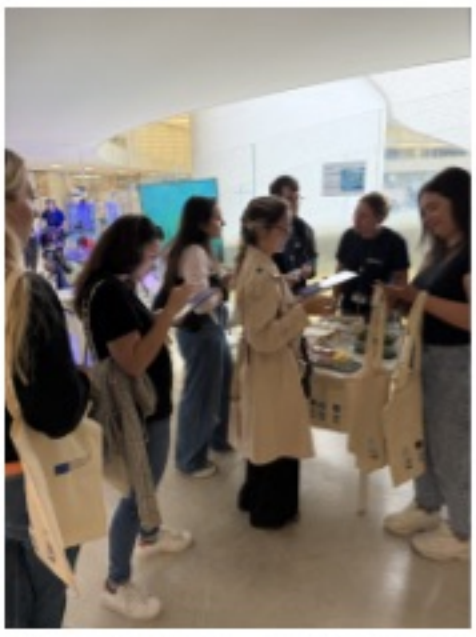
Smart Automation & Circular Economy

All pilot sites feature real-time monitoring of pH, conductivity, dissolved oxygen, turbidity, temperature, and flow rate via PLCs or custom Smart Industrial Control Units — enabling remote operation and process optimization. Beyond water treatment, CIRQUA explores MOF composites as nanostructured fertilizers with slow-release nutrient capacity. Ecotoxicity tests with *Daphnia magna*, *Danio rerio*, and plants confirmed the biocompatibility of treated water for safe agricultural reuse.

Project Highlights & Events

CIRQUA has been bustling with activity, fostering collaboration and sharing knowledge across the Mediterranean.

CIRQUA's Strong Presence at the Agrown Conference: Members of the CIRQUA consortium led a critical discussion at the Agrown Conference, focusing on the highly relevant topic of "Water Reuse and Precision Agriculture.



Promoting Sustainable Water Management: The event allowed for meaningful engagement with the community, proving once again that public involvement is key to a sustainable future.

CIRQUA Went global: Our team member Cristina Calheiros traveled to Maputo, Mozambique, to share the message of the CIRQUA Water project with the students at the Lycée Gustave Eiffel.

Engaging with young minds across the globe made this educational mission an incredibly rewarding experience for our team.

LOOKING AHEAD

Next steps: CW technology upscaling at demonstration scale; evaluating plant yields with biomass derived nanostructured fertilizers and CW effluent; Life Cycle and Techno-Economic Assessments; expanding citizen science through WaterWatchers and Soil Guardians; and further dissemination across all partner countries.

COMMUNICATION & DATA VISUALIZATION

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