LIFE PureAgroH2O

NATURAL BASED SOLUTIONS COMBINED WITH SOLAR PHOTOCHEMISTRY FOR URBAN WASTEWATER REGENERATION

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CIEMAT-Plataforma Solar de Almería

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ENI CBCMED Cooperating across borders in the Mediterranean

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REGIONE AUTÒNOMA DE SARDIGNA
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AQUACYCLE

CIESOL
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Outline

- Introduction & Motivation
- AQUACYCLE Project
- The APOC system at DEMO scale
- Simultaneous water decontamination & disinfection
- Conclusions

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Introduction & Motivation

Drought in the Mediterranean Region - January 2024

JRC Global Drought Observatory (GDO) of the Copernicus Emergency Management Service (CEMS) – GDO/EDO data up to 20/01/2024

Long-lasting, above-average temperatures, warm spells and poor precipitation have led to severe drought conditions in the Mediterranean region affecting numerous areas across southern Italy, southern Spain, Malta, Morocco, Algeria, and Tunisia.

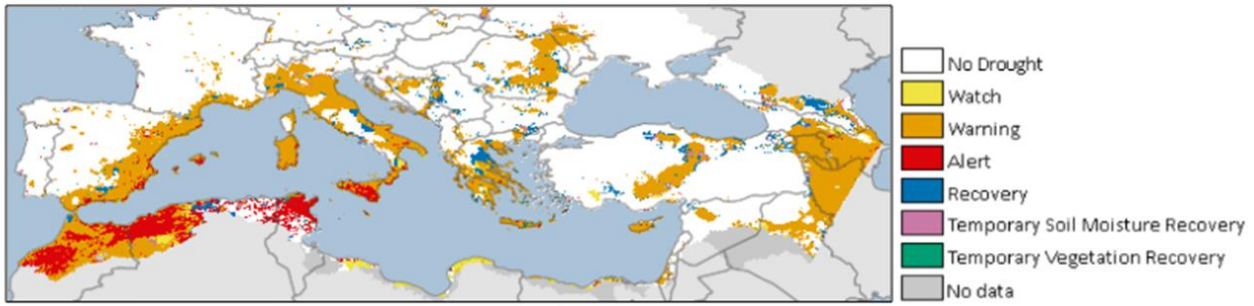


Figure 1: The Combined Drought Indicator (CDI), based on a combination of indicators of precipitation, soil moisture, and vegetation conditions, for mid-January 2024.[1]

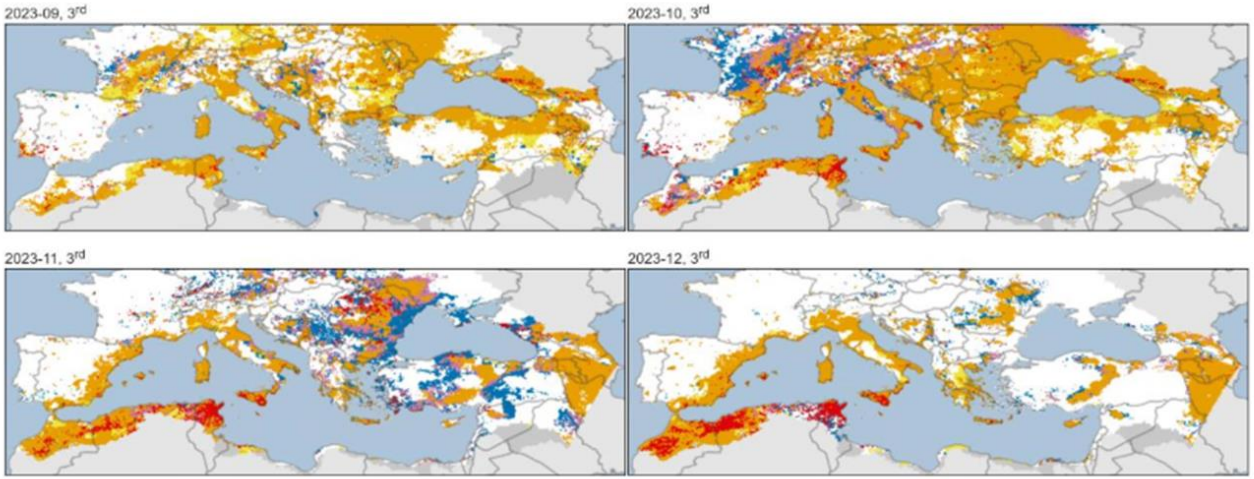


Figure 2: The Combined Drought Indicator (CDI), based on a combination of indicators of precipitation, soil moisture, and vegetation conditions, from September to December 2023.[1]

Introduction & Motivation: The MED challenges

Water Shortages

Limited water availability – Imbalance between water requirements and water supply due to population growth, urbanization and economic development

Changing Climate

Mediterranean is one of the **most vulnerable regions** in the world to the impacts of **global warming** – lower rainfall precipitation, extensive droughts, extreme wildfires

Untreated wastewater

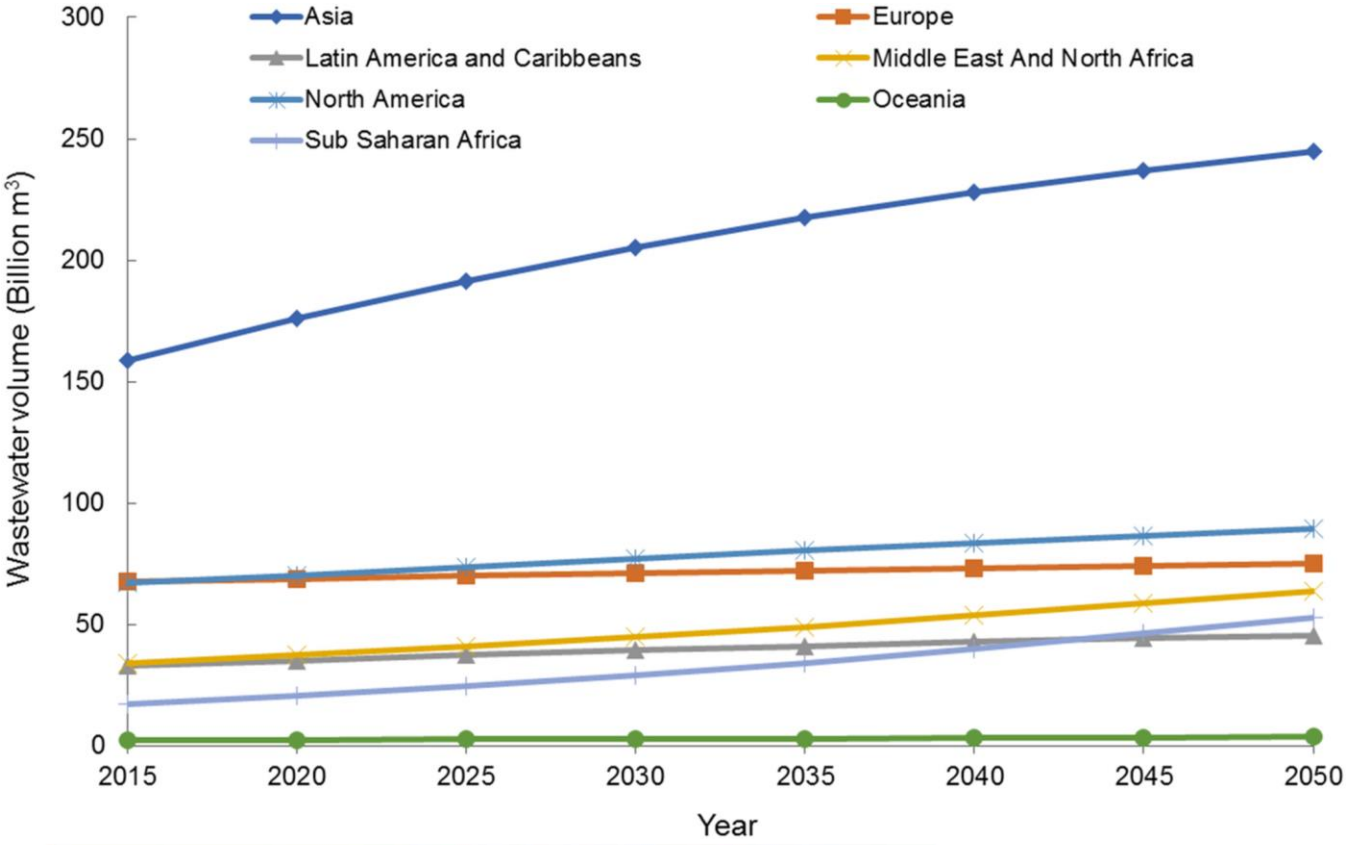
40% of cities in the Mediterranean with a population between 2,000-10,000 inhabitants are **not connected to any wastewater treatment plant**

Economic slowdown

The Mediterranean is affected by a generalized **economic slowdown** which is driven, among others, by the consequences of COVID-19 pandemic, the reduction in investments and a lack of sufficient employment opportunities

Introduction-Motivation: Water Reclamation, a global need

It is estimated an annual world production of **urban wastewater of 380 km^3**, that is 15% of water withdrawal for agriculture (42 millions ha).
World urban wastewater production is estimated to increase **24% in 2030 and 51% in 2050**.



Nutrients in urban wastewaters:
16.6 Tg (Tg = million of metric tons) of nitrogen; 3 Tg for phosphorous and 6.3 Tg for potassium.
Total recovery of nutrients from urban wastewaters would compensate the 13.4% of the world demand for agriculture.

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AQUACYCLE Project

AQUACYCLE Towards Sustainable Treatment and Reuse of Wastewater in the Mediterranean Region

ENI CBCMED
Cooperating across borders in the Mediterranean

4 EU partners, 3 Mediterranean partners, and 4 Associated Partners from Greece, France, Algeria, Morocco

01.09.2019-31.10.2023

Priority B.4.1 Water Efficiency

Support sustainable initiatives targeting innovative and technological solutions to increase water efficiency and encourage use of non-conventional water supply

AQUACYCLE Project: achieved targets

Target

150

hectares of land irrigated with non-conventional water

Target

2,700,000

m³/year of non-conventional water supply used for domestic purposes

North Governorate of Lebanon

Murcia Region of Spain

Zaghouan Governorate of Tunisia

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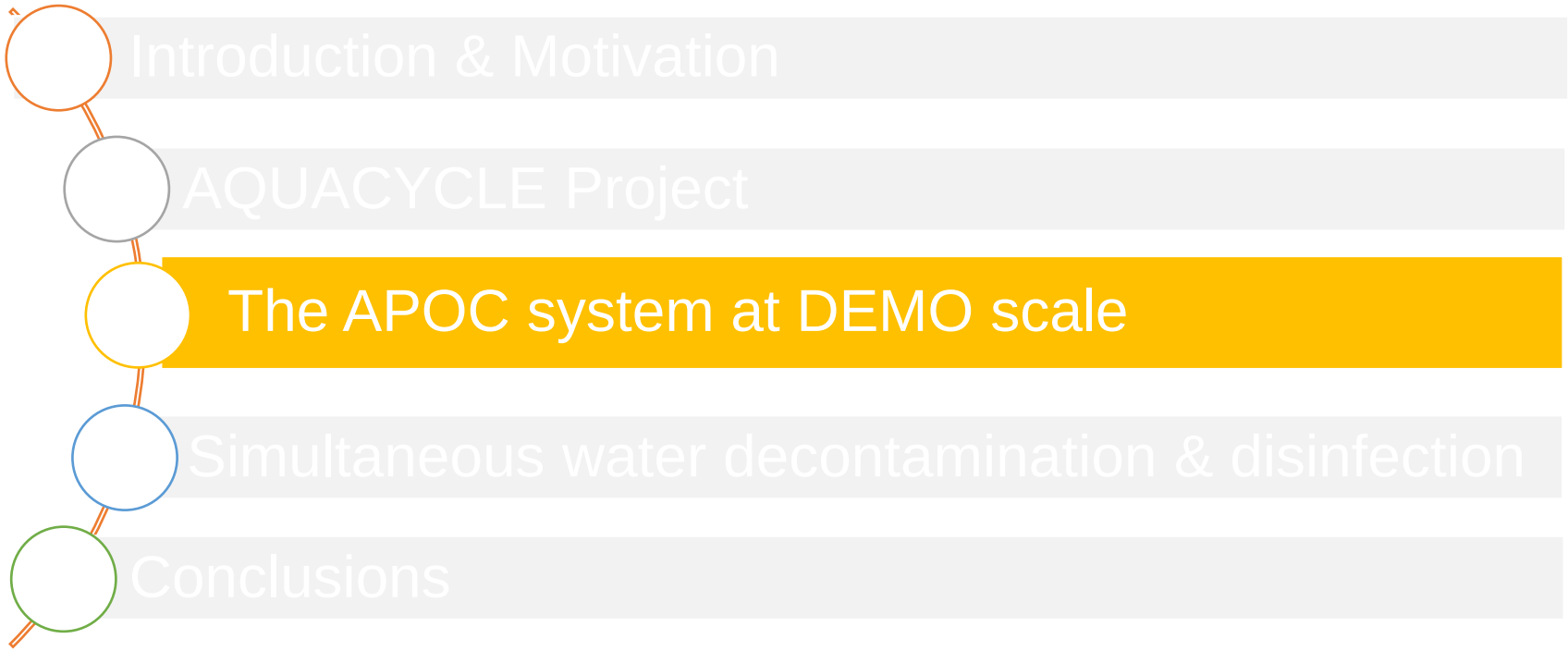
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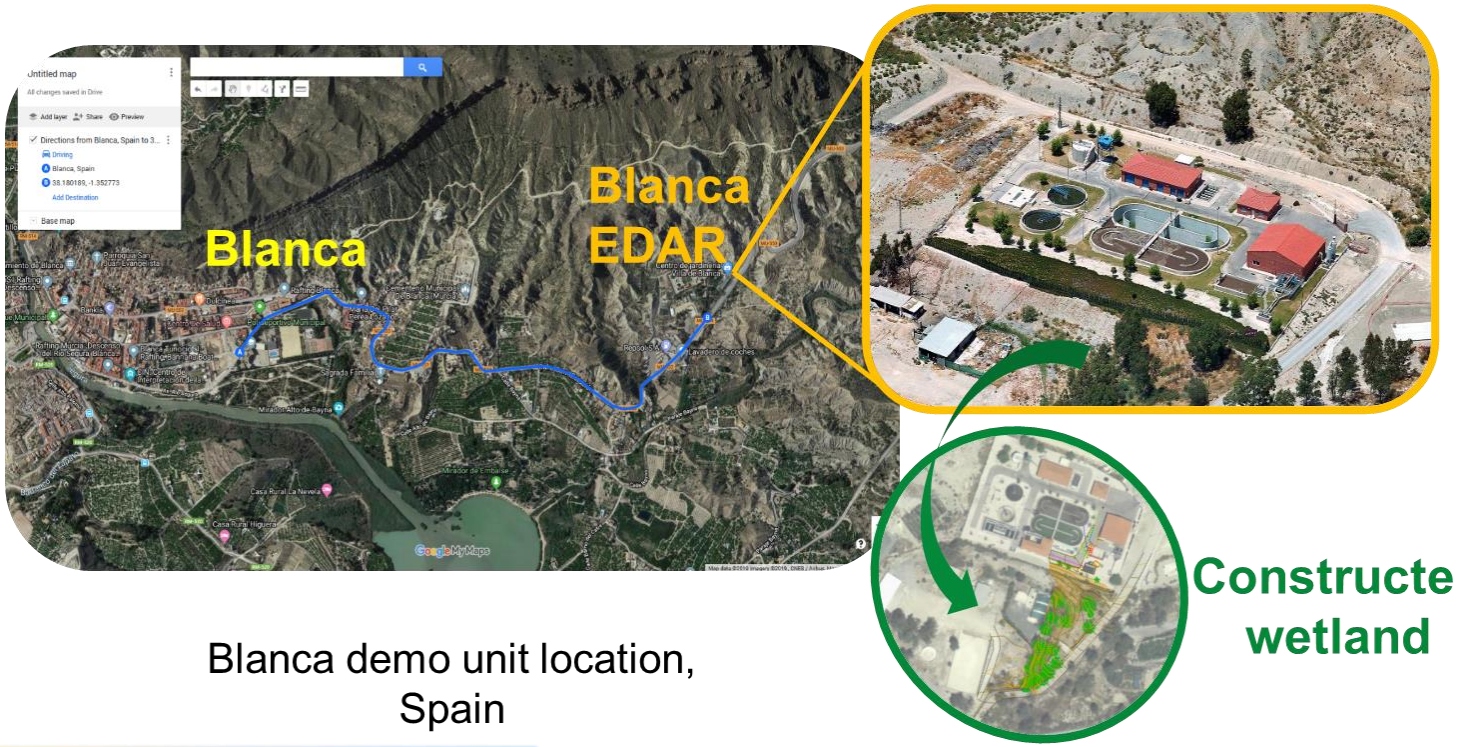
The APOC system at DEMO scale

Demo plant in Blanca WWTP, operated by ESAMUR and CIEMAT-PSA

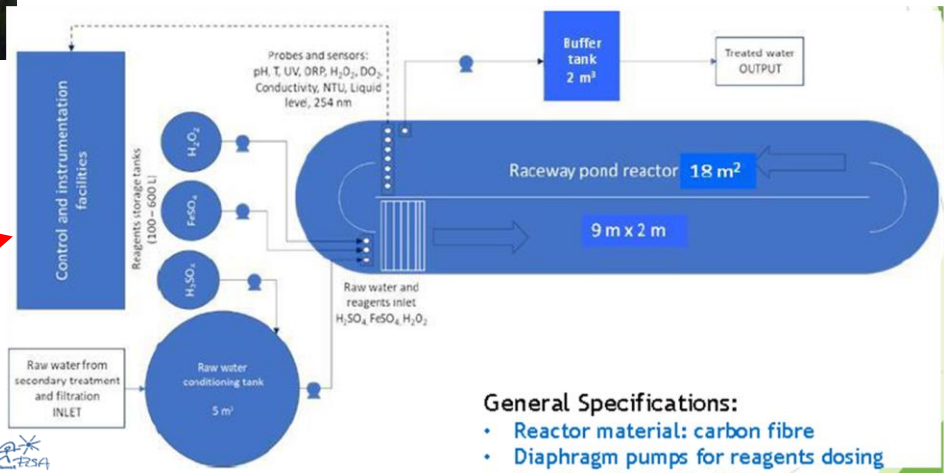
- ✓ Feed flow rate 5 m^3/d
- ✓ AD: existing ***Upflow Anaerobic Sludge Blanket*** (UASB) reactor
- ✓ CW: two CWs, connected in series, one ***subsurface vertical wetland*** and one ***subsurface horizontal wetland***
- ✓ PO: solar photoreactor in the form of a ***raceway pond (RPR)***



Blanca demo unit location, Spain

The APOC system at DEMO scale in Blanca (Murcia, Spain)

Anaerobic biorreactor
(700 m^3/day)



General Specifications:

- Reactor material: carbon fibre
- Diaphragm pumps for reagents dosing
- Sensors: pH, T, UV, dissolved oxygen

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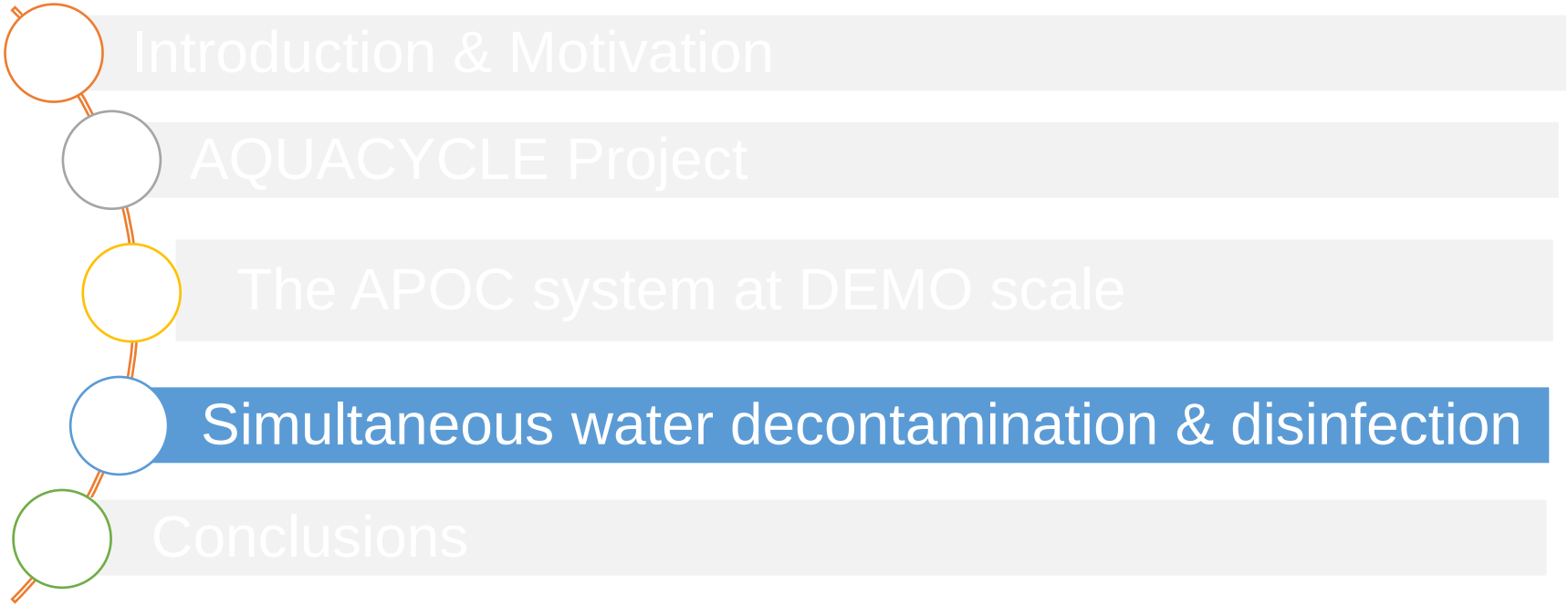
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Simultaneous water decontamination and disinfection

- To investigate and optimize an advanced solar quaternary treatment at pilot scale (90 L) based on the addition of H_2O_2, for further validation at demonstrative scale (2000 L) for compiling with the new EU regulation on minimum requirements for water reuse in agriculture.

EU Regulation 2020/741*(June 2023)*

*Legislative Limit (Class A)	*E. coli* ≤ 10 CFU/100mL	*Technology validation	≥ 5 LRV* *E. coli*
	Spore-forming SRB ≤ 20 CFU/100mL		≥ 5 LRV* Spore-forming SRB

tion Value

Challenges on wastewater reclamation

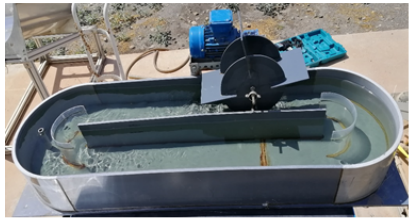
- Contaminants of Emerging Concern (CECs), persistent contaminants
- Microbial pathogens
- Antibiotic Resistance Bacteria and Genes (ARB, ARGs)
- Disinfection by-products

Crop irrigation water → Harmful to humans and ecosystems

Simultaneous water decontamination and disinfection

Pilot Plant

✓ **Raceway Pond Reactor (RPR)**



- Total volume: 90 L
- Illuminated surface: 0.6 m^2

✓ **Microorganisms**

- *Escherichia coli*: 10^2 CFU/100 mL
- *Enterococcus* spp.: 10^3 CFU/100 mL
- Total coliforms: 10^5 CFU/100 mL
- Spore-forming SRB: 10^3 CFU/100 mL

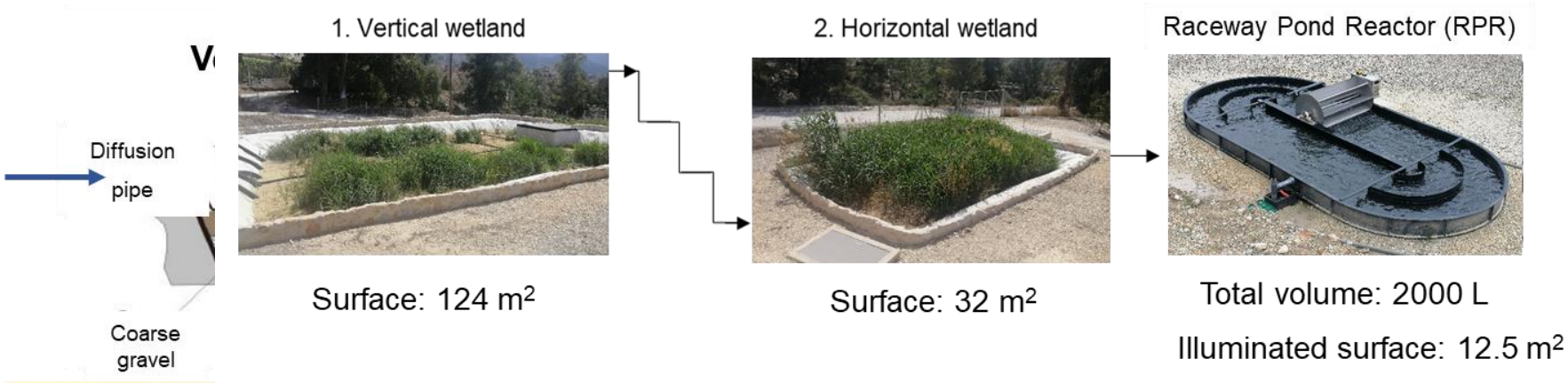
✓ **Oxidant**

- $[H_2O_2]$: 50, 100 mg/L

✓ **CECs**

- ∑ 223: antibiotics, pesticides, insecticides, etc.

Demo Plant



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- CWs+RPR system is an effective solution for wastewater quaternary treatment for being reused in crop irrigation.
- CECs average adsorption/degradation along CWs was 88% at ng/L.
- The best CEC removal in the RPR (at pilot plant and demo plant scale) was 50% with natural solar radiation and 100 mg/L of H_2O_2.
- Within such operating conditions, the water quality limit of *E. coli* and Spore-forming SRB required by the new EU Regulation for water reuse in agriculture is achieved confirming the non-regrowth of bacteria after 48 h of storage.
- Phytotoxicity and ecotoxicity results demonstrated the safe reusing potential of UWW treated by solar/H_2O_2.

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Thank you very much for your attention!

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