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Wastewater in Small Communities

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LIFE PHOENIX: Innovative cost-effective treatments for reusing water and nutrients for agricultural application in small communities

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BACKGROUND OF THE PROJECT

- 20% of the Mediterranean population lives under permanent water stress conditions (EEA), increasing to more than 50% in summer.
- In Spain, the reuse of wastewater is regulated by RD1620/2007, which set different requirements in terms of contaminants according to its final use.
- European Parliament → European Directive 2020/741, more severe water quality limits

Table 2 – Proposed reclaimed water quality requirements

Water quality class	Quality requirements				
	E. coli, cfu/100 ml	Biological oxygen demand (BOD_5), mg/l	Total suspended solids (TSS), mg/l	Turbidity (NTU)	Other
A	≤10*	≤10	≤10	≤5	*Legionella spp.*: <1,000 cfu/l where there is risk of aerosolisation in greenhouses Intestinal nematodes (Helminth eggs): ≤1 egg/l for irrigation of pastures or forage
B	≤100	25 mg/l O_2**	35 mg/l**	-	
C	≤1 000			-	
D	≤10 000			-	

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OBJECTIVES OF THE PROJECT

- The main objective is to obtain reclaimed water that meets the new European Regulation 2020/741, while eliminating microplastics (MPs) and contaminants of emergent concern (CECs).

1

Obtaining reclaimed water meeting A quality (WWR-EU):

-Solutions for large-medium WWTPs

-Solutions for small WWTPs

2

Develop a Decision Support System (DSS) and a Sustainability Tool to ensure feasibility for each case & waste water.

3

Minimize environmental & health effects caused by reclaimed water use by reduction of:

-Harmful disinfection/oxidation products & eco-toxicity (>80%)

- >90% Compounds of Emergent Concern (CECs) & antibiotic resistant bacteria (ARB)

-97% microplastics (MPs)

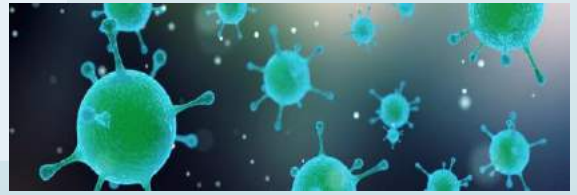
-C footprint (50%)

4

Ensure water quality by:

-Online monitoring: toxics (UV-vis); pathogens (enzymatic activity).

-Offline analyses: MPs, eco-toxicity, ARB.



5

Recover more than 90% nutrients (N,P)

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OBJECTIVES OF THE PROJECT

6 **Test reclaimed water & recovered fertilizer** at experimental crop fields (500 m^2)

7 **Reduce to 0.10-0.15 €/m^3 OPEX of the treatment**:

-30% lower fouling membranes

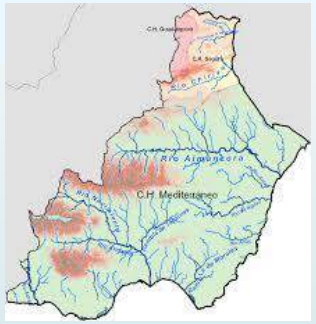
-Low energy UV-LED & Solar Photo-Fenton

-Residual O_3 reuse to advanced flotation (20%)

-Reduce size of disinfection due to efficient pretreatment

-Optimal technologies configuration by DSS

8 **Study of WWR-EU incidence in existing WWRTPs-Almeria-ES inventory**



9 **Promote replication, transferability & market uptake** by a Stakeholder Panel

10 **Evaluation of environmental, social & economic impacts**

11 **Results Dissemination**

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GENERAL OVERVIEW

WATER REUSE CASE STUDIES

DECISION SUPPORT SYSTEM

REPLICABILITY: ALMERIA CASE STUDY

Large-Medium WWTPs

PRETREATMENTS
Ballaste lamella clarification, high rate disolved ozoned flotation (DOF), disk filter, pre-ozonization…

DISINFECTION + AOPs
Ozone, UV, H2O2
Advanced Oxidation Systems (AOPs)

PATHOGEN ONLINE MONITORING

Small WWTPs

PRETREATMENTS
Microalgae HRAP + DAF
Innovative constructed wetlands

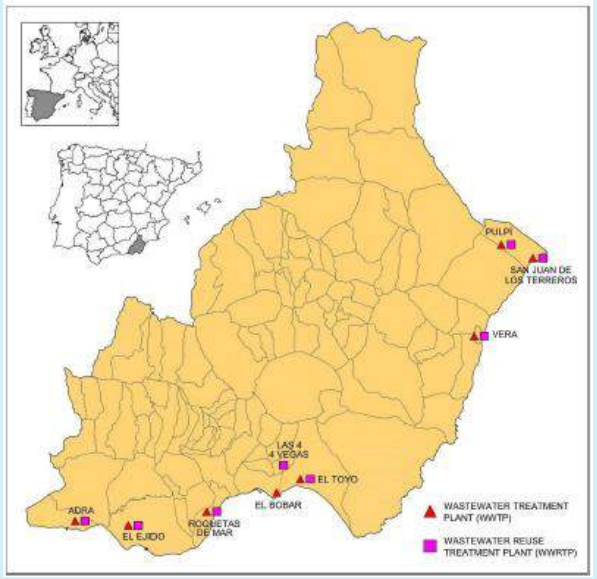
DISINFECTION + AOPs
Solar driven AOPs, UV-LED

NUTRIENT RECOVERY BY ZEOLITE

PATHOGEN ONLINE MONITORING

TRANSFERABILITY AND MARKET UPTAKE

CROP FIELD TEST



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EXPERIMENTAL PLANT AND TECHNOLOGIES

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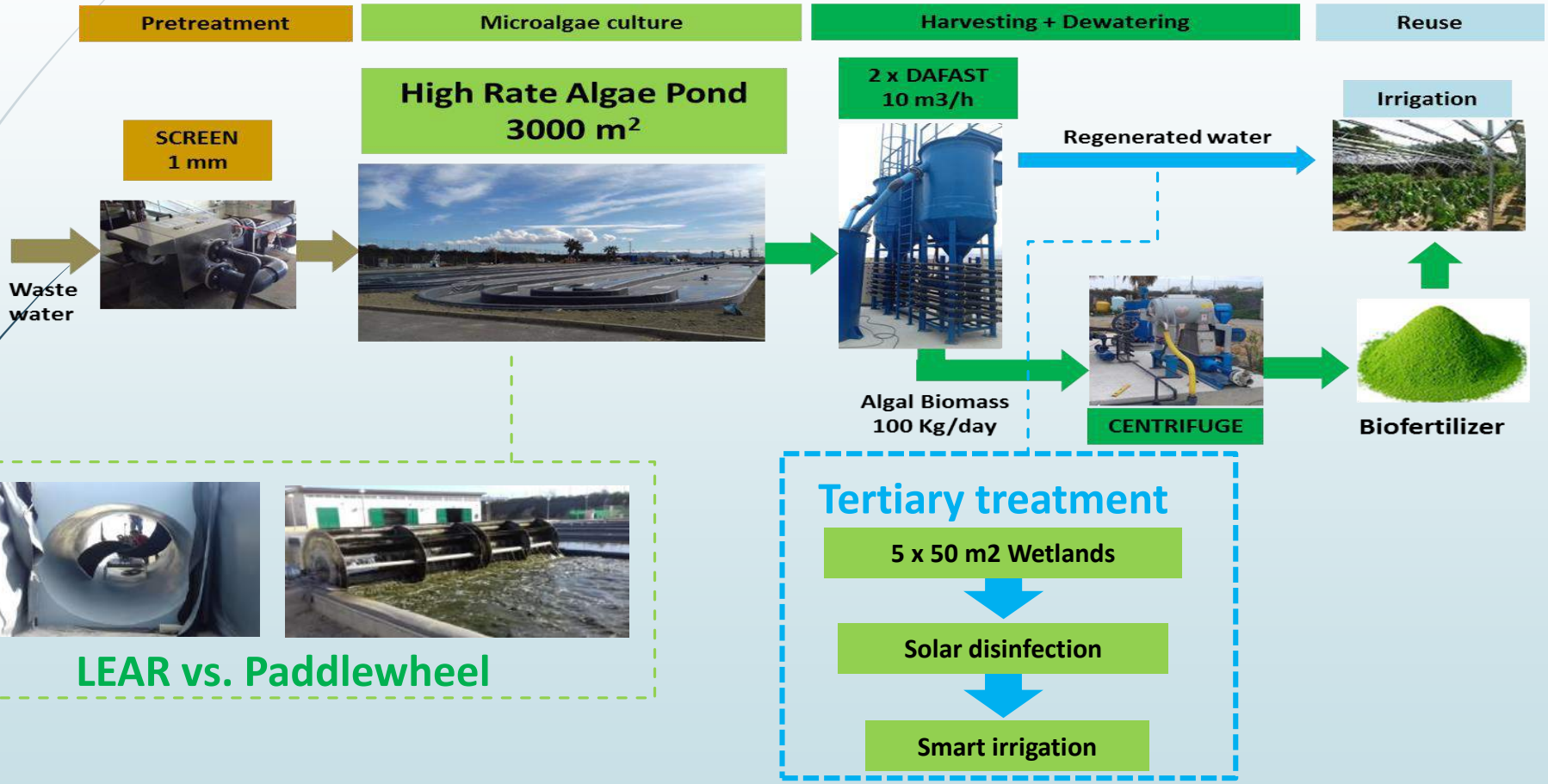

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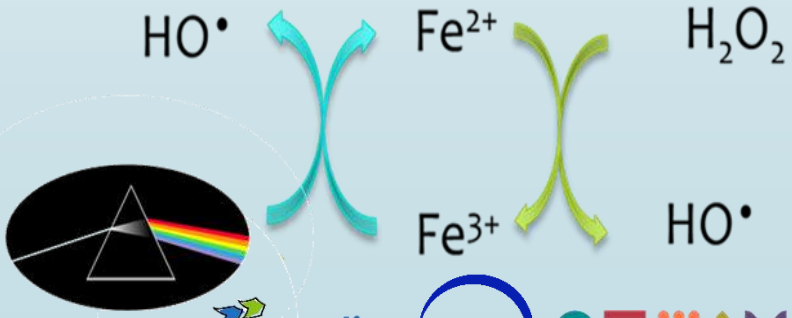
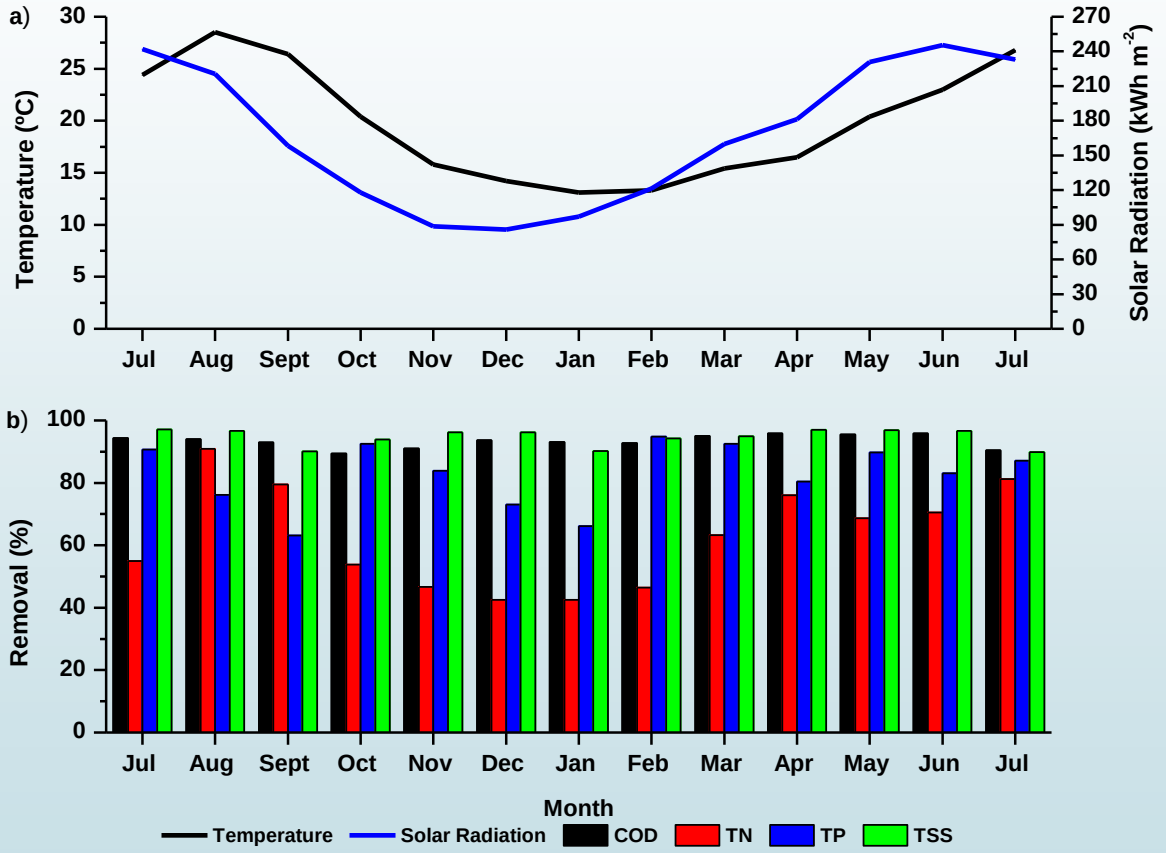
EXPERIMENTAL PLANT AND TECHNOLOGIES

- Photo-Fenton solar disinfection:
  - Sunlight as a source of radiation → advanced oxidation process (AOP)
  - Based on the generation of hydroxyl radicals (OH·)
  - Promising efficiency in terms of disinfection and removal of CECs
  - Low-cost raceway pond reactor (RPR) in continuous mode



PRELIMINARY RESULTS

- Microalgae raceway + harvesting
  - Monitoring of the COD, TSS, TN, TP, turbidity and pathogens in the inlet (pretreated WW) and outlet of the harvesting.
    - >90% COD removal
    - TN: 50% (Autumn – Winter) // 70-90% (Spring — Summer)
    - TP: 70% (Autumn – Winter) // 90% (Spring — Summer)
    - 98% turbidity removal
    - 95% TSS removal
    - 99% pathogen removal



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PRELIMINARY RESULTS

- Harvesting and dewatering
  - High recovery efficiency in the DAFAST
    - over 97% TSS removal
    - 44g/L
    - x48 concentration factor
  - Further centrifugation step → over 120g/L

Thickened biomass

Dewatered biomass

- Wetlands
  - TSS content <0.3 mg/L; turbidity <5NTU; pathogen content (E.Coli < 100 CFU/100mL)
  - Meets RD1620/2007 for several uses

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PRELIMINARY RESULTS

- Solar Photo-Fenton:
  - Neutral pH treatment requires Fe^{3+}–EDDS complex → higher operation costs
  - The application of Fe^{3+}-NTA complex is under study
  - Working at acid pH is investigated → lower operation costs, more oxidizing conditions
    - Further neutralization in calcium carbonate columns – also retains precipitated iron after neutralization
    - Results: [CECs] in the range of 20-50 µg/L – removal of >80%; HRT=30min
    - Laboratory studies → 305 m^3/m^2 year can be regenerated in 5cm depth, 30min of HRT and mild oxidation (30mg/L of H_2O_2 and 5mg/L of iron)

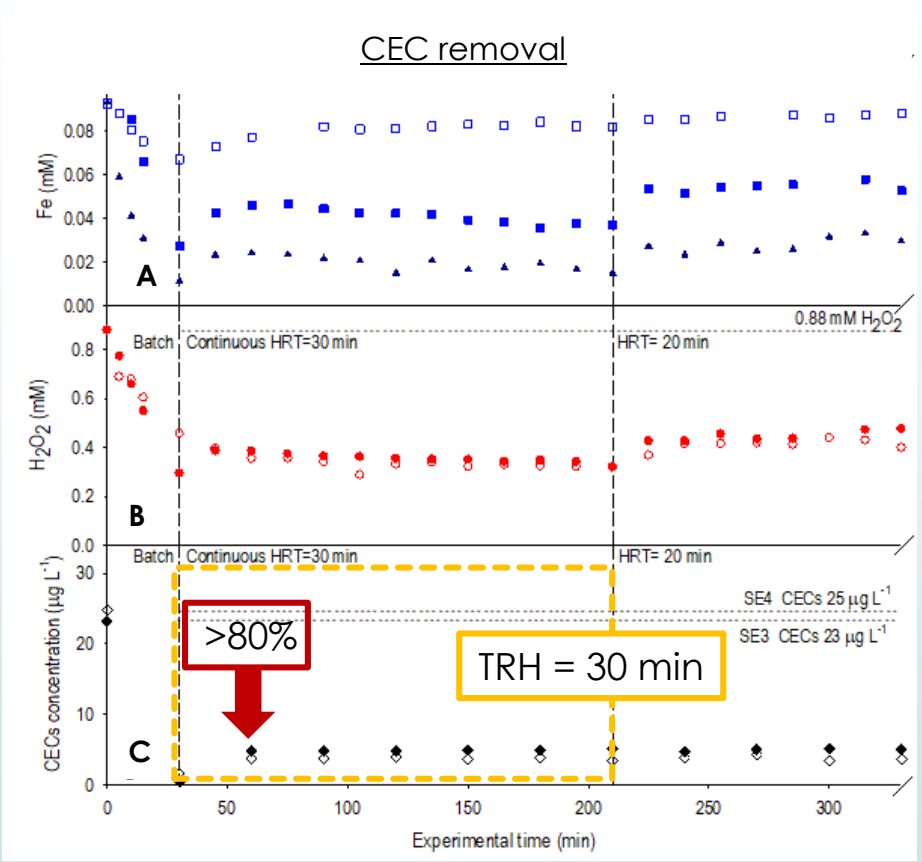

Fig. 1. (a) Concentration profiles of total dissolved iron (Fe_D) (■), (a) Fe^{3+}-EDDS (▲), (b) H_2O_2 (●), (c) and CECs (◆) during the continuous solar photo-Fenton process. Concentrations in the inlet stream are plotted with a dotted line, and concentrations in the outlet stream with discrete points; open symbols for acidic pH (HRT 30 and 20 min) and closed symbols for neutral pH (HRT 30 and 20 min).

J.A. Sánchez Pérez et al. 2020. Science of The Total Environment

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Wild bacteria inactivation

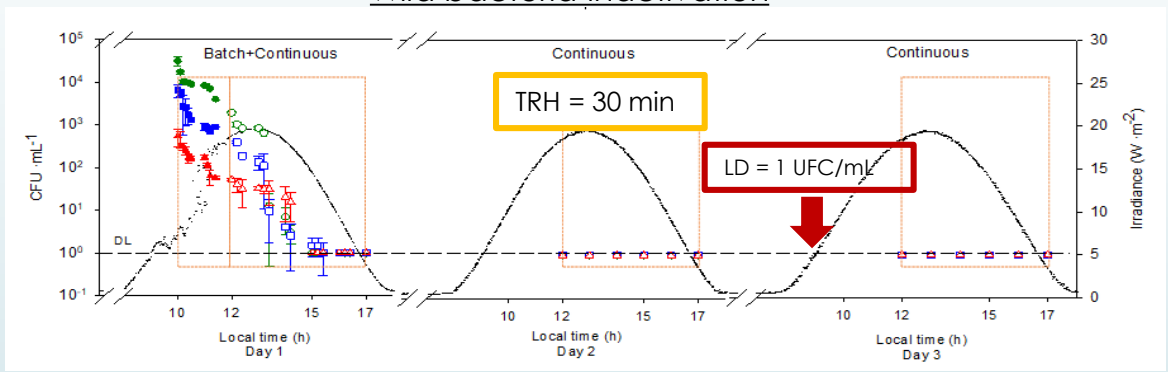

Fig. 2. Total coliforms (●), *E. coli* (■) and *Enterococcus* sp. (▲) inactivation by photo-Fenton process in batch (closed symbols; 50 mg H_2O_2 L^{-1}-20 mg Fe^{2+} L^{-1}) and continuous flow (open symbols; 30 mg H_2O_2 L^{-1}- 20 mg Fe^{2+} L^{-1}) under winter conditions at different HRTs.

I. De la Obra Jiménez el al. 2019. Applied Catalysis B:Environmental

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THANKS FOR YOUR ATTENTION!

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