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BIODAPH2O Eco-efficient system for wastewater tertiary treatment and water reuses in the Mediterranean region

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Introduction and objectives

LIFE BIODAPH2O is a demonstration project whose main objective is to scale up and implement an eco-efficient nature-based tertiary wastewater treatment (BIODAPH), developed in the INNOQUA project (https://innoqua-project.eu/), at two demo sites located in water-stressed regions of the Mediterranean area (Catalonia and Greece). This system is based on the depuration capacity of biological organisms: water fleas (Daphnia) and biofilms to remove pollutants and pathogens. In previous studies, we have demonstrated that *Daphnia* can remove particles <35 μm that do not settle in secondary clarifiers or do so slowly. The removal of solids is associated with a decrease in **organic matter and pathogens such as coliforms and *E. coli*** from secondary wastewater. However, *Daphnia* is sensitive to common contaminants when they are at raw wastewater levels (e.g. organic matter, ammonium and nitrite, and metals) and, thus, the integration of zooplankton in wastewater treatment lines is limited to a tertiary treatment (Pous et al., 2020, DOI: 10.1016/j.chemosphere.2019.124683). With regard to **organic micropollutants**, *Daphnia* filtration had shown high efficiencies (80% average) in the removal of pharmaceuticals and personal care products (Hidalgo et al. ecoSTP2023 T4, 4.8). As for microplastics, given that *Daphnia* are efficient filters for suspended solids, it can be expected that they are also efficient filters for **microplastics** (Colomer et al., 2019, DOI: 10.1016/j.envpol.2019.05.034). Up to now, no results have been published regarding the capacity of *Daphnia* to remove **perfluoroalkyl substances (PFAs) and antibiotic resistant genes (ARGs)**.

BIODAPH principles

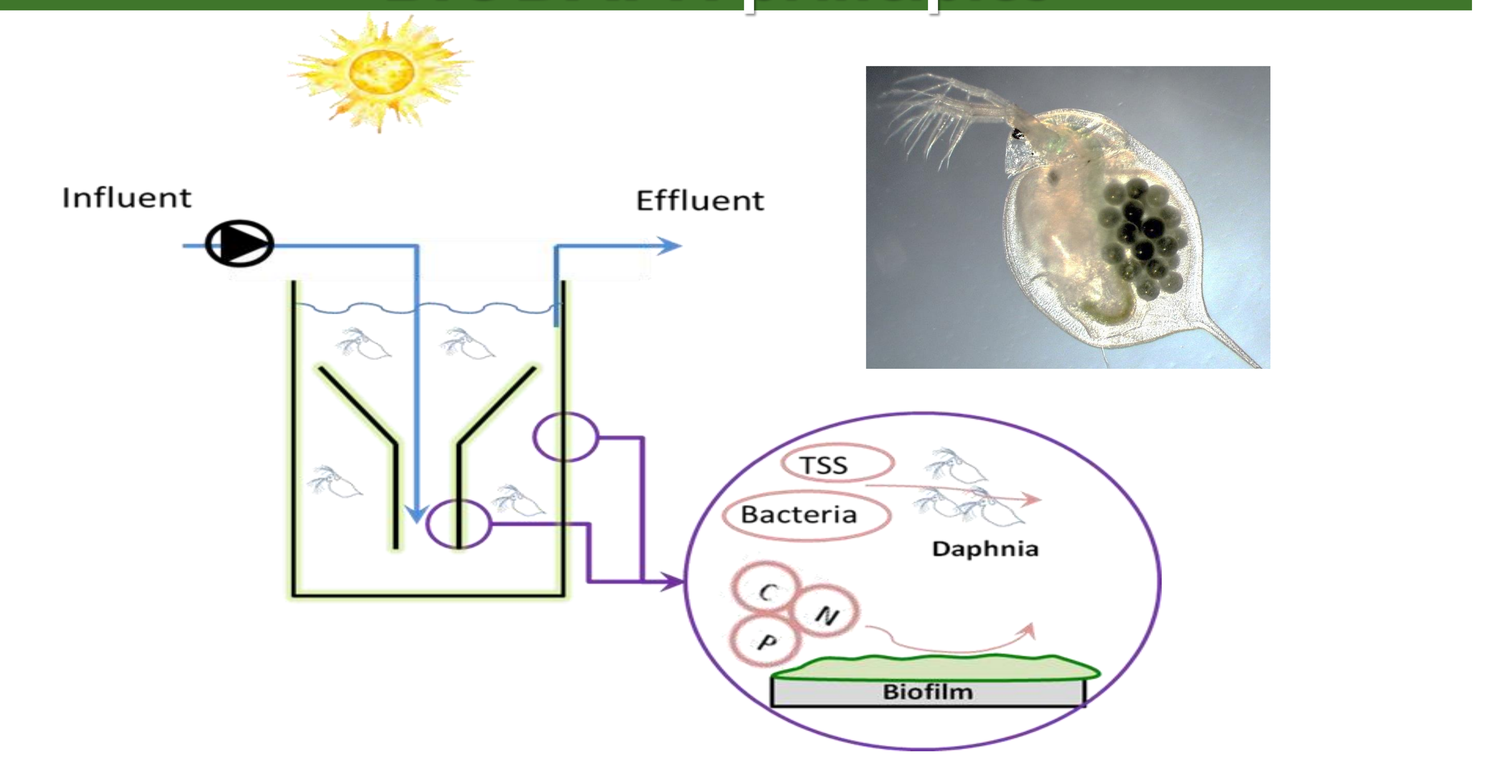

Figure 1. The BIODAPH technology combines the filtration capacity of zooplankton (*Daphnia Magna*) with the capacity of bacterial and algal biofilm to remove nutrients.

Scaling-up of the BIODAPH reactor

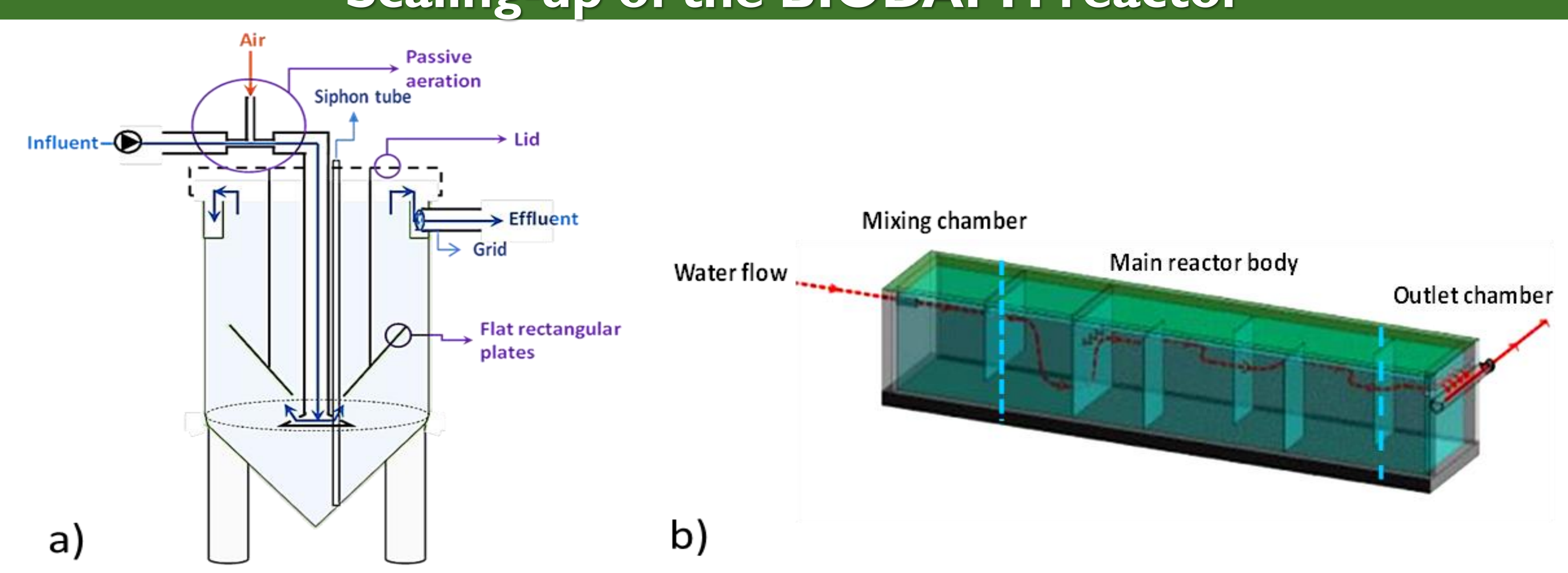

Figure 2. a) Design of the zooplankton-based reactor (1.5 m^3) and b) initial pre-design of the BIODAPH reactor (100 m^3).

Implementation of BIODAPH technology: demo-sites

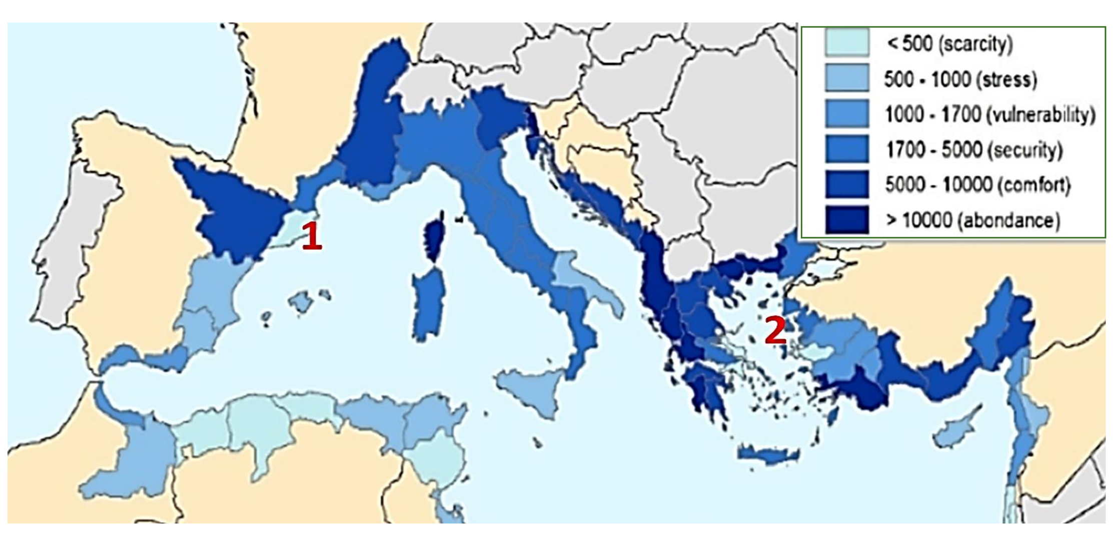

Figure 3. Location of the two demo-sites: (1) Quart (Spain) and (2) Antissa, Lesvos Island, Greece. The blue colours in the map show the water resources per capita (m^3/year).

1. There is currently no tertiary treatment at the Quart WWTP and the secondary effluent is directly discharged into the Onyar river.

2. HYDROUSA WWTP (https://www.hydrousa.org/) at Antissa combines anaerobic processes: (Up-flow Anaerobic Sludge Blanket reactor (UASB) with constructed wetlands. The water, nutrients and produced sludge are reused in agriculture. The anaerobic process recovers energy in the form of biogas.

Table 1. Values of the general physico-chemical parameters at the effluents of the treatments at both demo-sites.

		Antissa WWTP		Quart WWTP
(mg/L)	$UASB_{eff}$	CW1 SAT_{eff}	CW2 $UNSAT_{eff}$	Second. eff.
TSS	123±41	40±19	5±2	64±170
VSS	99±35	31±13	4±1	
BOD_5	134±21	79±14	7±2	14.7±7
tCOD	274±85	144±51	38±10	68±59
sCOD	78±12	74±14	35±8	
NH_4-N	56.3±6.4	59.3±7.3	5.3±3.1	29.5±14.6
NO_3-N	-	-	53±8.9	0.5-0.7
TN	84±15	79±0	67±6	30.4±14.3
TP	8.2±0.9	8.5±0.6	7.8±0.7	2.9±2.1
PO_4-P	7.4±0.5	8±0.4	7.8±0.7	4.4±7.3
pH	7.2±0.2	7±0.1	6.5±0.2	7.3±0.3
Cond (μS)	1342±55	1373±72	1173±62	1387±228
Turb (NTU)	178±74	55±35	4.1±2.7	105±260

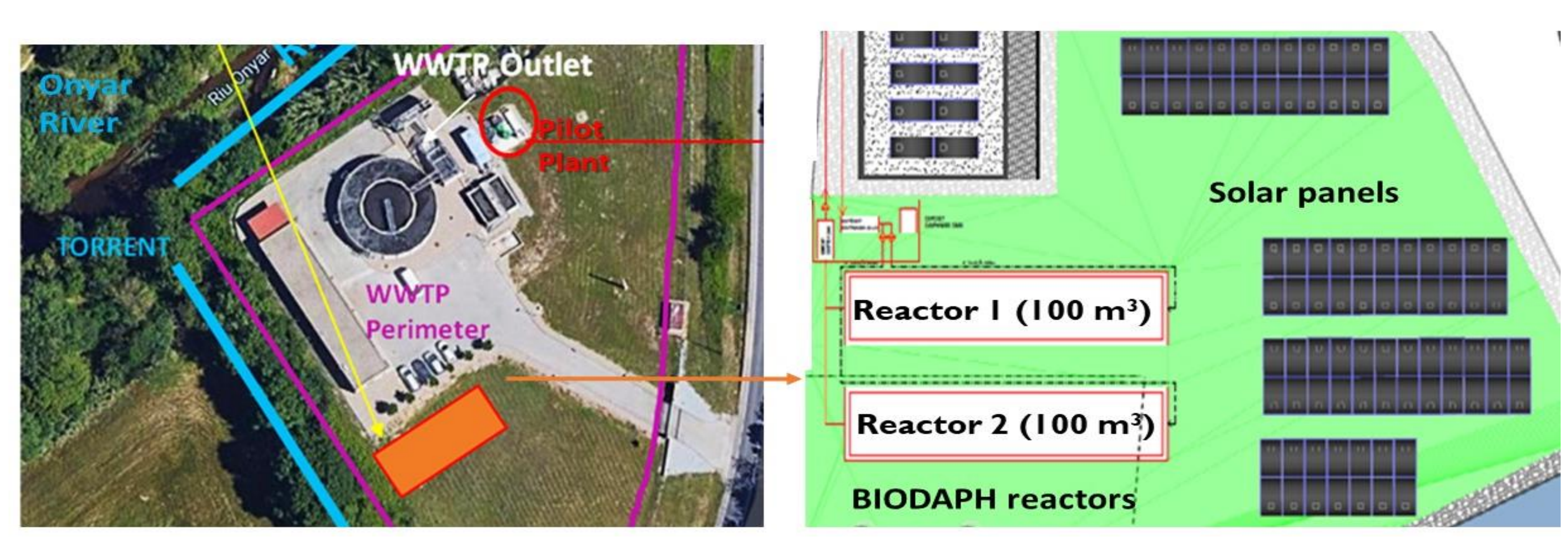

Figure 4. Installation of the BIODAPH reactors at Quart WWTP (Spain). Aerial image of the Quart WWTP and surrounding areas including the River Onyar.

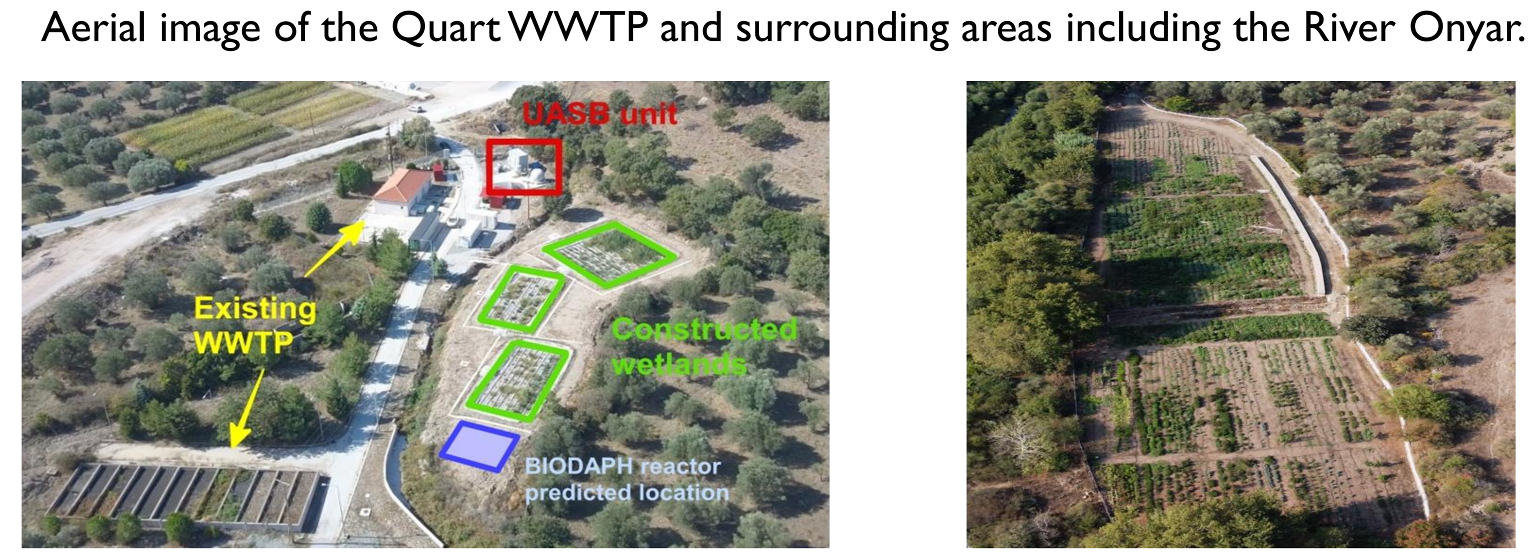

Figure 5. Aerial image of Hydrousa WWTP at Antissa (Greece) indicating the location of the BIODAPH reactor and the agroforestry area to be irrigated.

Expected results

- Demonstration of the capacity of the BIODAPH technology to remove emerging pollutants: **~70%, for pharmaceuticals, ~90% for antibiotic resistant genes (ARGs), ~80% for microplastics, and ~60% for perfluoroalkyl substances (PFAs).**
- Demonstration of the capacity of the BIODAPH system **to reach the standards set** in national wastewater reuse guidelines and recent EU regulations (2020/741 of the European Parliament) on minimum requirements **for water reuse (PE/12/2020/INIT).** To recover and recycle resources by discharging reclaimed water with **low nutrient content (~50%) and reduce the regulated microbiological parameters by between 90 and 99%.**
- **Production of reclaimed water** with improved quality to reduce the impact generated by the discharge of treated sewage waters in the River Onyar at the Spanish site. At the Greek site, a reduction in the use of freshwater and potable water for agricultural irrigation, which will also reduce the environmental impacts associated with wastewater release into the aquatic media.
- **Energy consumption reduction of more than 90%** and a **carbon footprint and greenhouse gas production reduction of more than 80%** in comparison with conventional tertiary wastewater treatments.
- **Significant reduction in operating costs (OPEX)** as the treatment is free from chemicals and is less energy intensive.

Coordinator **Partners**

PROJECT COSTS: 2,128,772 €

DURATION: 1/08/2022 - 31/01/2026

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