



# Daphniafilter: a nature-based tertiary treatment

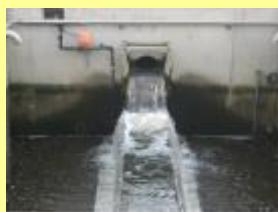
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**Earthworms, water fleas and algae: the future of wastewater treatment?**

**November, 17th, 2020**

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# INTRODUCTION-Tertiary treatments



Bed-filters



Lamella clarifier



Membrane filtration

Chlorination

Advanced oxidation

Other advanced treatments

UV radiation



Constructed wetland



Polishing pond



## WATER REUSE

Urban use

Groundwater recharge

RD 1620/2007

Environmental/agricultural applications

Industrial use

# INTRODUCTION – PREVIOUS STUDIES



Zooplankton (Daphnia, Cladocerans)  
Filter-feeder organism

Reduction of suspended solid content → Filtration  
(Pau et al., 2013)

Reduction of bacterial load → Disinfection  
(Serra et al., 2014; Pous et al. 2020)

Nutrient removal?

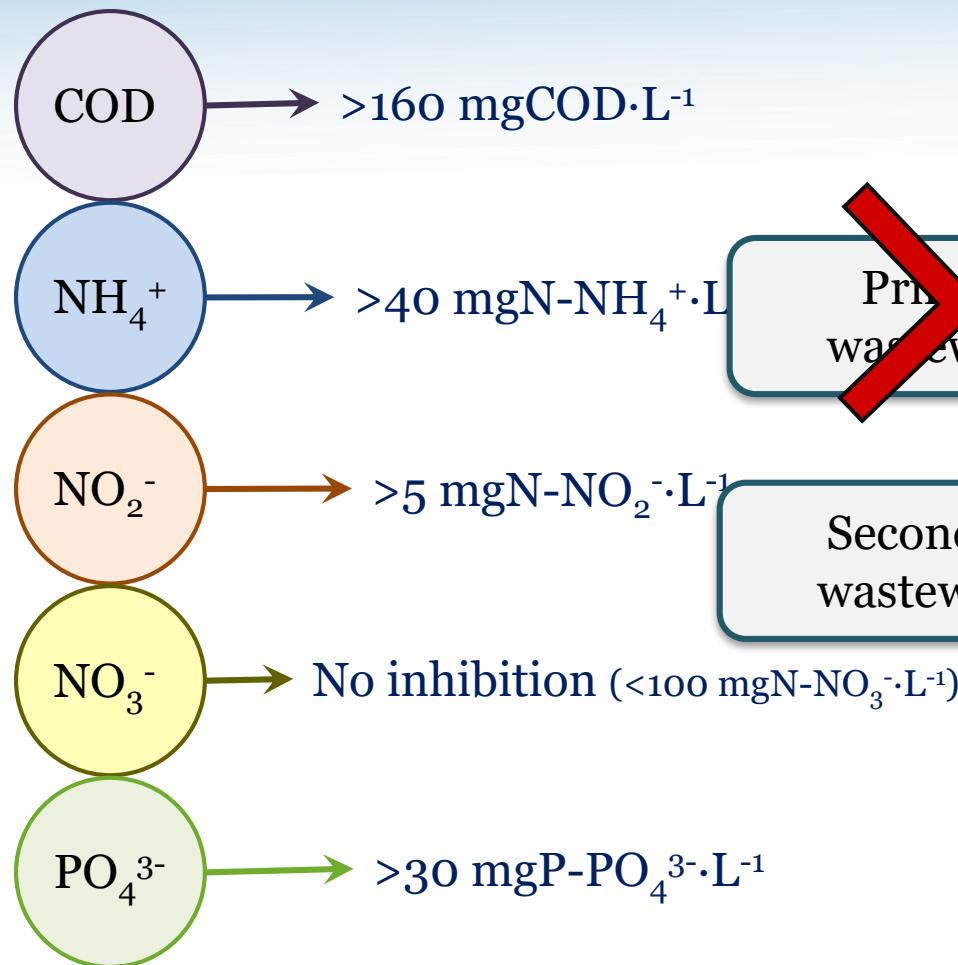
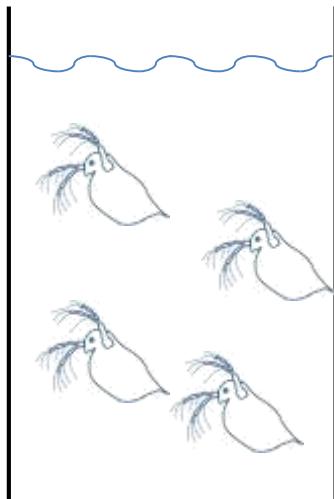


# INTRODUCTION- INHIBITION TESTS

Compatibility of Daphnia with wastewater



## Inhibition of the filtration capacity:



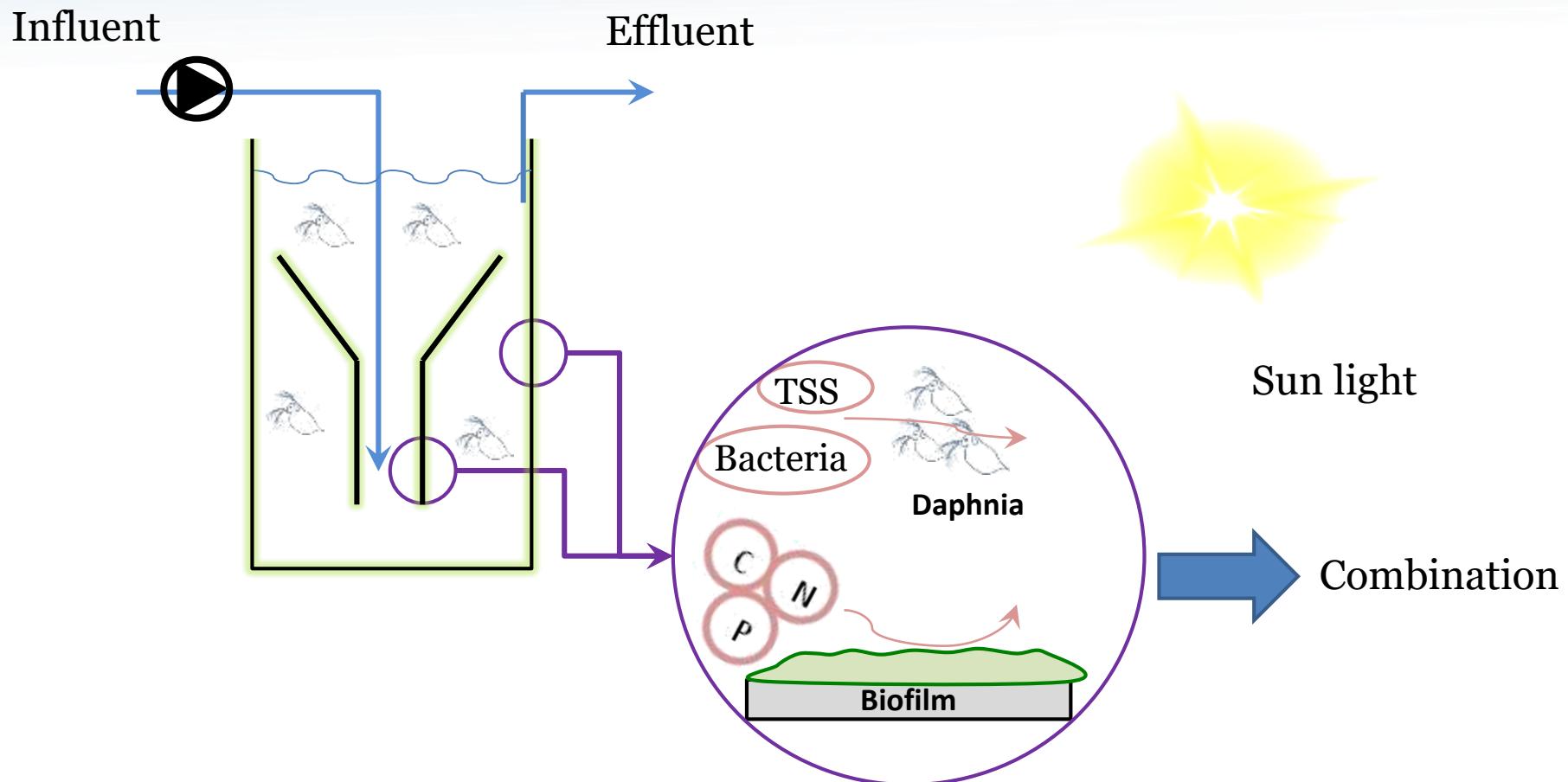
# NUTRIENT REMOVAL LAB-SCALE



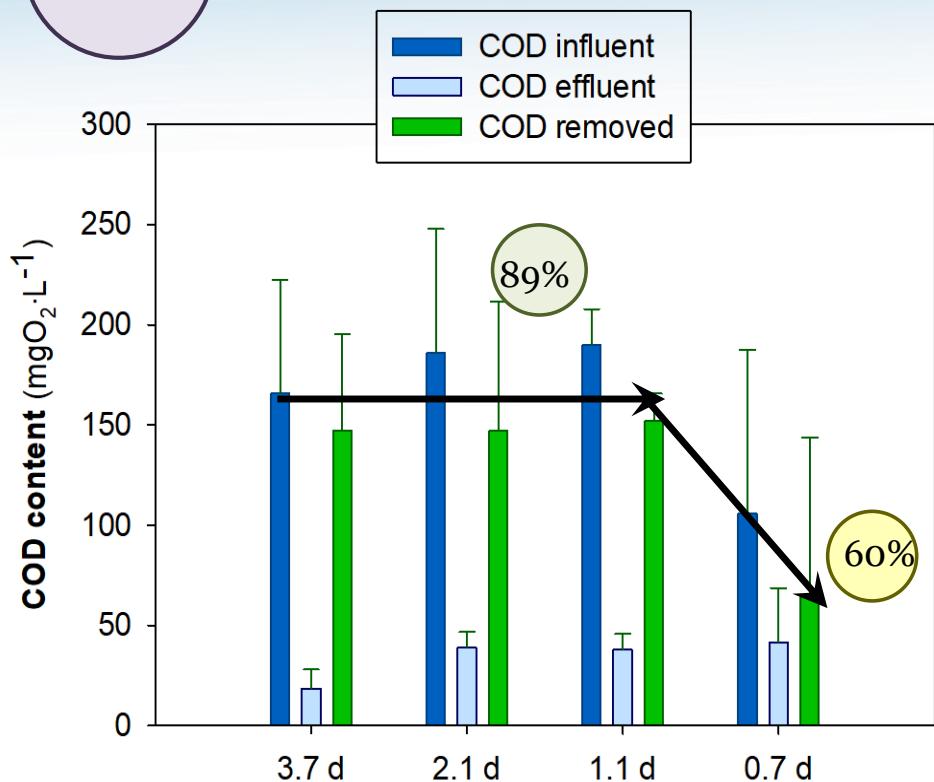
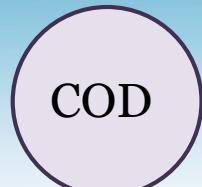
Removal of nutrients in secondary wastewater at different HRTs?



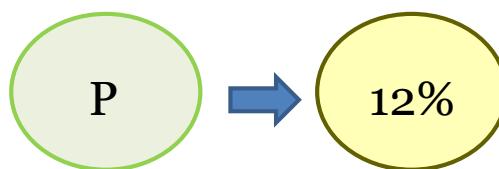
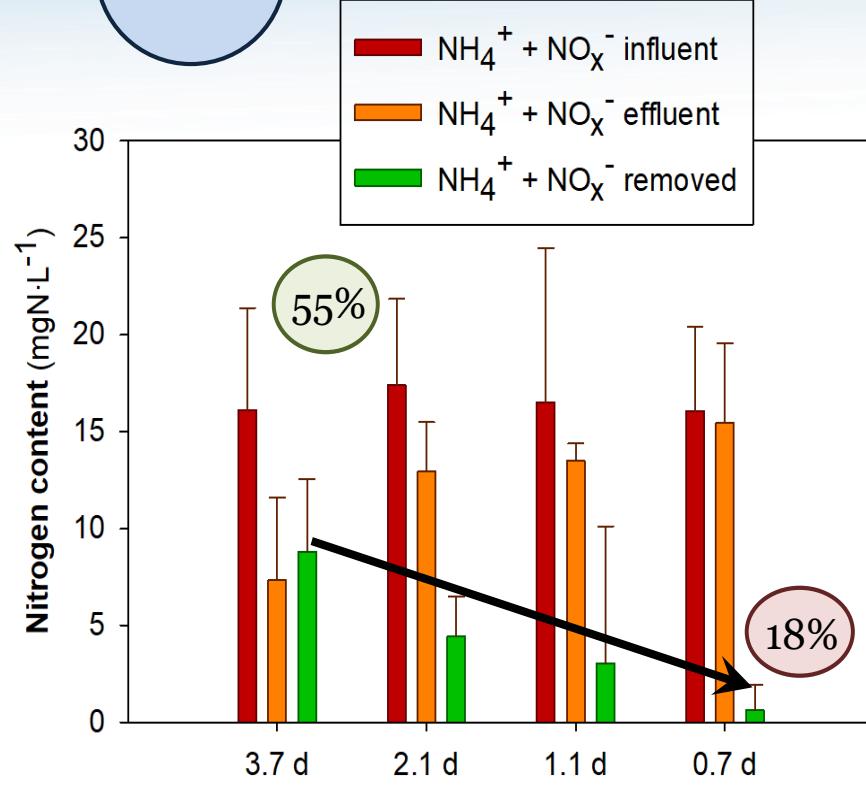
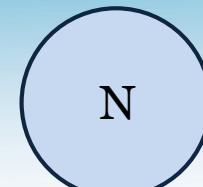
Zooplankton-based reactor = Daphniafilter®



# RESULTS- LAB-SCALE



## Nutrient removal



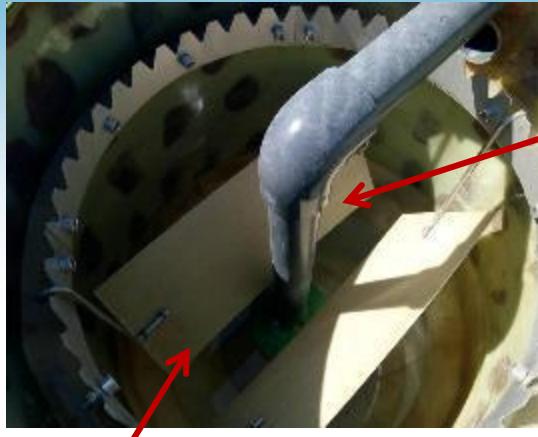
at the highest HRT

# UDG PILOT SITE - QUART WWTP



## DAPHNIAFILTER® REACTOR

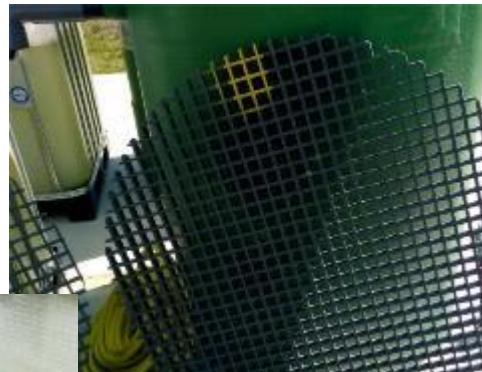
10 PE  
1500 L.d<sup>-1</sup>



Lamella  
separator



Outlet



Covers

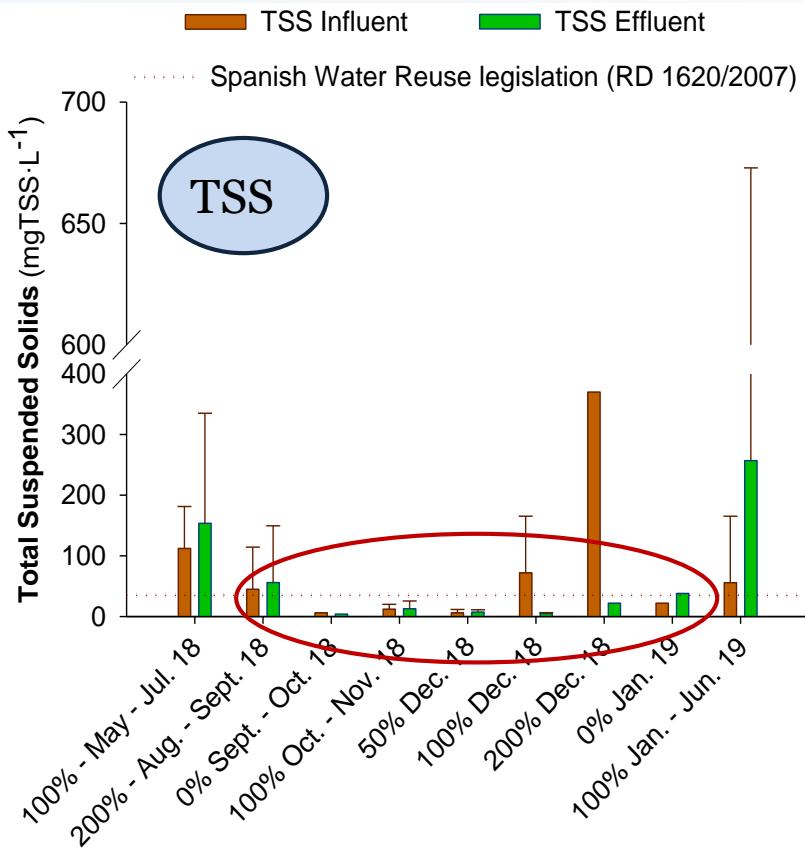


# RESULTS – PILOT-SCALE

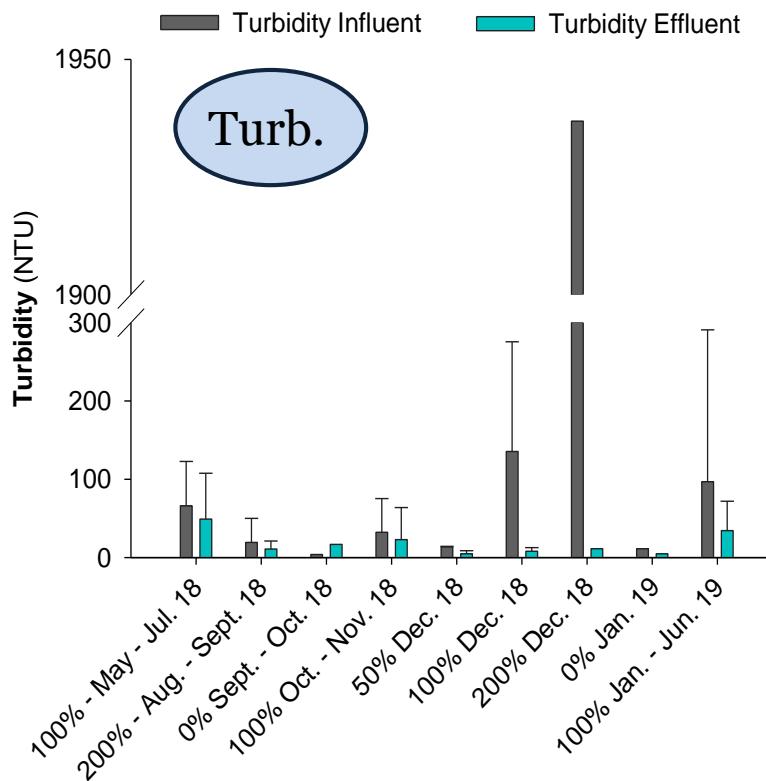


**Secondary wastewater**

1 year  
operation



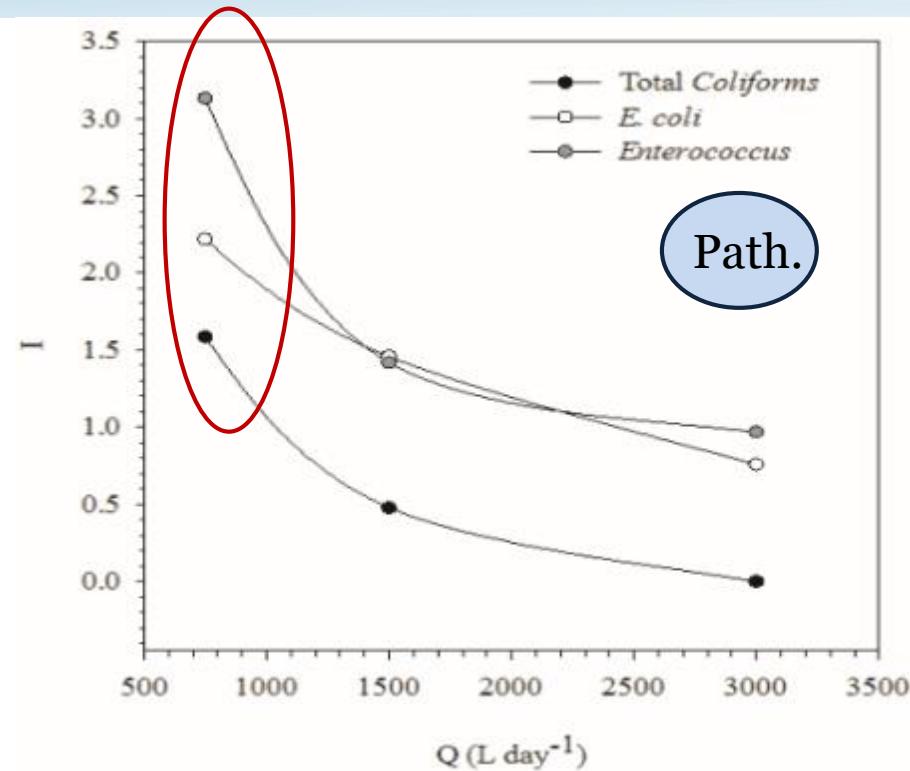
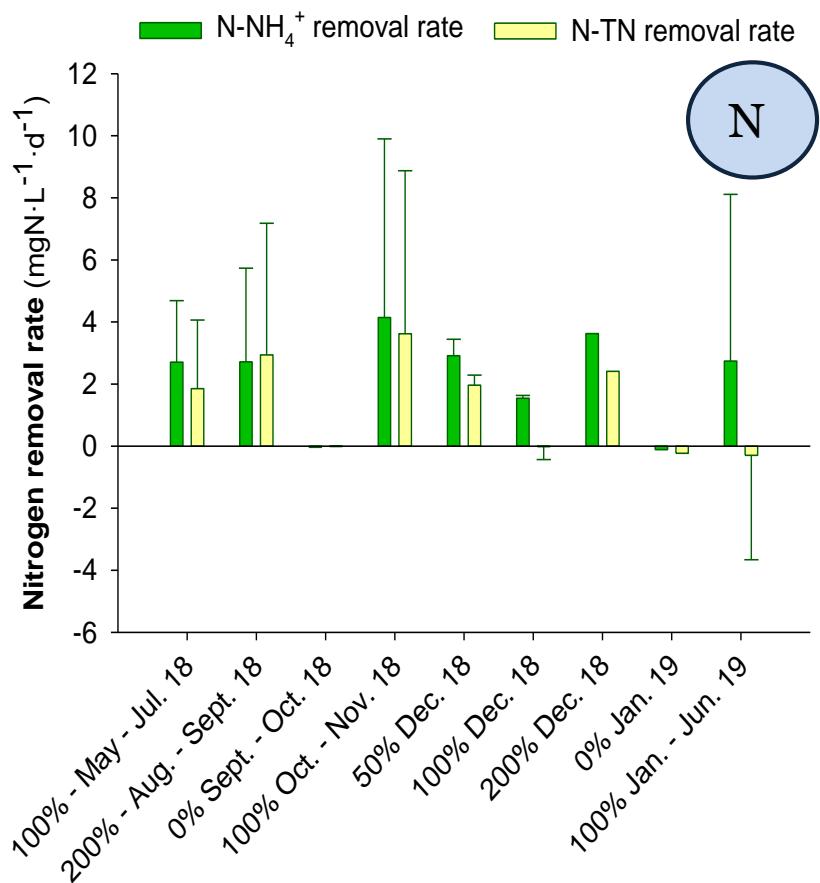
<b>Cond.</b>	$1425 \pm 244 \mu\text{S} \cdot \text{cm}^{-1}$
<b>pH</b>	$7.4 \pm 0.2$
<b>COD</b>	$70 \pm 31 \text{ mgCOD} \cdot \text{L}^{-1}$
<b>NH<sub>4</sub><sup>+</sup></b>	$30 \pm 14 \text{ mgN-NH}_4^+ \cdot \text{L}^{-1}$
<b>NOx<sup>-</sup></b>	$1,0 \pm 1,0 \text{ mgN-NO}_x^- \cdot \text{L}^{-1}$
<b>PO<sub>4</sub><sup>3-</sup></b>	$4,1 \pm 4,4 \text{ mgP-PO}_4^{3-} \cdot \text{L}^{-1}$



# RESULTS - PILOT-SCALE



## NUTRIENT AND PATHOGEN REMOVALS



# RESULTS - WATER REUSE



$$\text{Quality ratio } QR = \frac{C P_1}{\text{Std } P_1} + \frac{C P_2}{\text{Std } P_2} + \dots + \frac{C P_n}{\text{Std } P_n} \quad (\text{E.coli, TSS, Turbidity, TN, N-NO}_3)$$

Uses		100% nominal load Jun. 18	50% nominal load Dec. 18	100% nominal load Dec. 18	200% nominal load Dec. 18	100% nominal load May 19
		N/A	N/A	N/A	N/A	N/A
<b>Urban</b>	1.1. Residential	N/A	N/A	N/A	N/A	N/A
	1.2. Services	9.7	2.8	11.1	107.2	11.1
<b>Agriculture</b>	2.1.2 Direct contact edible parts	14.7	4.8	21.1	212.2	19.6
	2.2 No direct contact edible parts	2.9	0.6	2.1	21.6	2.0
	2.3. Non-food uses	2.0	0.2	0.3	2.7	0.4
<b>Industrial</b>	3.1.a Process water non-food processing ind.	2.9	0.6	0.9	3.5	1.9
	3.1.b Process water food processing ind.	2.9	0.6	2.1	21.6	2.0
	3.2. Refrigeration	N/A	N/A	N/A	N/A	N/A
<b>Recreational</b>	4.1. Golf	9.7	2.8	11.1	107.2	11.1
	4.2. Private lakes	2.0	0.2	0.3	2.7	0.4
<b>Environmental</b>	5.1. Aquifers, indirect injection	7.1	3.5	5.7	24.6	5.0
	5.2. Aquifers, direct injection	N/A	N/A	N/A	N/A	N/A
	5.3. Forest watering	1.9	0.2	0.1	0.6	0.3

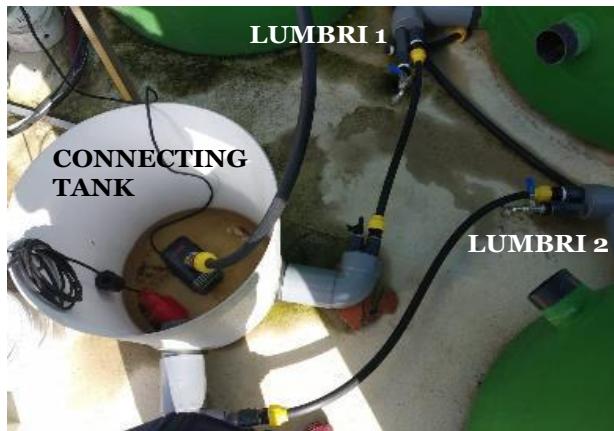
Red QR > 5 Orange 1 < QR < 5 Green QR < 1

# INTEGRATED SYSTEM: 2X5PE LF + 10 PE DF



Raw influent wastewater

Parameter	Mean $\pm$ sd (n=20)
Conductivity	$1686 \pm 469 \mu\text{S} \cdot \text{cm}^{-1}$
pH	$7.3 \pm 0.2$
COD	$632 \pm 262 \text{ mgO}_2 \cdot \text{L}^{-1}$
TSS	$396 \pm 258 \text{ mg} \cdot \text{L}^{-1}$
BOD <sub>5</sub>	$392 \pm 262 \text{ mgO}_2 \cdot \text{L}^{-1}$
NH <sub>4</sub> <sup>+</sup>	$40 \pm 12 \text{ mgN-NH}_4^+ \cdot \text{L}^{-1}$
NO <sub>2</sub> <sup>-</sup>	$0.03 \pm 0.05, 0 \text{ mgN} \cdot \text{L}^{-1}$
NO <sub>3</sub> <sup>-</sup>	$0.05 \pm 0.06 \text{ mgN} \cdot \text{L}^{-1}$



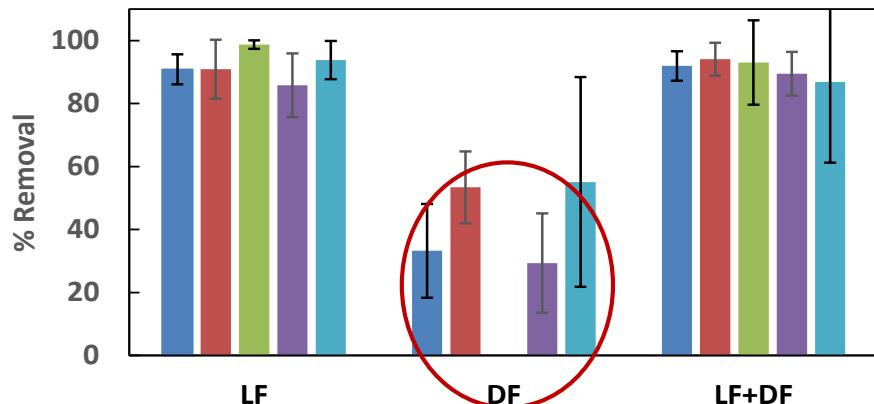
6 + 6 month  
operation  
2.5 month  
lockdown

# RESULTS- LT+DF PILOT SCALE

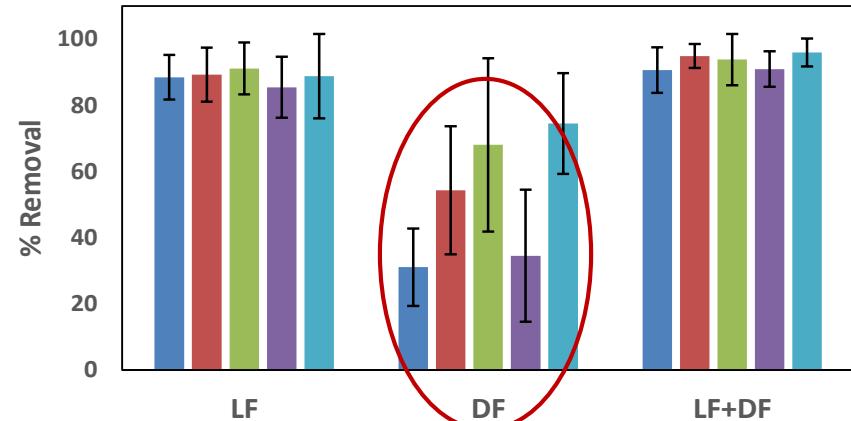


Nutrient, suspended solid and BOD removals

$750 \text{ L} \cdot \text{d}^{-1}$



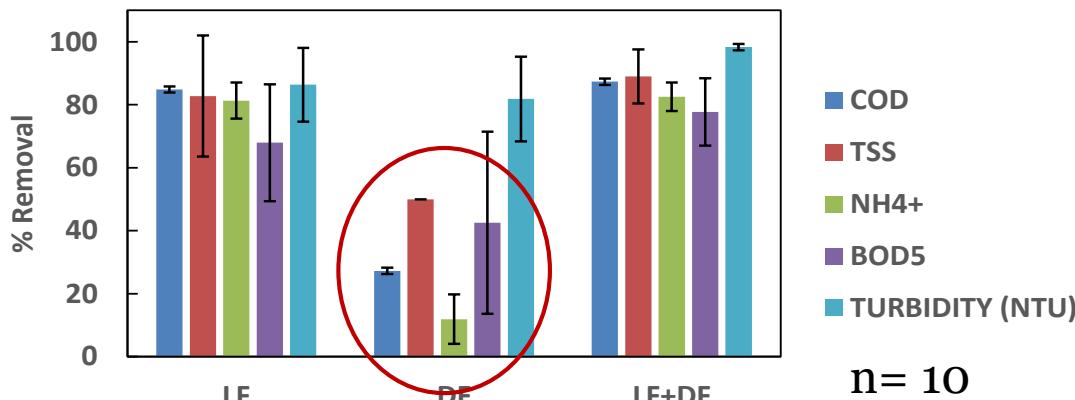
$1500 \text{ L} \cdot \text{d}^{-1}$



n = 20

n = 40

$3000 \text{ L} \cdot \text{d}^{-1}$

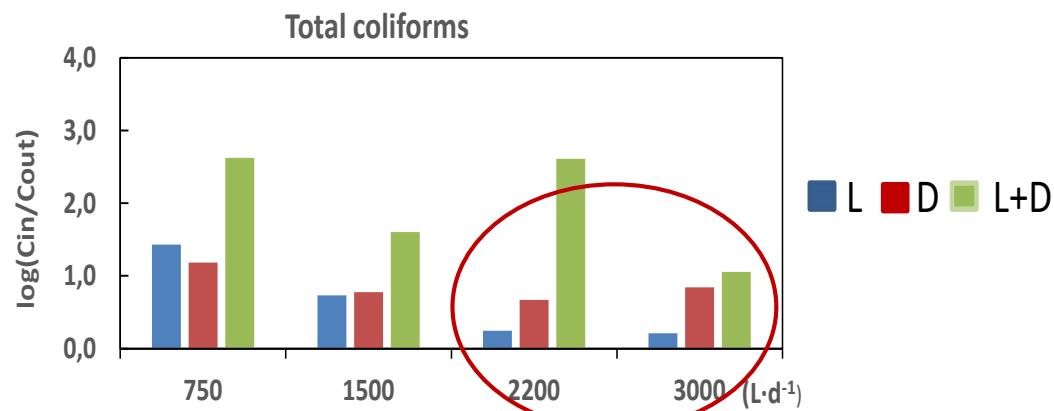
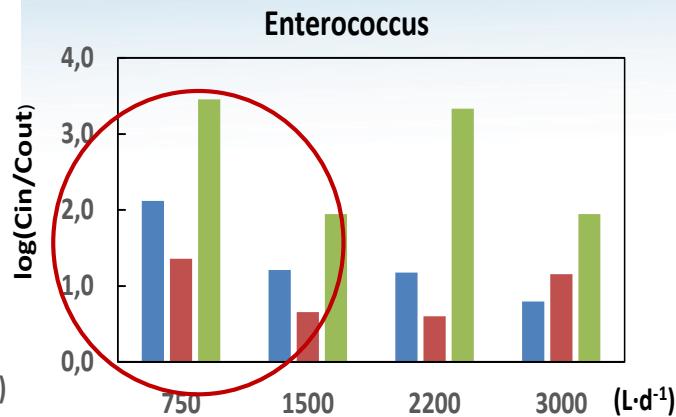
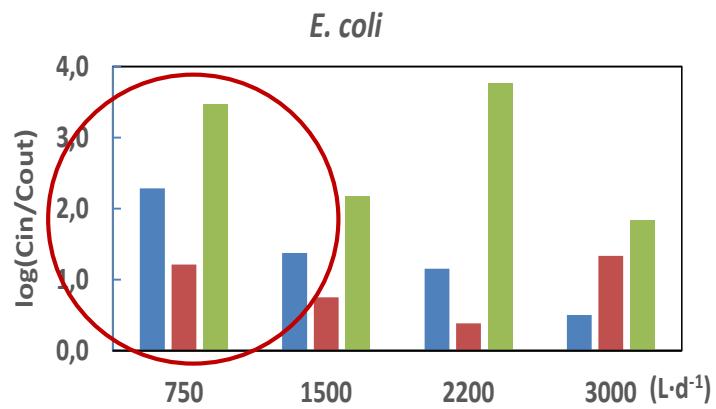


- COD
- TSS
- NH4+
- BOD5
- TURBIDITY (NTU)

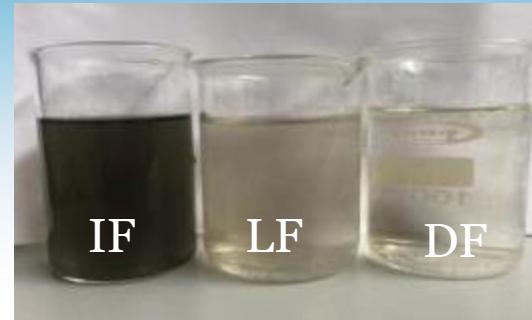
# RESULTS-LT+DF PILOT SCALE



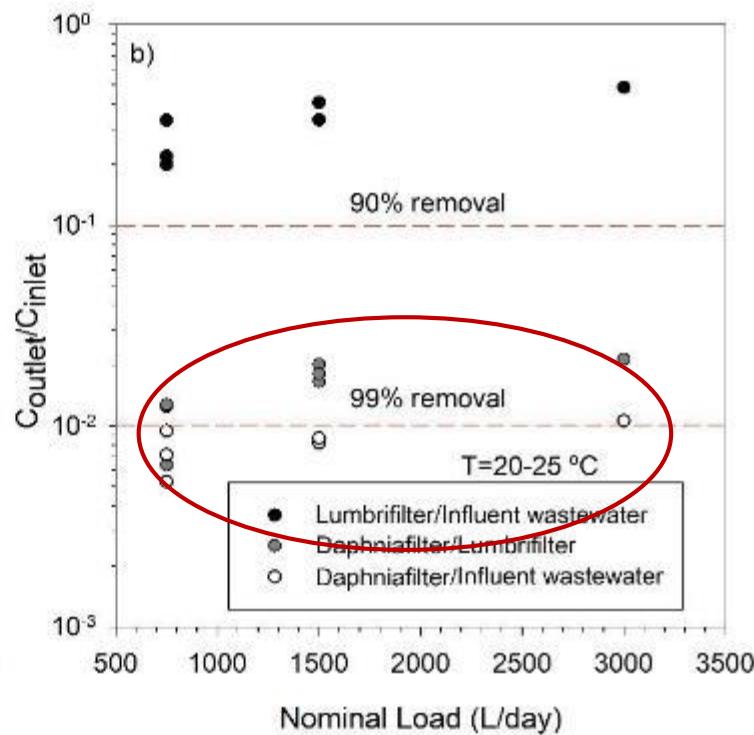
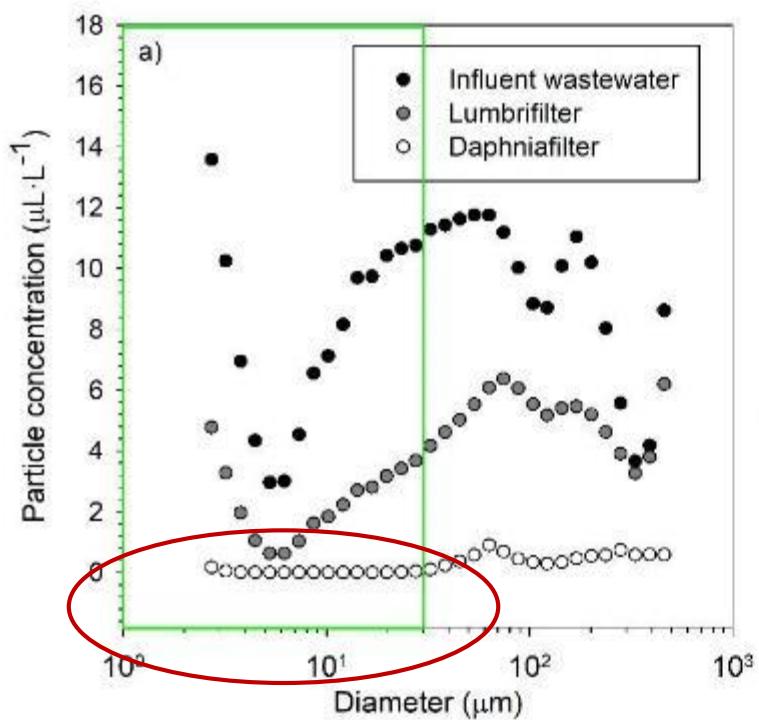
## Pathogen removal



# RESULTS- LT+DF PILOT SCALE



## Removal of suspended particles



# COMPARISON-LT+DF PILOT SCALE



**Quart (Spain)**



**Bangalore (India)**

Quality Parameter	DF Spanish demo-site Average removal STD n=30	DF Indian demo-site Average removal STD * n=18
Total suspended solids (mg SS L <sup>-1</sup> )	54.27±19.39 %	80.48±24.14%
Turbidity (NTU)	74.48±15.25 %	-
COD (mg oxygen L <sup>-1</sup> )	31.03±11.71 %	60.56±24.4%
BOD <sub>5</sub> (mg oxygen L <sup>-1</sup> )	34.50±19.98 %	76.16±17.61%
Ammonium NH <sub>4</sub> <sup>+</sup> -N(mg NH <sub>4</sub> <sup>+</sup> -N L <sup>-1</sup> )	68.02±26.22 %	50.09±22.64%

\* Data from T. Schellenberg

# CONCLUSIONS



- Daphniafilter shows its value in inhibiting pathogens, achieving high elimination rates of around  $99\pm1\%$ .
- Daphniafilter has an important role in removing small particles improving the capacity of UV lamp disinfection
- DF acts as a polishing stage, improving effluent quality by also reducing nutrients (tertiary treatment)
- LF+DF allows effluent quality criteria for safe discharge to be reached and reuse criteria for certain agricultural and industrial applications
- At design loading rates the Daphniafilter can be maintained for extended periods without the need to desludge. No performance differences were found in the periods before and after shut-down
- The low energy consumption, minimal maintenance, the absence of chemicals, and the small sludge production make the concept Daphniafilter both ecologically and economically sustainable

# ACKNOWLEDGMENTS



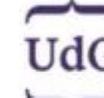
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OÈ Gaillimh  
NUI Galway



New insight on water recycling



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N. Pous, A. Barcelona, M. Hidalgo, L. Sbardella, J. Colomer, T. Serra, V. Salvadó

**Thank you for your attention!**