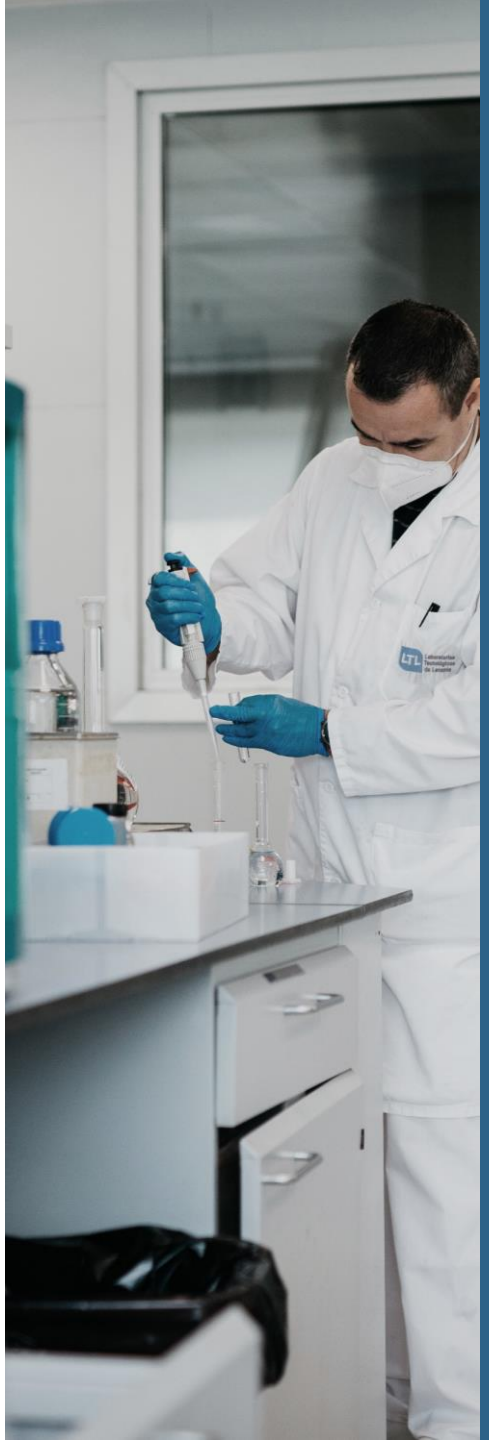
Laboratorios Tecnológicos de Levante



Beatriz Vallejo
R&D Manager

LIFE EMPORE

Development of an efficient and sustainable methodology for Emerging Pollutants Removal in WWTPS

EUSDR Conference on drinking water and microplastics

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Objectives

Demonstrate an innovative, efficient and replicable technology for the removal of emerging contaminants (ECs) from the effluents of European wastewater treatment plants (WWTPs).

LIFE15 ENV/ES/000598

GLOBAL BUDGET: 1,783,824 € (Funded by LIFE Programme of the European Union)
DURATION: 36 months. Sept-2016/Aug-2019 (extension dic2019)

Specific objetives:

- Design, build and operate a pilot plant that combines different technologies (conventional filtration, membranes, advanced oxidation processes and electrochemical processes) to remove ECs and priority substances from WWTP secondary treatment effluents.
- Evaluate the problem of the presence of ECs in Europe.
- To characterize the ECs and their seasonal variability in Benidorm WWTP.
- To evaluate the environmental and socioeconomic impact of the application of this methodology.
- To analyze the technical and economic feasibility of the proposed methodology.
- To evaluate the transferability of the project results to other European sites with a similar scenario.
- To disseminate the benefits of the use of the technologies employed.

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Demo Location

BENIDORM

BENIDORM WWTP (EPSAR)

- Benidorm is a popular tourist destination in Spain, whose population fluctuates considerably during Christmas, Easter and the summer period.
- In the agricultural activity of the area, the most important is the cultivation of citrus fruits (e.g. persimmons).

Presence in the influent of the Benidorm WWTP.

Pharmaceuticals and hormones

Some pesticides

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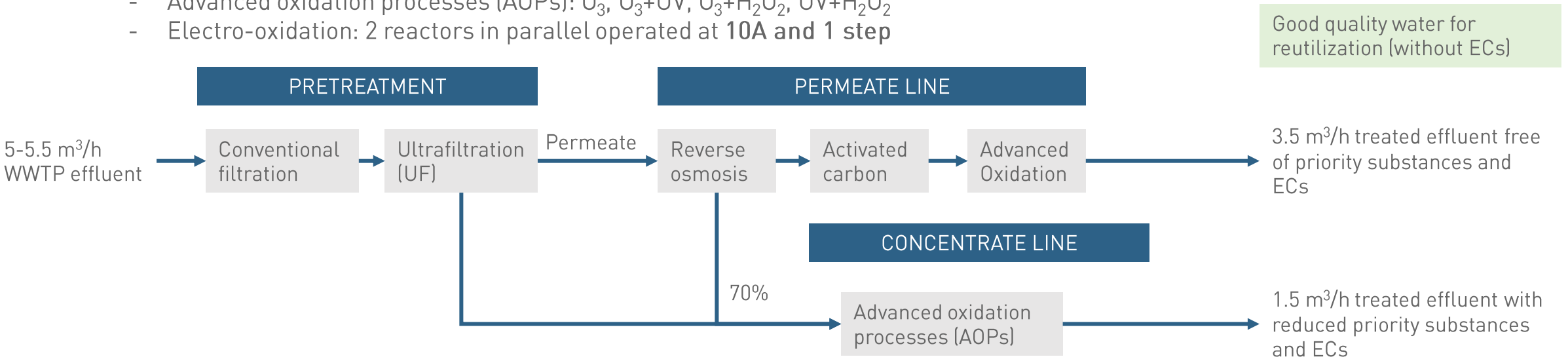
Demo Plant

EMPORE pilot plant design: versatile, transportable and sequential distribution of technologies

- Hydraulic capacity: ± **5-5.5 m^3/h** effluent from secondary clarifier
- Ultrafiltration: 3 modules SFP 2660 DOW (**total filtering Surface: 99 m^2**)
- Reverse osmosis conversión: **70 %** (two steps without recirculation) employing membranes BW30-40-40 Dow 4
- Advanced oxidation processes (AOPs): O_3, O_3+UV, O_3+H_2O_2, UV+H_2O_2
- Electro-oxidation: 2 reactors in parallel operated at **10A and 1 step**



Good quality water for reutilization (without ECs)

Less discharge of ECs to the environment

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Demo Plant

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Methodology

- Duration: 12 month
- Micropollutants: 19 chemicals selected after characterization Champaign (1 year)
- Methodology: weekly sampling. Analysis performed: GC-MS/MS and HPLC-MS/MS

Priority substances included in the directive 2013/39/UE

DEHP, Chlorpyrifos, 4-t-OP, Trifuraline, Isoproturon, Diuron

Substances included in the Watch List (Decision 2018/840)

Estrone, 17-α- ethinylestradiol,17-β- estradiol, Eritromicine

Ether ECs not included in the above categories

Dichlorophenac, Chloramphenicol, Carbamazepine, Ibuprofen, Fluoxetine, Sulfomethoxazole, Ketoprofen, Glyphosate, Estriol

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Methodology

→Effluent quality evaluation

- Determine each pollutant concentration
- Application of a general dimensionless index that allows an easy and quick interpretation of water quality with respect to the presence of micropollutants.

Canadian Water Quality Index (CWQI). Referred to the concentration of the 19 micropollutants studied

$$CWQI = 100 - \frac{\sqrt{F_1^2 + F_2^2 + F_3^2}}{1.732}$$

(escala 0-100, 100 ideal)

Scope (F1): percentage of variables that do not meet their objectives at least once during the period under consideration in relation to the total number of variables measured.
Frequency (F2): percentage of measurements of variables that do not meet their target values.
Amplitude (F3): factor representing the amount by which the measured values of the variables do not meet their target values.

It has been defined:

- Water mass: effluent
- Time period: monthly (4-5 test/month)
- Variables: each pollutant concentration
- Target values: maximum allowable concentration according to Directive 2013/39/UE and "n" times the LOQ for other ECs (n=2)

Classification	CWQI	Description
Excellent	95-100	All variables are on target virtually all the time
Good	80-94	Variables rarely deviate from their target values
Normal	65-79	Variables sometimes deviate from their target values
Regular	45-64	Variables frequently deviate from their target values
Low	0-44	Variables generally deviate from their target values

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Results

Presence of priority substances and ECs in the secondary effluent of the Benidorm WWTP.

NO DETECTED: pesticide (trifuraline), industrial product (4-t-octilfenol), pharmaceutical (cloranfenicol), hormones (17-β-estradiol, 17-α-estradiol and estriol)

SPORADICALLY: pesticides (clorpirifos e isoproturon), industrial product (DEHP), farmaceuticals (ibuprofen and ketoprofen) and hormones (estrone)

PERMANENTLY: pesticides (diuron and glyphosate), farmaceuticals (eritromicine, fluoxetine, sulfomethoxazole, carbamazepine and diclofenac)

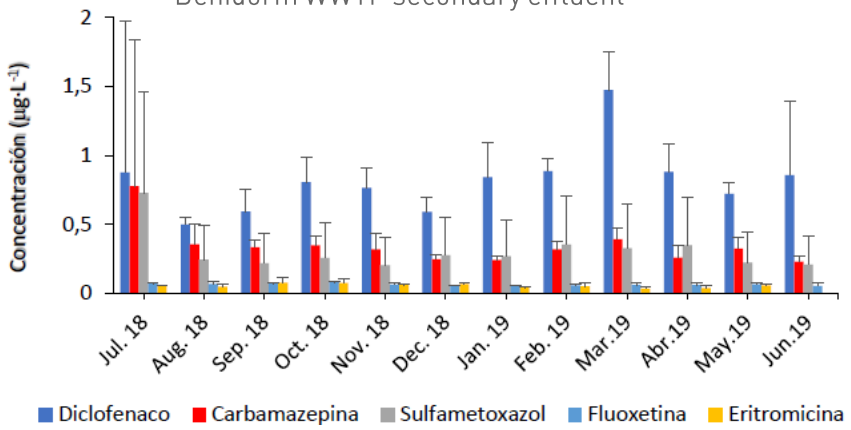
The ECs detected at the highest concentrations were the drugs diclofenac, carbamazepine and sulfamethoxazole and the pesticide glyphosate.

High conductivity for agricultural irrigation 2.500-3.000 µS/cm

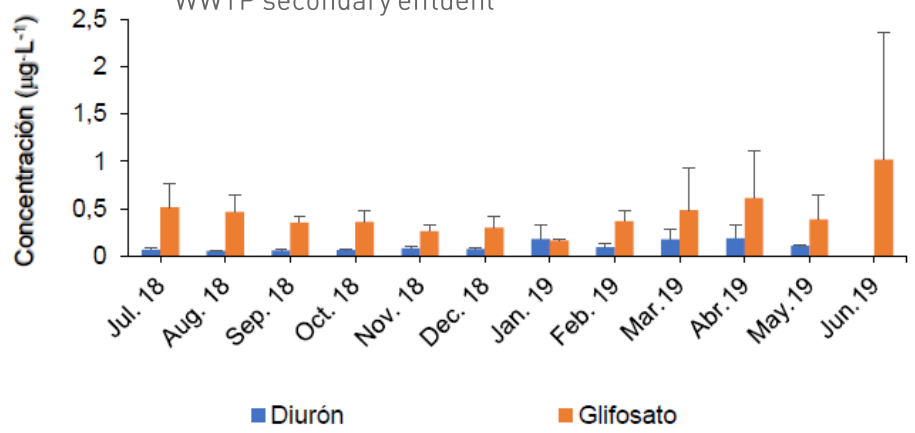
Regular-low water quality due to the presence of ECs

CWQI: 45-60

Pharmaceuticals continuously detected in Benidorm WWTP secondary effluent



Pesticides continuously detected in Benidorm WWTP secondary effluent



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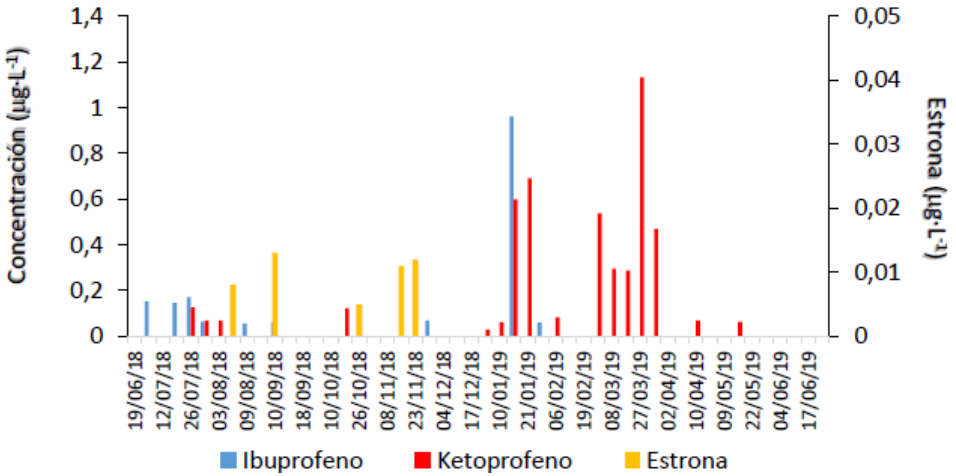
Results

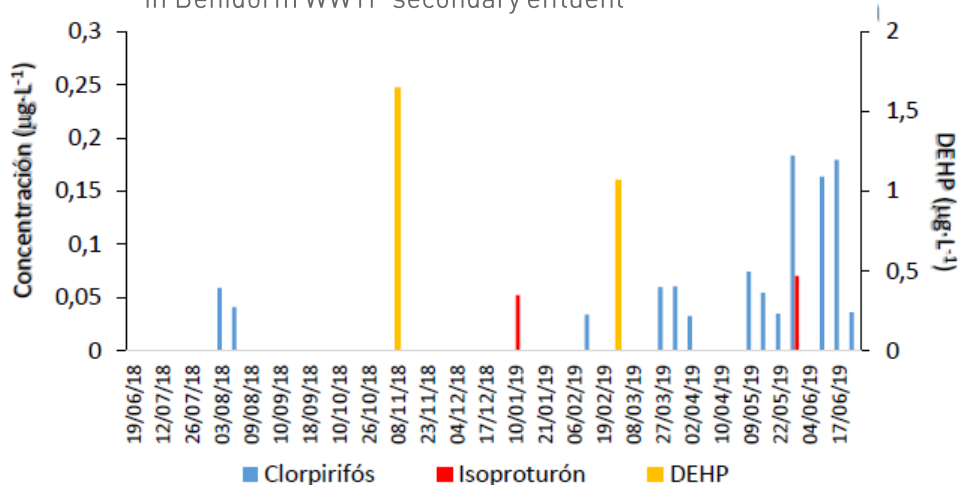
Presence of priority substances and ECs in the secondary effluent of the Benidorm WWTP.

Seasonal Variability

Pharmaceuticals continuously detected in Benidorm WWTP secondary effluent



Pesticides and industrial products continuously detected in Benidorm WWTP secondary effluent



- Chlorpyrifos pesticide was detected mainly in August 2018 and May-June 2019 (used against pests such as cotonet in citrus crop).
- The anti-inflammatory drug ketoprofen was detected mainly in July-August 2018 and March 2019, periods of higher confluence of people in Benidorm. A significant increase in its concentration was observed in these periods in the influent of the Benidorm WWTP.

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Results

Secondary effluent and UF
Regular-Low Quality
CWQI = 45-60

RO permeate and AC effluent
Excellent Quality
CWQI > 95

Permeate line: Effluent free of ECs

ULTRAFILTRATION

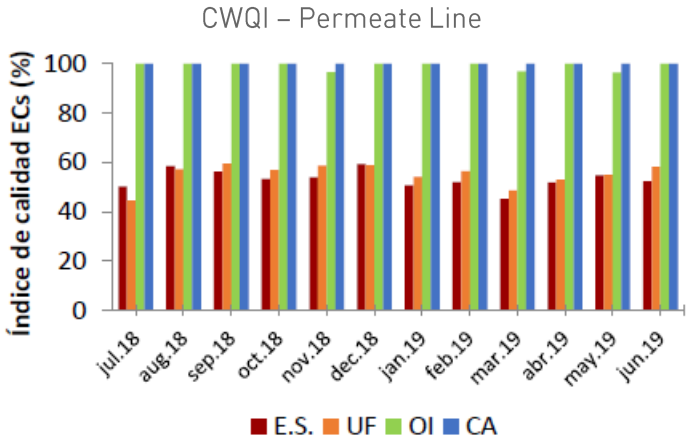
- Low reduction (0-50%) in the concentration of ECs with respect to the secondary effluent, depending on the compound (greater elimination of erythromycin and fluoxetine).
- Reduction of turbidity (< 0.1 NTU) and free of suspended solids.

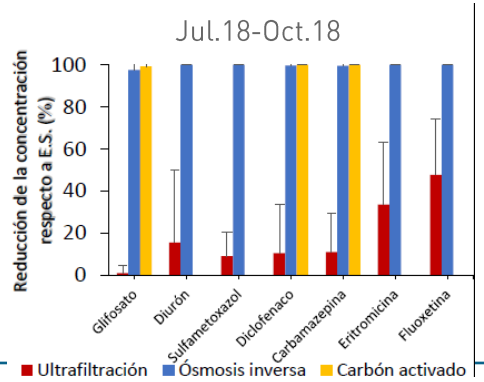
REVERSE OSMOSIS

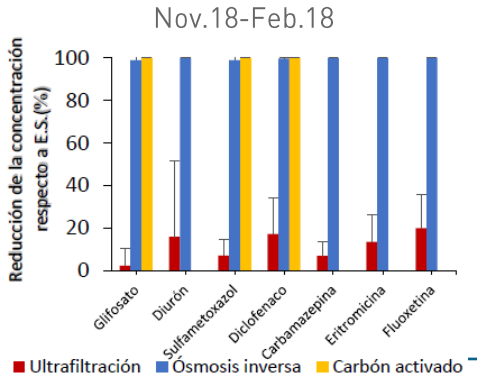
- Free of ECs detected in the secondary effluent (**concentration reduction with respect to secondary effluent**, except for traces in some samples of glyphosate, carbamazepine, diclofenac and sulfamethoxazole (>86% reduction).
- Low conductivity (< 200 µS/cm)

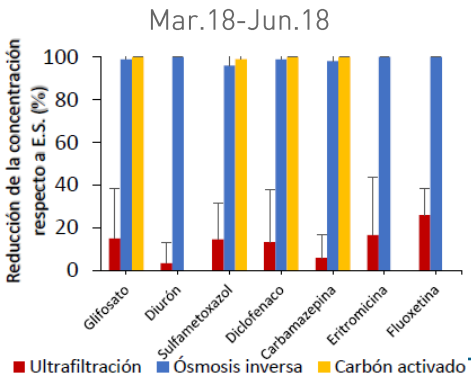
ACTIVATED CARBON

- Complete removal of traces detected in RO permeate.









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Results

Concentrate line: Reduction of the load of ECs to the environment

CONCENTRATES UF/RO

- **Effluent with high turbidity** and **presence of SS** and **high conductivity (6.000-8.000 µS/cm)**
- Micropollutants detected:
  - **Continuously**: pesticides (diuron and glyphosate), drugs (diclofenac, erythromycin, carbamazepine, fluoxetine and sulfamethoxazole).
  - **Occasionally**: pesticides (isoproturon and chlorpyrifos), drugs (ketoprofen, ibuprofen and estrone).

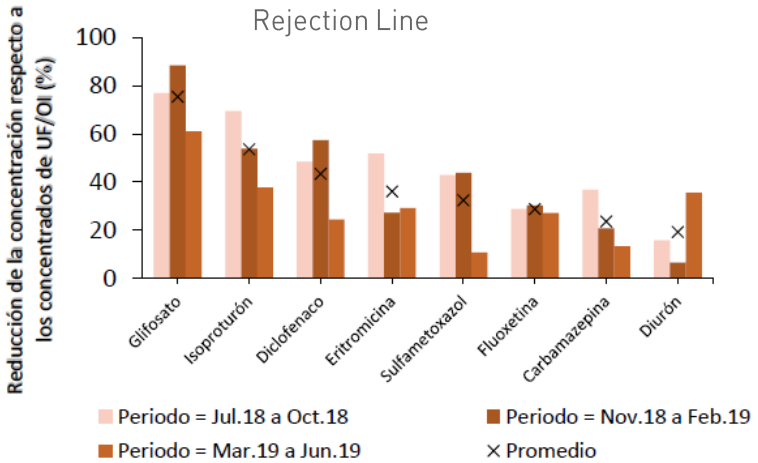
Low Quality
CWQI > 45

AOPs (Electro-oxidation + UV)

- Given the **low quality of the concentrates** (high turbidity and presence of SS) the **UV treatment was not effective.**
- With **electrooxidation** (carried out at 10A and with 1 passage through the cells), **different removal efficiencies were obtained depending on the nature of the compounds.**

Regular-Normal Quality
CWQI = 45-80

Rejection Line



Similar quality or higher to secondary effluent

- Reduction 60-90%: glyphosate and isoproturon
- Reduction 25-70%: diclofenaco, sulfametoxazol and eritromicine
- Reduction <40%: fluoxetine, carbamazepina and diuron

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Results

- The **effluent quality of the Benidorm WWTP secondary clarifier was low** (CWQI = 45-60) in the demonstration period (Jul-18/Jun-19) due to the **presence of ECs and priority substances**, which evidences the need to apply tertiary treatment.
    - It is worth noting the continued presence of the drugs **diclofenac**, **carbamazepine**, **fluoxetine**, **sulfamethoxazole** and **erythromycin** and the pesticides **diuron** and **glyphosate**.
- The pretreatment line processes (**conventional filtration** and **ultrafiltration**) hardly contributed to the removal of ECs but did condition the effluent for subsequent reverse osmosis treatment, reducing turbidity and suspended solids
- The reverse osmosis allowed to obtain a quality effluent (CWQI > 95) in which only traces of the compounds glyphosate, carbamazepine, diclofenac and sulfamethoxazole were detected in punctual samples, during the demonstration period
    - The subsequent permeate filtration through activated carbon allowed obtaining effluents free of the ECs studied (CWQI = 100), **without the application of a subsequent AOPs process for these compounds**
- The **electrooxidation processes** in the concentrate line allowed reducing the concentration of micropollutants in the UF and RO rejects. the removal efficiencies were diverse, depending on the nature of the compounds, being significant for compounds such as glyphosate
- The **proposed methodology** allows the elimination of priority substances and ECs present in WWTP effluents, reducing the environmental impact of the discharge of these effluents into the aquatic environment.

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Results

DURATION

2016-2019

COORDINATOR

Laboratorios Tecnológicos de Levante

BUDGET

1.783.824 €

EU Financial contribution 1.030.407 €

PARTNERS

AIDIMME INSTITUTO TECNOLÓGICO METALMECÁNICO, MUEBLE, MADERA, EMBALAJE Y AFINES

CONSOMAR, s.a. ingenieros consultores

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GENERALITAT VALENCIANA

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Universitat d'Alacant Universidad de Alicante

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Thank you for your attention.

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