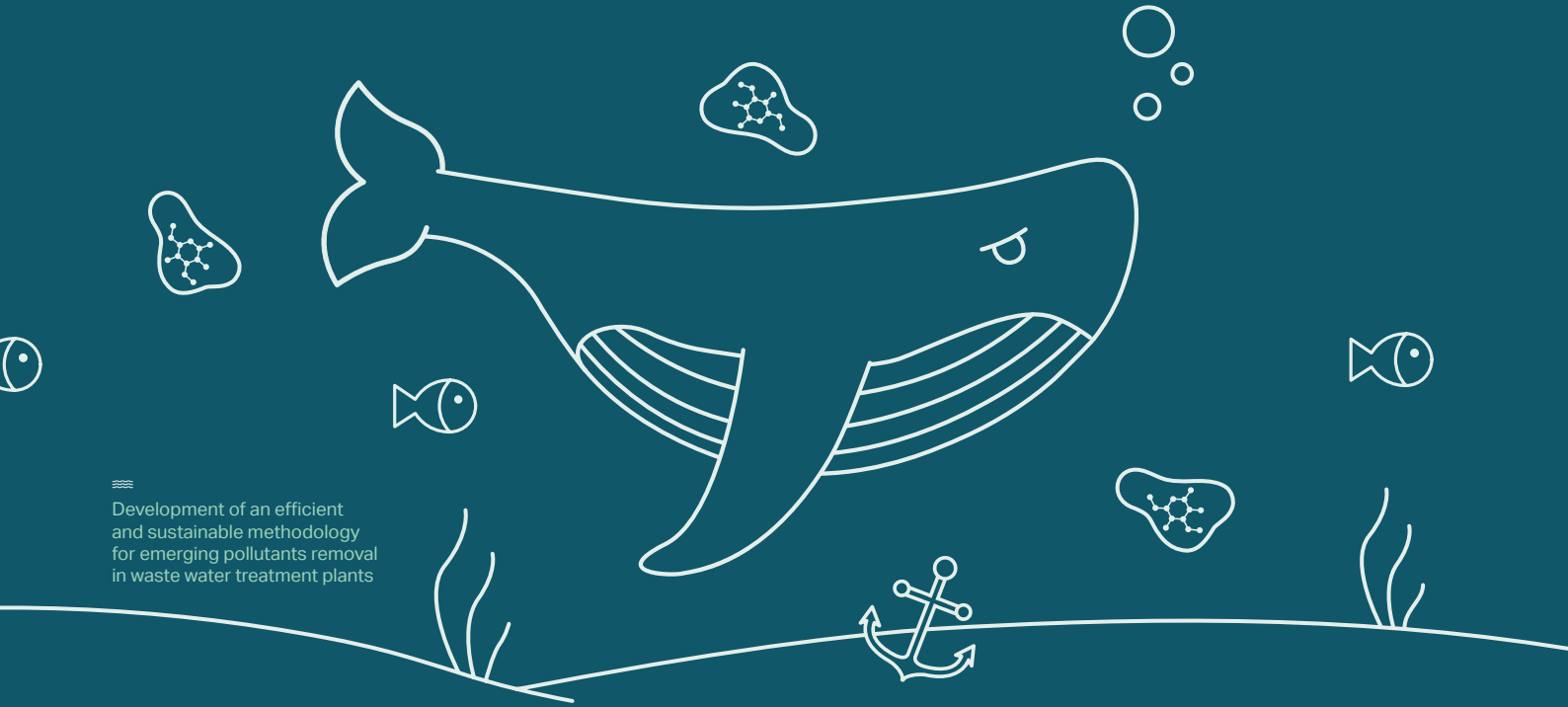
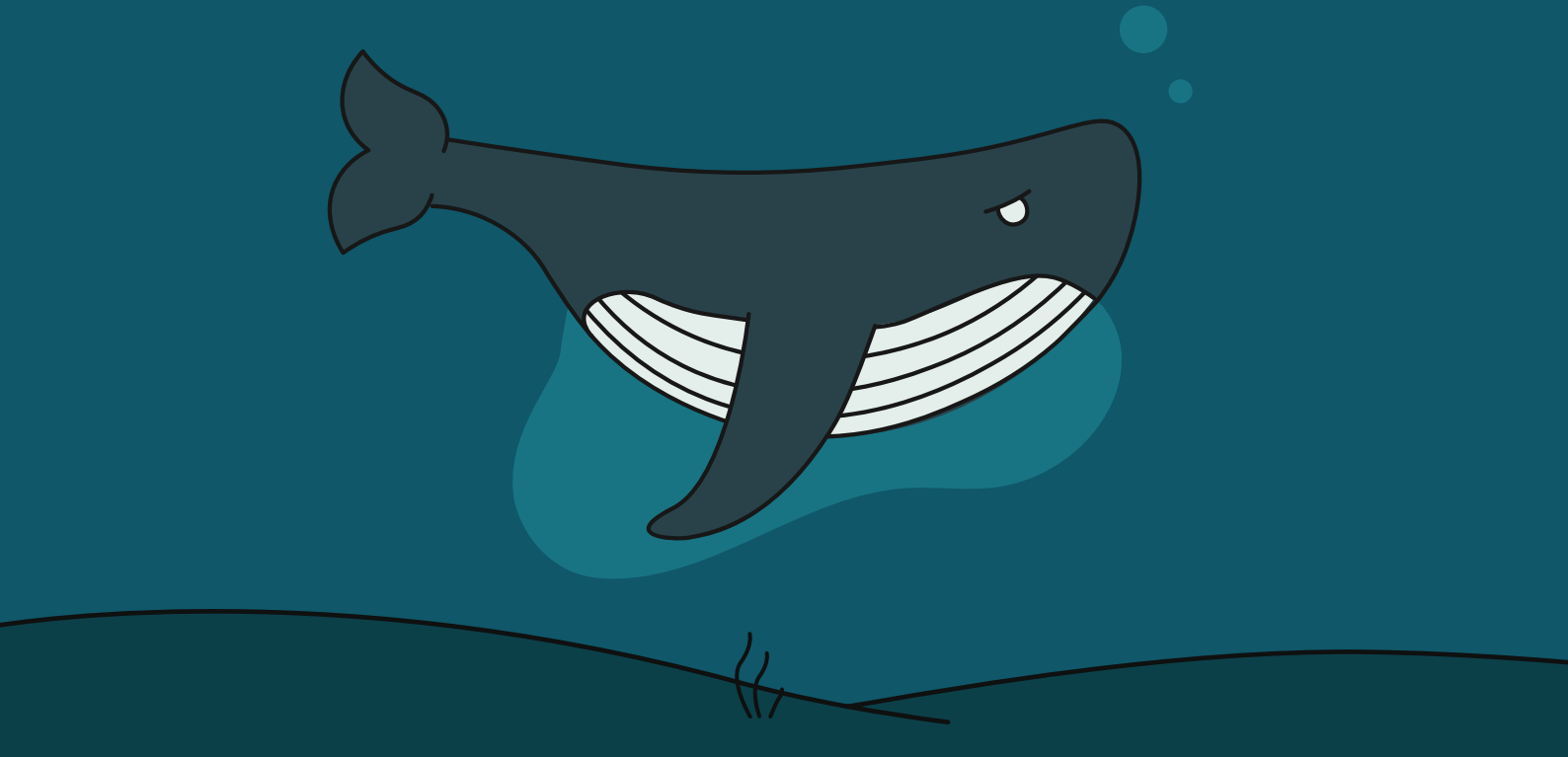
LIFE EMPORE PROJECT
LAYMAN'S REPORT



Development of an efficient and sustainable methodology for emerging pollutants removal in waste water treatment plants



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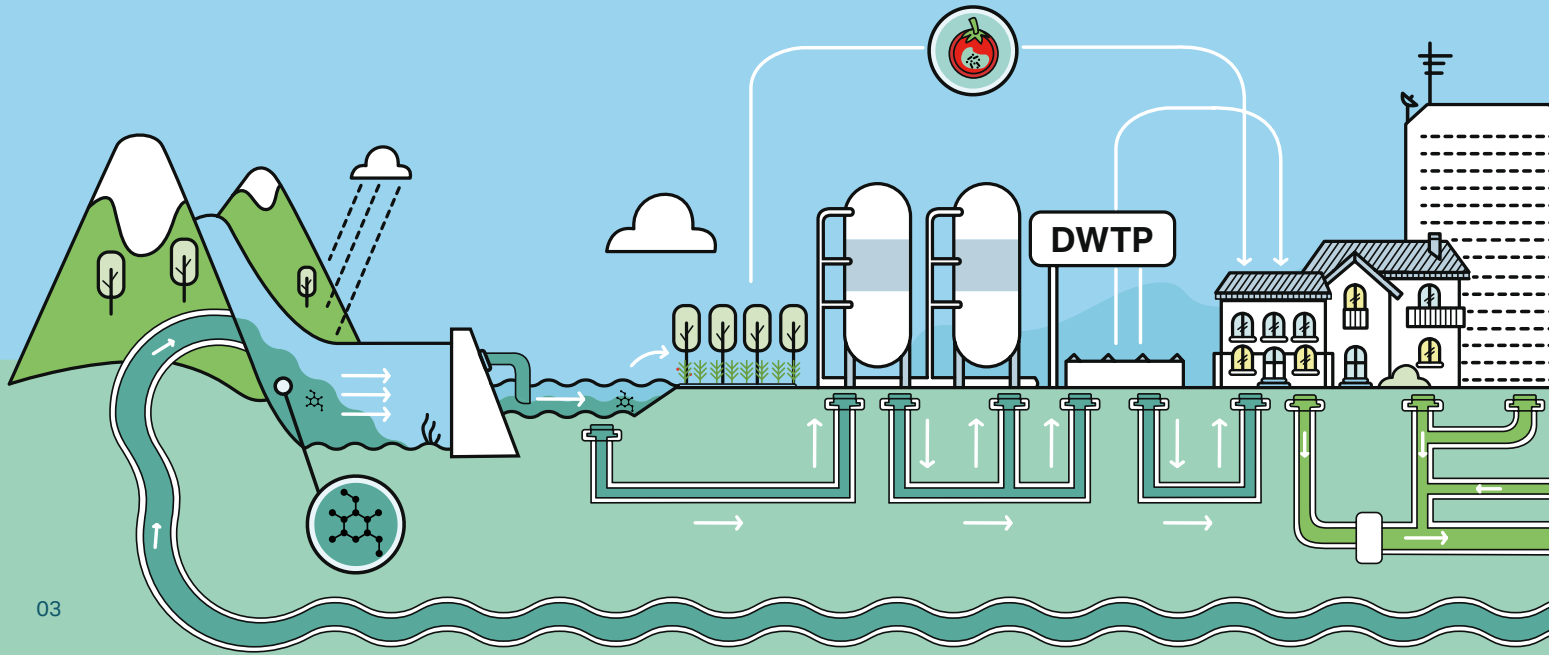
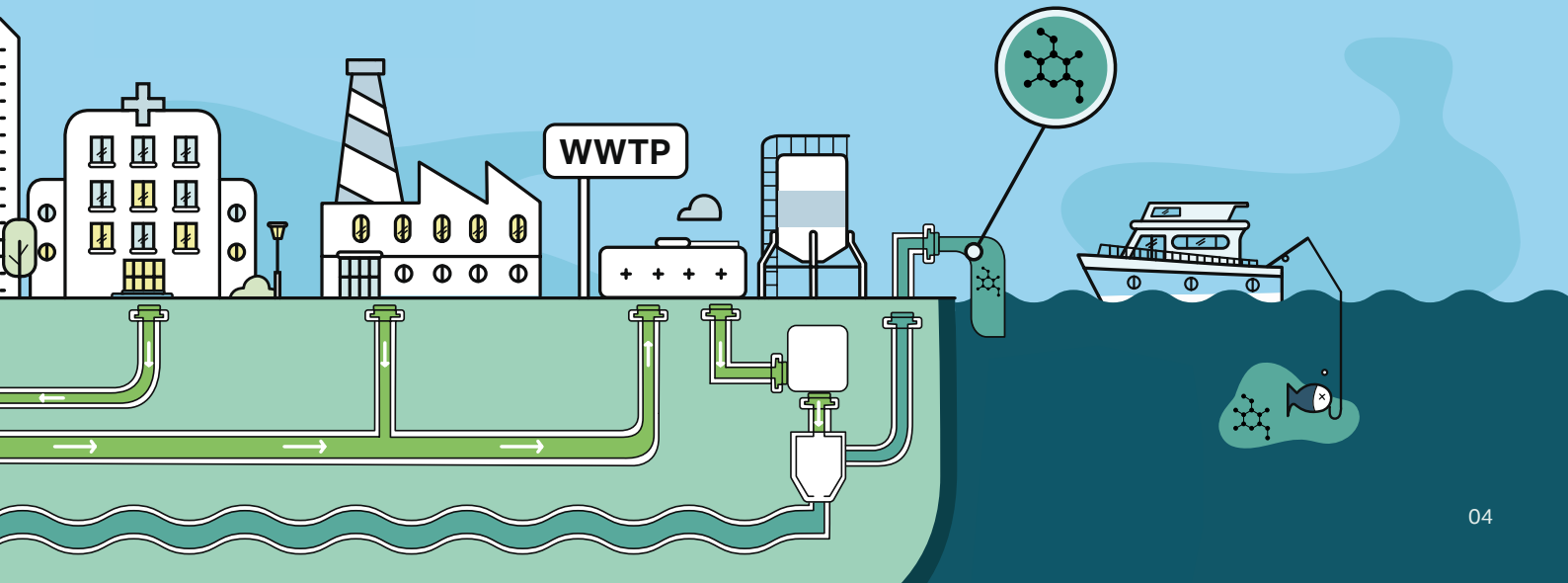
01. Context and background

The continuous synthesis of new chemicals and their widespread use resulted in the incorporation of these compounds to the water cycle. Many chemicals, which were not traditionally considered as pollutants, are now found in the aquatic environment at very small concentrations, and their effects on the environment and the human health are not yet well known. Furthermore, no regulations yet exist over some of these chemicals.



→ What are emerging pollutants?

Emerging pollutants (EPs) are compounds, commonly generated by new synthesis within the last decades, that are currently ubiquitous in water, though generally found at very low concentrations. Precise descriptive information regarding the effects of their exposure to the biota or their occurrence in water bodies is either missing or not et well described. The physical and chemical characteristics of these compounds may cause adverse effects to the environment and its biota, and/or to the human health.
EP's are becoming an increasing risk as they are permanently released to the environment. Currently, WWTPs are not designed for the treatment and removal of emerging pollutants, whereas their bioaccumulative character and the biomagnification effects on human and environmental health are of concern.



→ Occurrence of emerging pollutants in Europe and its regulation status

The occurrence of emerging pollutants in WWTPs inflows and outflows, as well as in natural water bodies, can be observed both in the liquid and solid matrices. The compounds may be either dissolved in water or adsorbed onto suspended particles, as well as in the sediments.

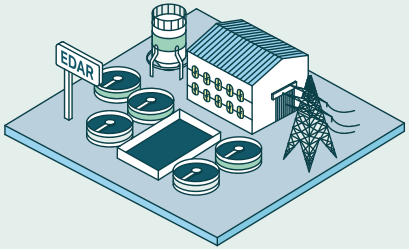
The concentration of a particular compound in the influent of a WWTP can vary notably among WWTPs, depending, among others, on the type of wastewater disposal (domestic, industrial, runoff, ...). Moreover, the concentrations of these pollutants may vary seasonally. In addition, the concentrations of emerging pollutants in the effluents of conventional WWTP depend on their suitability to be removed, as well as on the removal capacity of the WWTP processes.

What kind of emerging pollutants can be found in the effluents and influents of WWTPs? **pharmaceutical compounds** such as analgesics/anti-inflammatories, antibiotics, hormones and psychiatric drugs, among others; **pesticides** from industries that manufacture these type of products, from domestic use and, especially, from agricultural runoff; **Phthalate esters (PAEs)**, such as those used as additives in the manufacture of polyvinylchloride (PVC). PAEs can also be found as additives in paints, lubricants, adhesives, insecticides, packaging industry and cosmetics. Phthalate esters are one of the most frequently found persistent pollutants in the environment. Finally, **personal care products (PCPs)** such as fragrances, disinfectants, UV filters and insect repellents, are also a source of emergent pollutants.
Although many EPs are under suspect of causing adverse effects in humans and wildlife, only 45 of them are regulated so far (Directive 2013/39/UE).

The EU Commission strategy to combat surface water pollution was outlined in the European Water Framework Directive 2000/60/EC (EU-WFD). This Directive offered the first list of 33 substances or groups of substances to be identified, requiring action priorities at the Community level, the list being reviewed every 4 years. Substances such as DEHP, Chlorpyrifos, 4-t-OP and Trifluralin were listed as priority hazardous substances in the EU-WFD and the final EU Decision No. 2455/2001/EC.

The EU-WFD has undergone several revisions until its current status. The Directive 2013/39/EU updated the list of priority substances and priority hazardous substances. This revision established a watch list of substances for which data have to be gathered through the European Union. These data will support future prioritization exercises in accordance to the Article 16-2 of EU-WFD. Diclofenac, 17-beta-estradiol and 17-alpha-ethinylestradiol, for instance, were included. Contrarily, other EPs, such as Chloramphenicol, Carbamazepine, Ibuprofen, Fluoxetine and Estrone were not yet included due to the lack of knowledge of their impact.

Treated effluent discharges from domestic WWTP in the EU contribute significantly to the occurrence of EPs in EU water bodies. Some studies showed the need for improving the performance of WWTP by incorporating updated treatment procedures that may be able to reduce the EPs load in European water bodies.



02. The Life Empore project

→ Objectives

To demonstrate an innovative, cost-efficient and highly replicable technology for the removal of Emerging Pollutants in European Wastewater Treatment Plants.

→ Specific objectives

To design a technology capable to reduce the preselected concentration of emerging pollutants as follows:

1. To reduce the levels of the following priority emerging pollutants below the limits established by the Directive 2013/39/EU: Chlorpyrifos (agricultural), Trifluralin (agricultural), 4-t-OctylPhenol (industrial), DEHP (industrial), Diuron (agricultural) and Isoproturon (agricultural).

2. To reduce the levels of the concentration of the following emerging pollutants listed in the "watch list" of the Commission Implementing Decision (EU) 2018/840 of 5 June 2018 by a 95% of their original concentration: 17-alfa-ethynilestradiol (hormone), 17-Beta-Estradiol (hormone), Estrone (hormone) and Erythromycin (antibiotic).

3. To reduce the concentration of the following emerging pollutants by a 95% of their original concentration: Diclofenac (anti-inflammatory), Chloramphenicol (antibiotic), Carbamazepine (psychiatric drug), 2-(p – isobutylphenyl) propionic acid (anti-inflammatory), Fluoxetine hydrochloride (Psychiatric drug), Estriol (hormone), Glyphosate (agricultural), Sulfamethoxazole (antibiotic), and Ketoprophen (anti-inflammatory).

- To evaluate the occurrence of emerging contaminants in Europe.
- To characterize the emerging pollutants and their yearly variability in the WWTP of Benidorm (Alicante, Spain).
- To analyze the feasibility of the tested technologies for the emerging pollutants removal.
- To assess the initial and final environmental status in the effluent of the Benidorm WWTP according to different physical and chemical water parameters.
- To assess the socio-economic impact of the implementation of the demo plant for emerging pollutants removal in the local economy, as well as in regions with similar problems in Europe.
- To transfer the project results to other identified European sites experiencing a similar situation regarding emerging pollutants.
- To disseminate among stakeholders, the benefits of using Life-EMPORE technologies for the reduction of emerging pollutants in European WWTPs effluents.

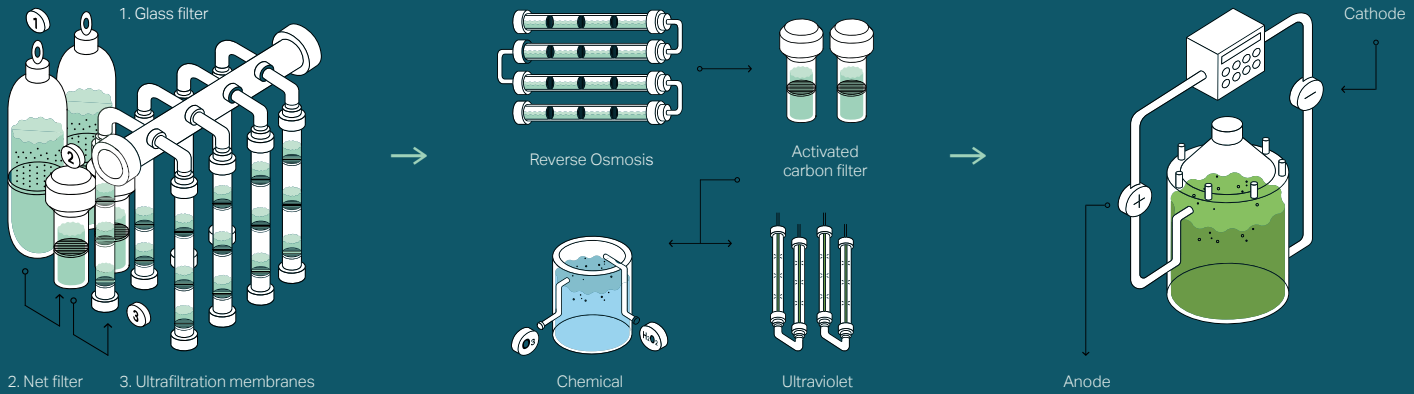
→ Methodology

For this purpose, a pilot plant has been designed and integrated into the WWTP of Benidorm (Spain).
The prototype is a mobile plant with a sequential distribution of technologies. First, the water is subjected to a pre-treatment by conventional filtration and ultrafiltration processes (UF). Then, the permeate obtained is treated by reverse osmosis (RO) plus activated carbon (AC), and subsequently to advanced oxidation processes (AOP's). Additionally, the rejection products (concentrated line) are treated by an Electrochemical Advanced Oxidation Processes.

Level one
—
Filtration +
Ultrafiltration.

Level two
—
Reverse Osmosis +
Advanced Oxidation Processes (AOPs)

Level three
—
Electrochemical Advanced
Oxidation Processes (EAOPs)



03. Case study

→ Location

The demonstration action was carried out in the **Benidorm WWTP**, placed in the district of Marina Baja (X:754564, Y:4270829, Z:143), in the province of Alicante (Spain).
The Benidorm WWTP treats 62.320 m^3 of water per day (served population of 237.380 equivalent in habitants). This WWTP treats mainly urban wastewater from the towns of Benidorm, Alfaç del Pi, Finestrat, Polop and La Nucia. It comprises a secondary biological sludge treatment with prolonged aeration followed by a tertiary membrane treatment of UF and RO.

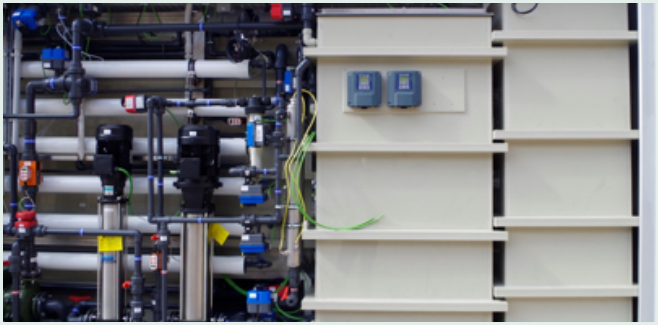
→ Data collection and pollutants analyzed

The treated water obtained after each one of the three assayed treatments (UF, RO-AC, and EOAP, respectively) was collected for the intensive evaluation of the global performance of the combination and the effectiveness of each of the treatments for the removal of the industrial/agricultural emerging pollutants of the collected wastewater. Once a week, a sample from the inlet (the secondary effluent of Benidorm WWTP) and from the outlet of each level of treatment of the pilot plant was taken, and the emergent pollutants concentrations were analyzed. In addition, some physical and chemical variables, such as turbidity, pH, conductivity, and suspended solids, were also measured.

→ Pilot plant

* Location of the pilot plant within the Benidorm WWTP

* Pilot plant view



* Pilot plant view

* Pilot plant view

→ Results

During the study period (July 2018 to June 2019) different EP's were detected in the secondary effluent of WWTP of Benidorm. Some of these EP's were continuously detected in the WWTP effluent and others just occasionally. These EP's included priority compounds and other not regulated compounds. However, other compounds originally included in the design of the project were not detected in this secondary effluent, therefore, Life-Empore methods could not be tested for these compounds.

Not detected: trifluralin (herbicide), 4-t-octylphenol (industrial), chloramphenicol (antibiotic), (17-beta-estradiol, 17-alfa-ethynilestradiol and estriol) (hormones).

Occasionally detected: chlorpyrifos and isoproturon (pesticides), , 2-(p -isobutylphenyl) propionic acid (ibuprofen) and ketoprophen (anti-inflammatory), and estrone (hormone).

Continuously detected: glyphosate and diuron (agricultural), erythromycin and sulfamethoxazole (antibiotic), diclofenac (anti-inflammatory), carbamazepine and fluoxetine hydrochloride (psychiatric drugs).

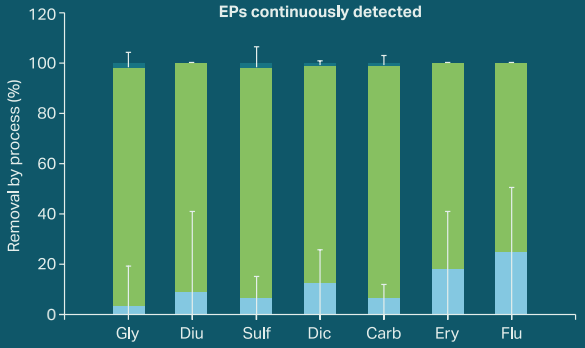
→ Permeate line

Conventional filtration plus ultrafiltration (UF)

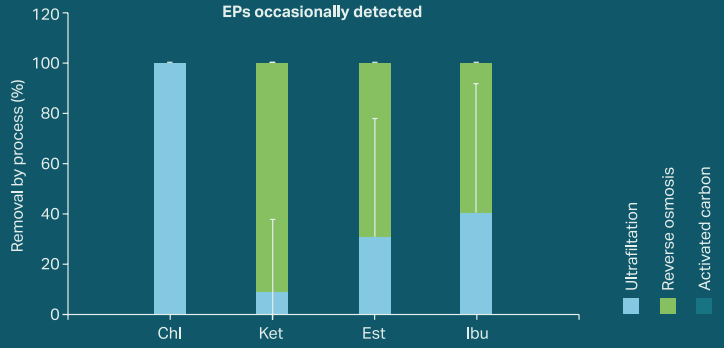
This treatment was not very effective in removing EP's, except in case of chlorpyrifos, which was completely removed by UF. For most cases, UF played as a pre-treatment since it was very effective in removing turbidity and suspension solids and conditioned the permeate before being treated by the reverse osmosis.

Reverse Osmosis (RO) plus activated carbon (AC)

The permeate obtained after the UF process was subsequently treated by reverse osmosis (RO). After the reverse osmosis process, the permeate was almost free of EP's. This process reduced by almost a 100% the EP's concentration with respect to the secondary effluent from WWTP, Just a few samples still presented traces of glyphosate, carbamazepine, diclofenac and sulfamethoxazole; though the reduction by RO was always higher in these few samples than 86%. The complete removal of the traces of EP's in these samples was achieved after treating them with activated carbon.
Therefore, the combination of reverse osmosis plus activated carbon after the pre-treatment of conventional filtration plus ultrafiltration was completely effective in the removal of EP's and consequently, Advanced Oxidation Process (AOP's) could not be tested as methodology to remove these pollutants since they were already removed by the previous treatments.



** Figure 1. Percentage of elimination by process of the EP's continuously detected in WWTP effluent of Benidorm: Gly (glyphosate), Diu (diuron) Sulf (sulfamethoxazole), Dic (diclofenac), Carb (carbamazepine), Ery (erythromicine) and Flu (fluoxetine)*

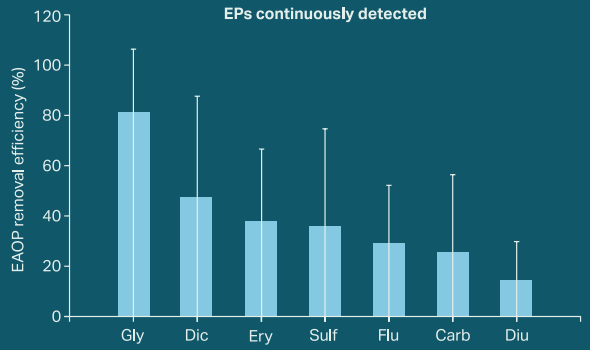


** Figure 2. Percentage of elimination by process of the EP's occasionally detected in WWTP effluent of Benidorm: Chl (chlorpyrifos), Ket (ketoprophen), Est (estrone) and Ibu (ibuprofen).*

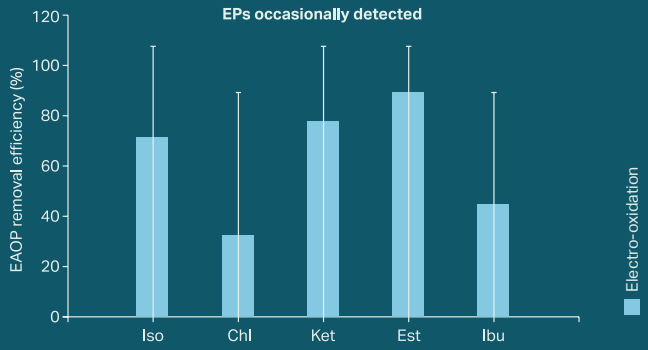
→ Concentrate line

The electrochemical advanced oxidation process (EAOP's) reduced the concentrations of some of the pollutants present in the rejections or concentrates of the UF and RO processes. These rejections were the inlet to the reactors of the electrochemical advanced oxidation process.
The following figures shows the percentage of removal by the EAOP of both continuously and occasionally detected EP's on the concentrates.

The EAOP's treatment was an effective method of removing contaminants that were rejected from the other methods.



** Figure 3. Percentage of elimination by EAOP's of the EP's continuously detected in WWTP effluent of Benidorm that remained in the rejection of UF and RO processes: Gly (glyphosate), Dic (diclofenac), Ery (erythromicine), Sulf (sulfamethoxazole), Flu (fluoxetine), Carb (carbamazepine) and Diu (diuron).*



** Figure 4. Percentage of elimination by EAOP's of the EP's occasionally detected in WWTP effluent of Benidorm that remained in the rejection of UF and RO processes: Iso (isoproturon), Chl (chlorpyrifos), Ket (ketoprophen), Est (estrone) and Ibu (ibuprofen).*

04. Communication activities

During the entire project, different communication activities have been carried out. The main objective of these activities was to disseminate the results of this project, enhancing the transferability of the best methodology to remove the EP's in Europe to end-users and stakeholders.

05. Dissemination and publications

→ Attended events

- *"1st. Symposium Novedar: "Presence and removal of microcontaminants in water"*. Oral presentation "Removal of micropollutants in WWTP effluents through the combination of membrane processes, advanced oxidation and electrochemical processes". Santiago de Compostela, June 13th and 14th, 2019.

- *"10th International Conference on River Basin Management"* organized by Wessex Institute and the University of Alicante. Presentation: "Assesing the social perception of emerging pollutants in the south-east of Spain". Alicante, May 8th, 2019.

- *"Workshop of the Interreg Europe project AQUARES"* organized by the Euro-Mediterranean Water Foundation. Oral presentation "Water reuse: The challenge of Emerging Pollutants. Practical Case: Project *"LIFE EMPORE"* Milan, March 27th - 28th, 2019.

- *"National Water Congress"*, organized by the University of Alicante and the City Council of Orihuela. Oral presentation of the *"LIFE EMPORE"* project. Orihuela, February 21st and 22nd, 2019.

- Technical conference "Treatment and elimination of emerging pollutants from effluents of urban wastewater treatment plants". Valencia, February 12th, 2019.

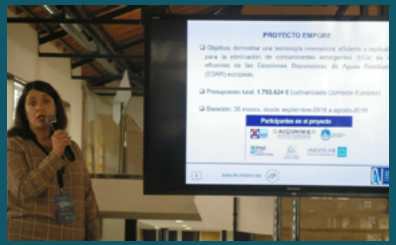
- ESAMUR Technical Conference on Sanitation and Purification. Lorca (Murcia), November 21st and 22nd, 2018. A survey on emerging pollutants was carried out regarding aspects such as regulations, analytic techniques, removal technologies, socio-economic impact and water prices.

- "Water Knowledge Europe". Organized by the WssTP (Water Supply and Sanitation Technology Platform), a water platform initiated by the European Commission in 2004 for Research and Technology Development in the water industry. Brussels, November 28th and 29th, 2018.

- Assistance to the II Conference on Climate Change organized by the Polytechnic University of Valencia (UPV) and the Generalitat Valenciana. Valencia, November 12th, 2018.

- Assistance to ECOFIRA 2018. Installation of a stand for the "LIFE EMPORE" project. Paterna, November 6th to 8th, 2018.

- XII International Congress of the Spanish Association of Desalination and Reuse (AEDyR). Paper presented: "Development of an efficient and sustainable methodology for the removal of emerging pollutants from WWTP's" Toledo, October 23rd, 2018.



* "National Water Congress", organized by the University of Alicante and the City Council of Orihuela. Oral presentation of the "LIFE EMPORE" project. Orihuela, February 21st and 22nd, 2019.

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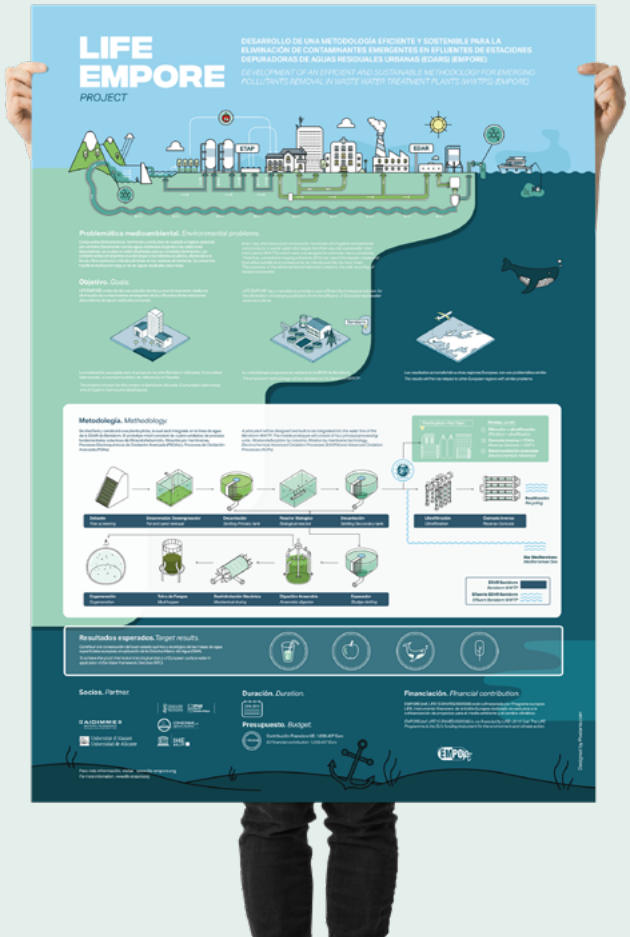
LIFE
EMPORE
PROJECT
DESARROLLO DE UNA METODOLOGÍA EFICIENTE Y SOSTENIBLE PARA LA ELIMINACIÓN DE CONTAMINANTES EMERGENTES EN EFLUENTES DE ESTACIONES DEPURADORAS DE AGUAS RESIDUALES URBANAS (EDARs) (EMPORE)
DEVELOPMENT OF AN EFFICIENT AND SUSTAINABLE METHODOLOGY FOR EMERGING POLLUTANTS REMOVAL IN WASTE WATER TREATMENT PLANTS (WWTPS) (EMPORE)
ETAP
EDAR
Problemática medioambiental. Environmental problems.
Objetivo. Goals.
Metodología. Methodology
Resultados esperados. Target results.
Socios. Partner.
Duración. Duration.
Presupuesto. Budget.
Financiación. Financial contribution.


LIFE
EMPORE
Life is water.
DEVELOPMENT OF AN EFFICIENT AND SUSTAINABLE METHODOLOGY FOR EMERGING POLLUTANTS REMOVAL IN WASTE WATER TREATMENT PLANTS (WWTPS) (EMPORE)
Partners.
Duration.
Budget.
Financial contribution.

04. Dissemination and communication material

→ 7 Organized events

→ 1 Brochure

→ 1 Noticeboard in pilot plant

→ 15 Networking events

→ 8 Newsletters

→ 1 Tote bag

→ 1 Notebook

→ 1 Motion graphics video

→ 20 News & Press

→ 1 Layman´s Report

→ 1 Press dossier

→ 16 Press releases

→ Social networking
life-empore.org
linkedin.com/company/life-empore

→ 1 Roll up

→ 1 Poster

** Motion graphics video*

** Noticeboard in the pilot plant.*


LIFE EMPORE
"El agua es vida"
Objetivo.
Socios.
Duración del proyecto.
Presupuesto.
Cofinanciado por el programa Life.
LIFE EMPORE
Life is water.
Antecedentes.
Resultados esperados.
Depuradora de Benidorm y el concepto EMPORE.
Concepto EMPORE.
LEVEL 1
LEVEL 2
LEVEL 3.

Life Empore project

Budget

1,783,824 Euro

Project duration

01/09/2016-31/08/2019

Contact email

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Co-financed by Life programme

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Partners

GENERALITAT VALENCIANA

EPSAR Entitat de Sanejament d'Aigües

CONSOMAR, s.a. ingenieros consultores

LABORATORIOS TECNOLÓGICOS de LEVANTE

Universitat d'Alacant
Universidad de Alicante

UNESCO IHE DELFT

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METALMECÁNICO, MUEBLE, MADERA, EMBALAJE Y AFINES

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