REGENERA Energy

LIFE19 ENV/ES/000447 LIFE-DESIROWS LAYMAN'S REPORT

Brackish-Groundwater desalination and denitrification for sustainable irrigation: Net Zero Waste and Energy

DESIROWS

Life

Universidad Politécnica de Cartagena

ARCO SUR MAR MENOR · COMUNIDAD DE REGANTES ·

HIDROTEC TRATAMIENTO DE AGUAS

HIDROGEA

PROJECT LOCATION: Murcia (Spain)

BUDGET INFO:

- **Total amount:** 1,614,051 Euro
- **% EC Co-funding:** 869,853 Euro
  (55 % of total eligible budget)

DURATION: Start: 01/09/20 - End: 30/06/24

PROJECT'S IMPLEMENTORS:

- **Beneficiary:** REGENERA, UPCT, ARCOSUR, HIDROTEC, HIDROGEA.

LIFE DESIROWS

LIFE-DESIROWS is a demonstration project that aims eliminate brine from water desalination processes, reaching the crystallization of salts and improving the quality of the reclaimed water for the agricultural sector at an affordable price and achieving zero discharges to the Mar Menor Coastal Lagoon protected area.

LIFE DESIROWS has installed a demo plant in an endangered area of Mar Menor Coastal Lagoon in the southeast of Spain, with the aim of maximising the reclaimed water recovery from the brine and remove relevant pollutants.

The plant is a combination of biological, membrane separation and thermal technologies that allows obtaining reclaimed water for irrigation and a dried salt with potential market value. The plant consists of an autonomous renewable energy off-grid solution to cover brine treatment energy demand, improving the cost efficiency of operation.

1. OBJECTIVES & SCOPE

LIFE-DESIROWS is a demonstration project that aims to **eliminate brine from water desalination processes**, reaching the crystallization of salts and **improving the quality of the reclaimed water** for the agricultural sector at an **affordable price** and **achieving zero discharges to the Mar Menor Coastal Lagoon protected area**. This is expected to decrease the negative impact of the pollutants (salinity, nitrates, pathogens) on the ecological equilibrium of fauna and flora in the area.

Further objectives:

Design, development, testing, demonstration and evaluation of an innovative **demo plant** with autonomous energy brine treatment system with environmental benefits:

- **Maximisation of reclaimed water** of rejected flows **(97% increase)**.
- **Elimination of pollutants**, avoiding their discharge in aquatic ecosystems.
- **Minimization of the brine's volume** to achieve its crystallization.
- **Promotion and increase of Renewable Energies**, combining solar and biomass.

- **Recycling of brine salts**: using as fertilisers in agricultural soils and in industry in road de-icing.
- Determination of the **potential replicability and transferability** of DESIROWS technology.
- **Promotion** of the **brine treatment technology**.

2. ENVIRONMENTAL PROBLEMS TARGETED

The environmental problems targeted in this project are: (1) the water scarcity and (2) the negative effects of contaminants contained in the brine (wastewater rejected from water desalinization): salinity, nitrates and pathogens on the surrounding flora and fauna. This project aims to boost safe and efficient use of water resources and improve quantitative water management.

Water scarcity, one of the common negative effects of climate change, affects at least 10.4% of the EU territory and 14.3% of the EU population, mainly in Southern Europe. Various solutions are being explored, such as desalination, being applied in 150 countries worldwide, with over 18,500 desalination plants producing freshwater from seawater and brackish water. Desalination is one of the technologies, according to the Spanish Law RD1627, to obtain reclaimed water.

Despite the benefits of desalinisation, there are concerns regarding the environmental effects of the residual brine, which can be up to 25% of the collected water and has high salinity. In addition, it contains other concentrated potential contaminants, such as pathogens and nitrates from the agricultural and human activity.

An excellent case study of this problem is the Murcia region as the synergy between the effects of climate change and brine discharges endangers the ecological stability of the Mar Menor saltwater lagoon.

This is an intensive agricultural area where water scarcity has promoted the installation of high number of small to medium sized desalinisation plants, located in the irrigation fields. The brine generated is discharged directly to the lagoon.

ENVIRONMENTAL PROBLEMS TARGETED

From 2015, the lagoon is on the brink of an ecological collapse, as a direct consequence of years of brine spills and drainages of agricultural origin, loaded with nitrates that synergise water eutrophication. Regional Law 1/2018 issued urgent measures to guarantee environmental sustainability of the lagoon environment, mainly focusing on decreasing contaminant concentration in the brine and prohibiting its discharge into the lagoon.

With this in mind, LIFE-DESIROWS is a demonstration project that will eliminate brine from water desalination processes, reaching the crystallization of salts and improving the quality of the reclaimed water for the agricultural sector at an affordable price and achieving zero discharges to the Mar Menor Coastal Lagoon protected area. LIFE DESIROWS is proposing the following solutions:

1) Design, development, testing, demonstration and evaluation of an innovative brine treatment demo plant with autonomous energy generation from renewable sources (solar and biomass) with environmental benefits. Such benefits include the maximisation of reclaimed water (98% increase) and eliminating pollutants in the process to avoid their discharge in the aquatic ecosystems.

2) Recycling of brine salts: using them as fertilisers in agricultural soils and in industry in road de-icing. The technology results in zero waste.

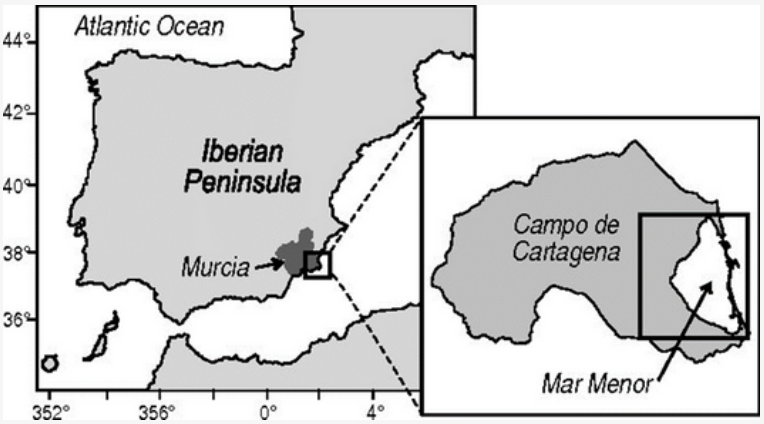
3) Determination of the potential replicability and transferability of DESIROWS technology.

4) Promotion of brine treatment technology by Introducing the technology and objectives of the Water Framework Directive (2000/60/EC) and other national/regional/local regulations, that have a significant contribution in the protection of coastal and ground waters. The project will also raise awareness of relevant target groups with respect to brine management and its treatment and identify solutions to overcome potential barriers related to the full-scale implementation of DESIROWS technology.

3. CONTEXT OF THE PROJECT

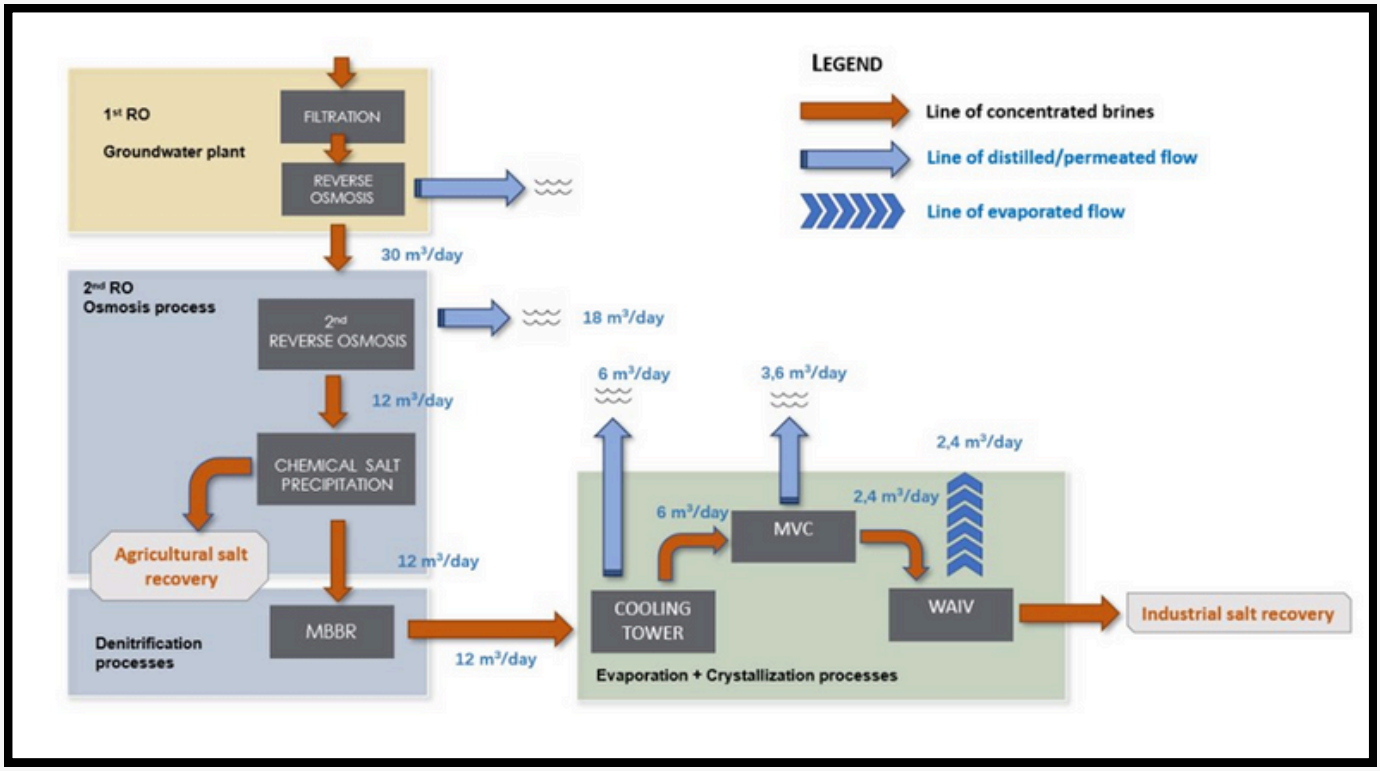
Mar Menor coastal lagoon

The Campo de Cartagena (185,514 ha) is large and complex hydrogeological area located at South-east Murcia, is an irrigable area (41, 562 ha) with high irrigation requirements and is **affected by environmental problems** derived from **nitrates** contamination and **brine** management, due to its proximity to the Mar Menor Coastal lagoon.



4. PILOT PLANT

FLOW DIAGRAM



Life DESIROWS demonstration plant is designed to treat 30 m^3 of brine per day. The following equipment is described below:

- **Moving Bed Biofilm Reactor (MBBR)**: This part of the device allows the removal of contaminants (nitrates) from the brine. The MBBR provides a high denitrification rate by combining natural carbon sources such as wood chips, molasses, and biodegradable polyester supports. This leads to a reduction in the reactor volume, allowing it to operate at a higher and more stable temperature (up to 25°C), which optimizes the biological operating conditions and increases the denitrification rate.

PILOT PLANT

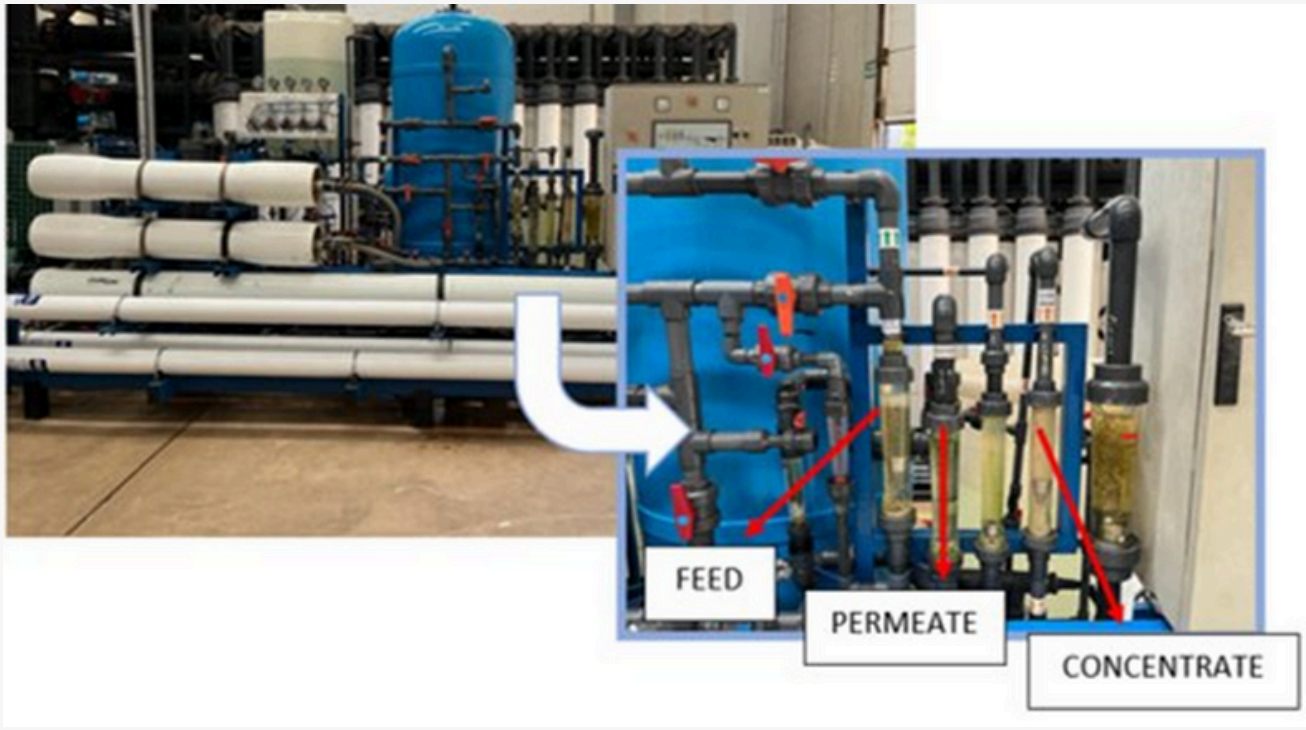
- **Zero Liquid Discharge (ZLD)**, composed of the following techniques: 1. Reverse Osmosis (RO), 2. Cooling Tower (CT), 3. Mechanical Vapor Compression (MVC), and 4. Crystallization through Wind-Aided Intensified Evaporation (WAIV). The combination of these technologies with an advanced heat recovery system (HRS) and the use of renewable energy sources (RES) enables a self-sufficient energy system. The system allows for salt recovery, maximizes recovered water, and eliminates pathogens.

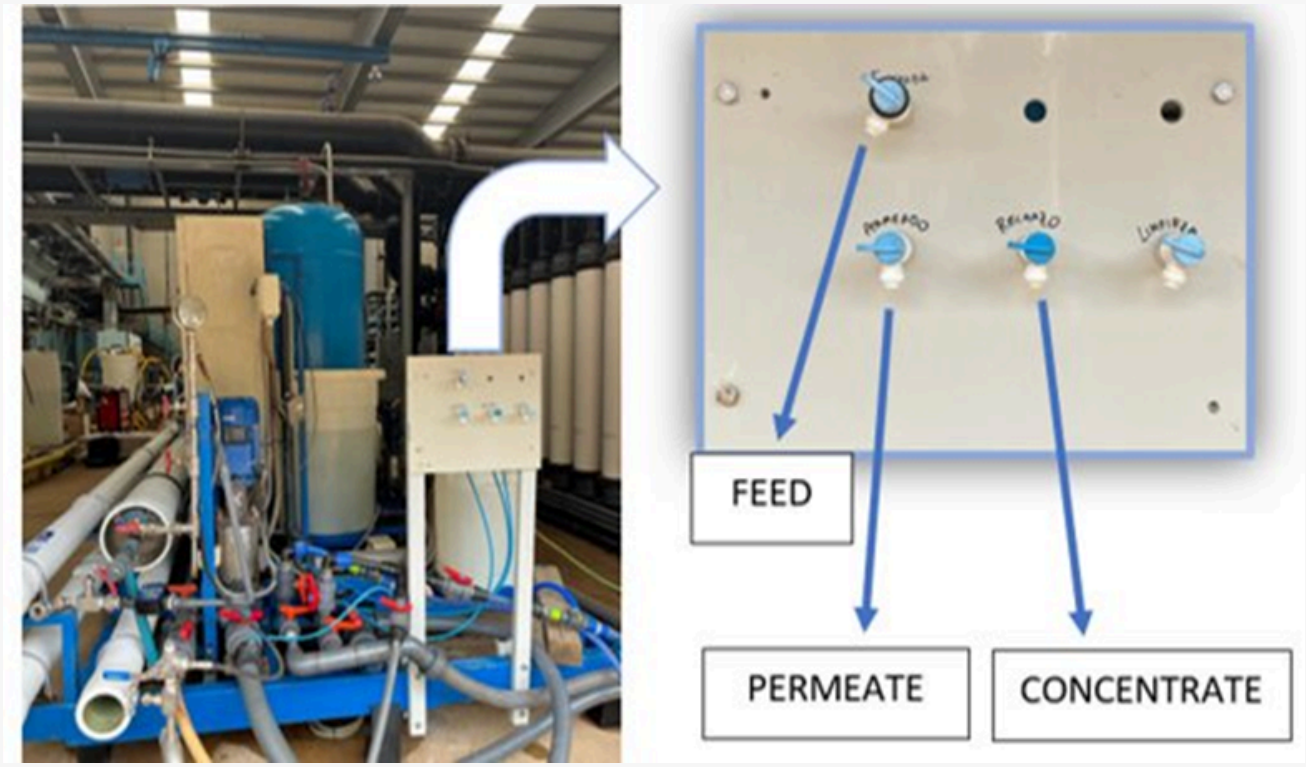
Thermodynamically, the energy required to evaporate 1 m^3 of brine is 695 kWh (n.c), while the energy requirement of the proposed ZLD system is less than 40 kWh.

- The **RO process** (which is the second step in the entire process, after the reverse osmosis prior to the entry of brine into the DESIROWS prototype) has a higher energy efficiency compared to evaporation processes. Through selective chemical precipitation of salts, higher molecular weight salts (CaCO3, MgCO3, CaSO4, K2SO4, MgSO4), representing around 6 g/L, are separated. Ultrafiltration is used before selective chemical precipitation of salts to optimize the process by reducing fouling issues, thus reducing energy and operational costs. This process reduces the brine to approximately 10% (from 30 to 12 m^3/day) with a TDS concentration of around 35g/L.

PILOT PLANT

Sampling and process control points of the pilot plant





PILOT PLANT

The role of the **Cooling Tower** is to take advantage of brine evaporation and thus increase its concentration. It is based on the evaporation of brackish water and the subsequent condensation of the humid air generated, mainly at ambient pressure. The amount of energy required to achieve a ZLD system is proportional to the volume of brine, so it is possible to reduce and concentrate the brine at a low energy cost using the CT. This technology reduces brine by about 50%.

- The **Mechanical Vapour Compressor** is used for ZLD but is not employed to achieve a concentration close to crystallization due to the high energy consumption of the process. The MVC technology focuses on reducing the volume of concentrated brine entering salt crystallizers or evaporation ponds, reducing incoming brine by approximately 50%.

- The last process in the prototype is **WAIV**, a crystallization technique. It is a natural system that uses the wind to evaporate a thin layer of brine that flows down vertically through high-density strips of wet-surface sails mounted parallel. It is a modular and scalable device with a very high packing density, reaching up to 20 m^2 of sails per m^2 of surface area. The reduction in brine flow, along with the aforementioned technologies, allows the WAIV system's footprint to be minimized.

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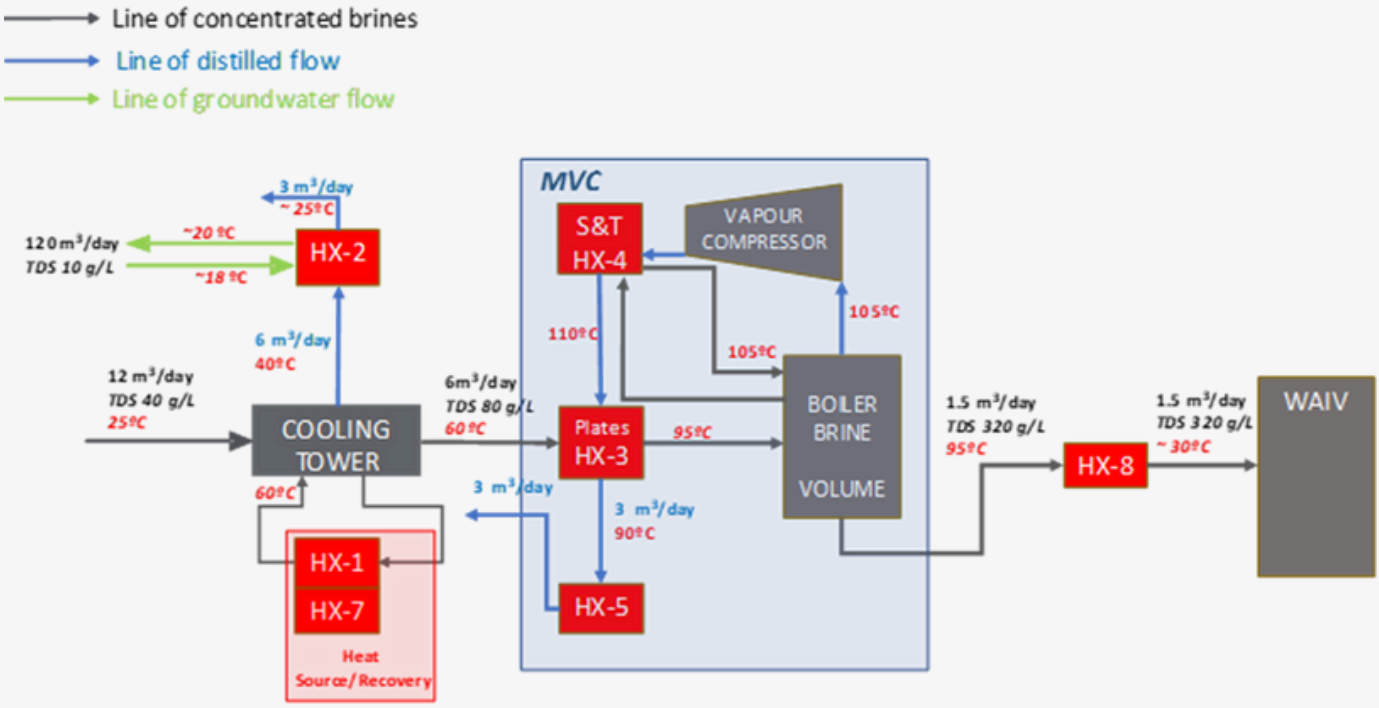
PILOT PLANT

WIND AIDED INTENSIFIED EVAPORATION (WAIV)

PILOT PLANT

The demonstration technology comprises a renewable energy system, photovoltaic solar energy (electric energy), and biomass (thermal energy), utilizing two important natural resources in the Region of Murcia: the sun and biomass produced in agriculture, enhancing the circular economy approach of the project.



5. RESULTS

Life Desirows tests the effectiveness of up to seven desalination and denitrification technologies

Life Desirows project have verified the effectiveness and feasibility of up to seven desalination and denitrification technologies to recover groundwater from the Campo de Cartagena for agricultural use. This water, which contains high levels of salinity and nitrates, is treated without generating waste and using only renewable energy sources: photovoltaics, biomass, and wind for drying processes.

RESULTS

To demonstrate that it is possible to eliminate brine and nitrates from well water in the Campo de Cartagena using renewable energy at an affordable cost, researchers have combined up to seven technologies, including reverse osmosis with next-generation membranes, denitrification with series bioreactors, cooling tower technology, mechanical vapor compression, and atmospheric evaporation using parallel fabric structures to reduce the required surface area.

Life Desirows aligns with circular economy strategies

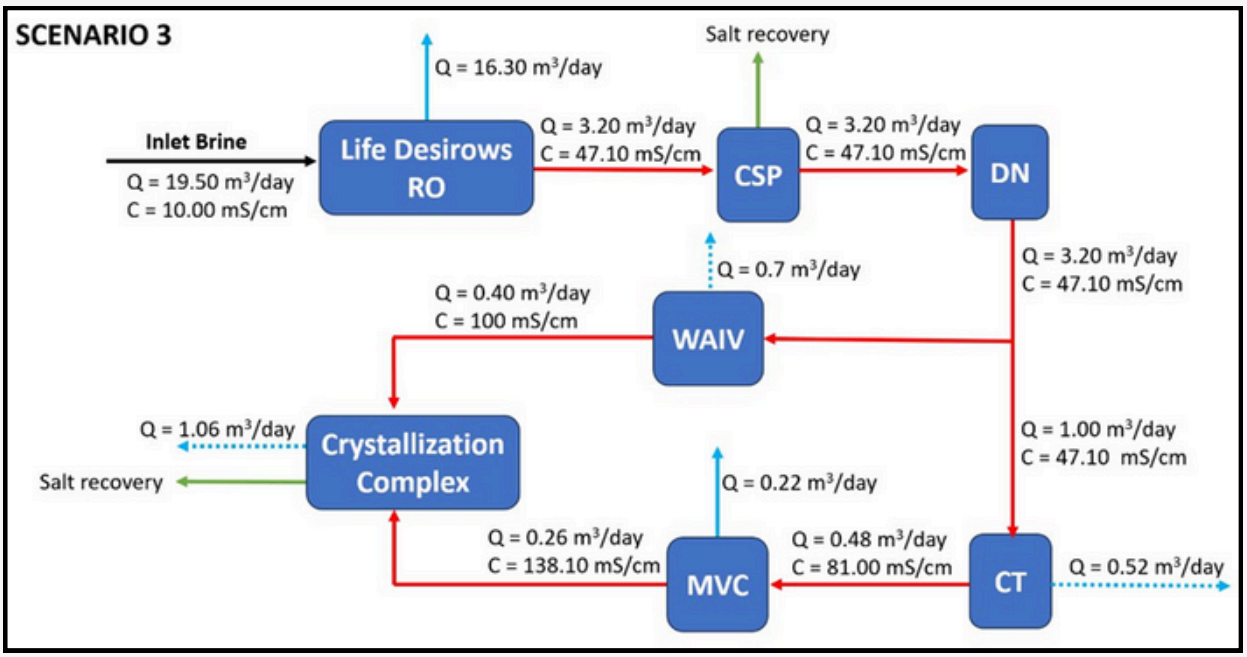
The Life Desirows project also aimed to minimize energy consumption and costs for farmers, prevent greenhouse gas emissions and discharges into the Mar Menor, and eliminate waste through the crystallization of brine, so that the resulting salts can be reused as a byproduct for the industry

RESULTS

Water resource utilization has been maximized, achieving water recovery rates exceeding 92%.

Another objective of the Life Desirows project was to recover the maximum amount of water used in order to optimize the use of water resources. This has been successfully achieved, with water recovery rates exceeding 92%. The Life Desirows pilot plant, composed of various elements with different technologies, has successfully treated up to 20 cubic meters of water per day. The pilot plant was located at the Arco Sur Mar Menor wastewater treatment plant, and its equipment operated for approximately ten hours daily.

Life Desirows calcuates the different electricity consumption for each combination of technologies and concluded that the option requiring the least installed power is the use of reverse osmosis and atmospheric evaporation, with consumption rates identical to those of seawater desalination, at 4 kWh/m³.



RESULTS

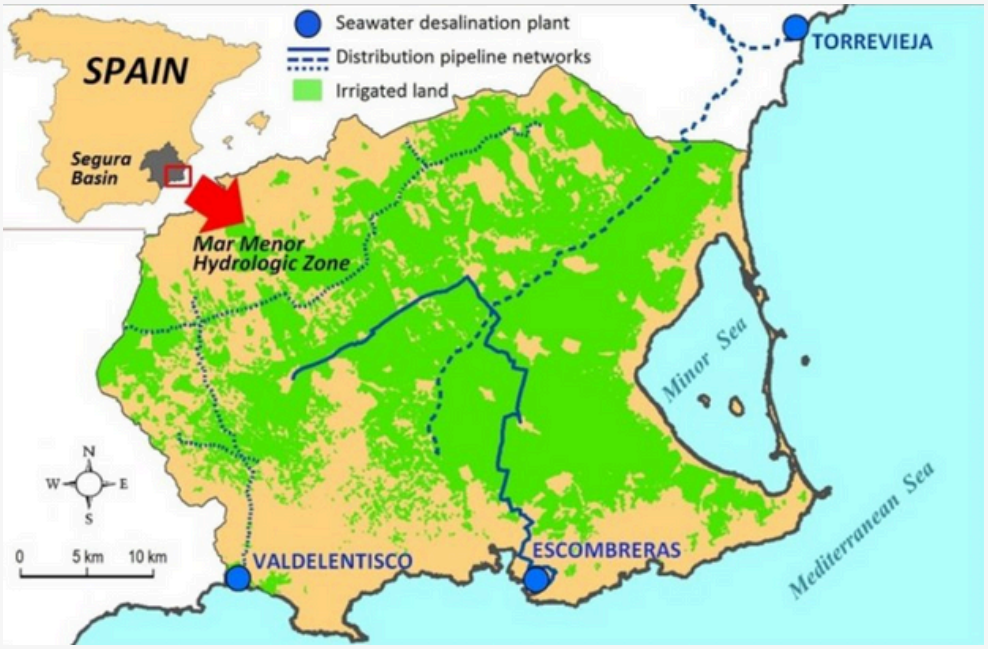
CONCLUSIONS

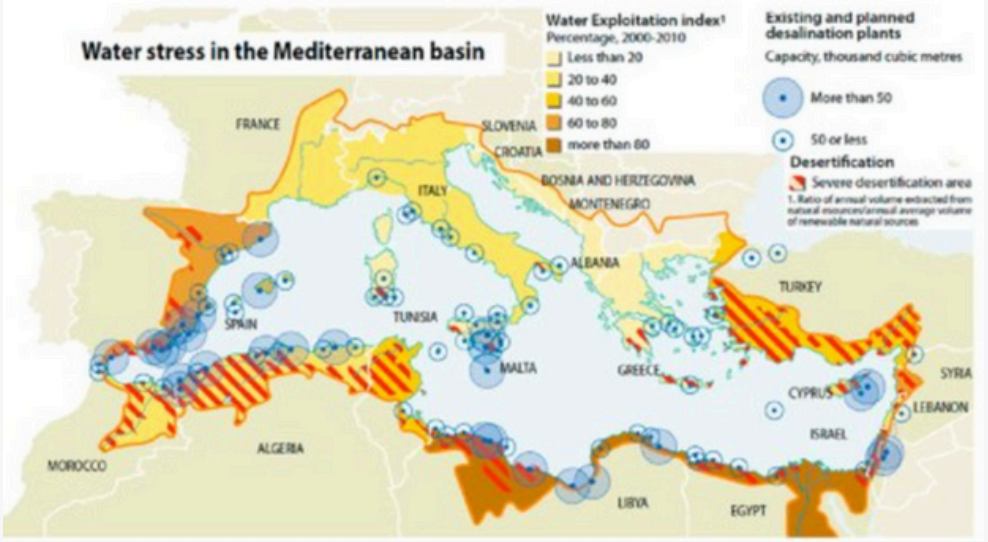
- Recovery of more than 92% of water resources from brackish groundwater feed cost-effective
- Reduce the nitrates in brine to accomplish legislation
- Testing of at least 7 different technologies and their combinations in order to study and analyze the optimal working combination (RO, DN, SP, CT, MVC, WAIV-CO, WAIV-CR)
- Use of 100% energy consumption through renewable energy: photovoltaic solar energy and biomass (up to 30 kWh PV + 69 kWh biomass)
- Reduce and crystallize dissolved ions throughout the process to generate a valuable by-product for other industrial and agricultural uses

6. REPLICATION, TRANSFERABILITY AND IMPACT

RESULTS: WHERE?

In short term, the **replicability and transferability** will be focused in **Spain** (765 desalination plants). In medium term, the consortium will focus on the commercialization in other countries of the **Mediterranean** area like Cyprus, Italy, Portugal, Malta and non-EU countries in the Eastern and Mediterranean and North Africa.





REPLICATION, TRANSFERABILITY AND IMPACT

LEGISLATION AT RIVER BASIN SCALE

- The Hydrological Plan of the Segura river basin in its document in ANNEX X Regulatory provisions, Article 52 Actions in coastal aquifers in the process of salinisation11 states:

"that administrative concessions may be granted when a desalination plant is required on condition that the **brine is correctly collected and evacuated to the sea or eliminated through concentration and evaporation processes**, as well as any other conditions that may be imposed by the competent administrations."

THE ANSWER TO LEGISLATION AT RIVER BASIN SCALE REQUIRES:

- **A Zero Liquid Discharge (ZLD)**: processes that manage to separate a flow of water without dissolved ions to be used as a water resource available for irrigation on the one hand, and on the other to concentrate salts whose selective crystallization allows them to be used in various industries.

- The project, which achieves these objectives, therefore enables compliance with the **Spanish Circular Economy Strategy (EEEC)** with regard to the following objectives: - Reducing the national consumption of materials - Reduce the generation of waste - Increase reuse.- Improve efficiency in the use of water.- Reduce the emission of greenhouse gases.

REPLICATION, TRANSFERABILITY AND IMPACT

LIFE DESIROWS MAIN MOTIVATION

A Zero Liquid Discharge (ZLD) demonstrative project

- To maximize the water resource available for irrigation
- To eliminate the residuals in terms of dissolved ions in brines through its crystallization
- To carry all the process with renewable energy resources
- To contribute to protect the water bodies
- To minimize the energy consumption
- Cost-effective for the producers

RESULTS: WHEN AND HOW MUCH?

LIFE DESIROWS technology is expected to be implemented in a period of **5 years** in **12 desalinization plants and 15 industrial activities for the wastewater treatment**.

Year	Replication			Transfer		
	Number	Flow (m^3/day)	Total Flow (m^3/year)	Number	Flow (m^3/day)	Total Flow (m^3/year)
2025	1	100	36,500	0	0	0
2026	2	100	73,000	2	20	14,600
2027	3	200	219,000	3	30	32,850
2028	3	300	328,500	5	50	91,250
2029	3	300	328,500	5	50	91,250
TOTAL	12	-	985,500	15		229,950

REPLICATION, TRANSFERABILITY AND IMPACT

A "highly replicable" project for all sectors to eliminate waste and optimize water use

The Life Desirows project has achieved significant results in water recovery and the elimination of waste such as brine and nitrates. It is considered highly replicable, not only in the water and desalination sector but also in the agri-food industry, helping to reduce waste across various sectors.

These results are aligned with European and national hydrological policies on zero liquid discharge and water economy. Additionally, the project addresses environmental challenges in the Region of Murcia, such as water scarcity and ecosystem contamination, providing technological solutions proposed by the European Union.

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THANKS FOR YOUR ATTENTION!

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