conquer
Water reuse for irrigation

LIFE19 ENV/ES/000226
www.life-conquer.eu

Reused water to irrigate the city of Murcia

DD1.6 - Layman's report

Index

Full name: DIVIDE & CONQUER: Closing the loop of water, nutrient and resource management for irrigation activities

Acronym: LIFE Conquer

Funding: LIFE Programme, the funding instrument of the European Union for environment and climate action

Budget: €1,655,288 (EU contribution: €910,408)

Duration: 48 months (from November 2020 to October 2024)

Coordinator: Cetaqua Barcelona

Consortium: Aguas de Murcia (EMUASA) and Aquambiente Circular Economy Solutions (ACES)

Demo site: Former Zarandona WWTP (Murcia, Spain)

Website: www.life-conquer.eu

CETAQUA CENTRO TECNOLÓGICO DEL AGUA

AGUAS DE MURCIA

AQUAMBIENTE Circular Economy Solutions

A bit of context

Climate change is increasing the frequency, duration, and severity of drought periods. This, combined with higher water demand and at times inefficient management, means that water is becoming an increasingly scarce resource. In fact, according to data from the Intergovernmental Panel on Climate Change (IPCC), **approximately 50% of the world's population suffers from severe water shortages for at least part of the year.**

In the case of the European Union, the European Environment Agency (EEA) states that 30% of countries experience water stress during at least one season. **The region of Murcia is one of the most affected on the continent**, with intense agricultural activity causing water demand to exceed the amount of freshwater available.

Therefore, it is necessary to employ sustainable strategies to prevent and mitigate these situations of water scarcity and drought, ensuring this resource for the future. **One of the most environmentally and socially sustainable strategies currently available is the reuse of groundwater for non-drinking water purposes such as irrigation.**

However, conventional groundwater treatment processes in wastewater treatment plants (WWTPs) and reclamation plants (RPs) in areas with high salinity either fail to produce water that meets the requirements for irrigation reuse or are highly energy-intensive processes that remove all salts, including nutrients.

Treated water that does not meet reuse requirements is returned to the environment, causing eutrophication, which is an excess of nutrients—mainly nitrogen and phosphorus—in aquatic ecosystems, leading to the overgrowth of algae.

To obtain reclaimed water suitable for irrigation, it is essential to develop treatments that reduce the salinity of treated water from these regions without eliminating nutrients like nitrates, which are important for proper plant growth, as they act as fertilisers.

With the aim of establishing a sustainable and circular treatment that protects water resources by producing high-quality reclaimed water and adds value to the waste generated during the process, the LIFE Conquer project was born.

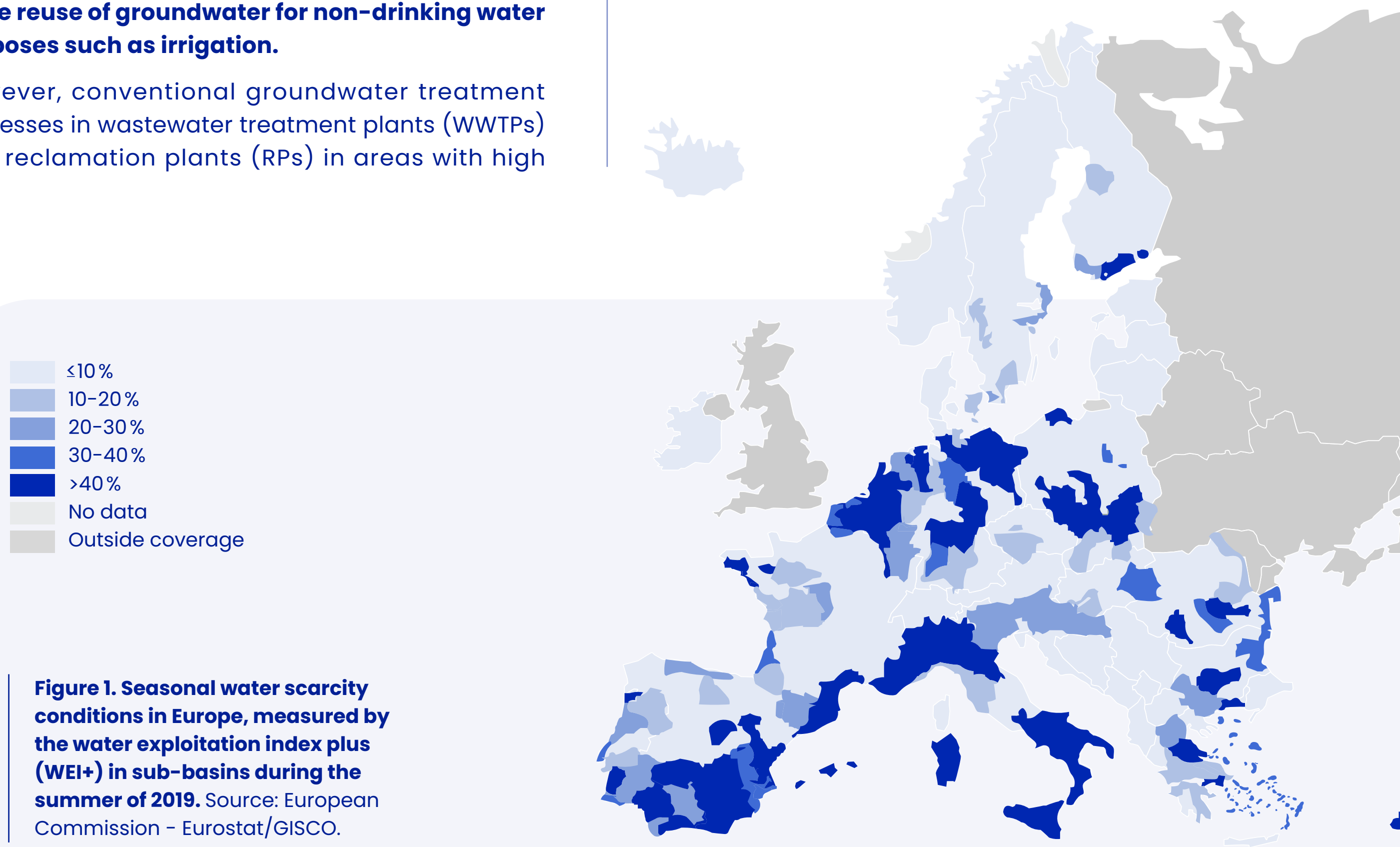

Figure 1. Seasonal water scarcity conditions in Europe, measured by the water exploitation index plus (WEI+) in sub-basins during the summer of 2019. Source: European Commission - Eurostat/GISCO.

LIFE Conquer: promoting the use of reclaimed water for irrigation in the city of Murcia

The city of Murcia currently has an urban irrigation network that meets the water needs of 405 hectares of parks and green areas. This demand represents a minimum requirement of 1,750,000 m^3 of water per year, equivalent to 58,000 tanker trucks, to supply the city's parks and gardens.

Currently, this need is met with freshwater resources—55% from groundwater and 45% from drinking water—with the drinking water coming from the Segura River basin and the Tajo-Segura transfer. Given the critical situation of water scarcity in the region, it is vital to work on the development and use of alternative water sources to reduce the current pressure on freshwater resources.

LIFE Conquer, **a project co-financed by the LIFE Programme of the European Commission**, aims to **promote the circular economy** through the development of an innovative system that both **treats groundwater contaminated by nitrates and salts to obtain water for irrigating parks and gardens in the city of Murcia** and **recovers brine**, the waste produced by the treatment of contaminated water.

Thus, LIFE Conquer, led by **Cetaqua-Water Technology Centre**, in collaboration with **Aguas de Murcia (EMUASA)** and **Aquambiente Circular Economy Solutions (ACES)**, seeks to contribute to the transformation of **water treatment plants into facilities with more efficient treatments and waste recovery capabilities** that not only produce irrigation water rich in nutrients but also transform the waste generated into valuable products.

To achieve its goal, this initiative relies on **pioneering nanofiltration technologies** to produce **reclaimed water with low salinity** while retaining nitrates. It also includes a treatment system for the brine produced and an **innovative electrolyser that transforms the brine into** sodium hypochlorite (NaClO), commonly known as **bleach**, overcoming the limitations of currently available systems.

The LIFE Conquer pilot, located at the Zarandona water reclamation plant (WRP) in Murcia and operated by EMUASA, **has achieved full-scale validation in the city of Murcia**. It injects reclaimed water suitable for irrigation directly into the urban irrigation network, freeing up part of the freshwater previously used for this purpose for other uses.

LIFE Conquer aims to promote the circular economy through an innovative system that both treats groundwater contaminated by nitrates and salts to obtain water for irrigating parks and gardens in the city of Murcia and recovers brine

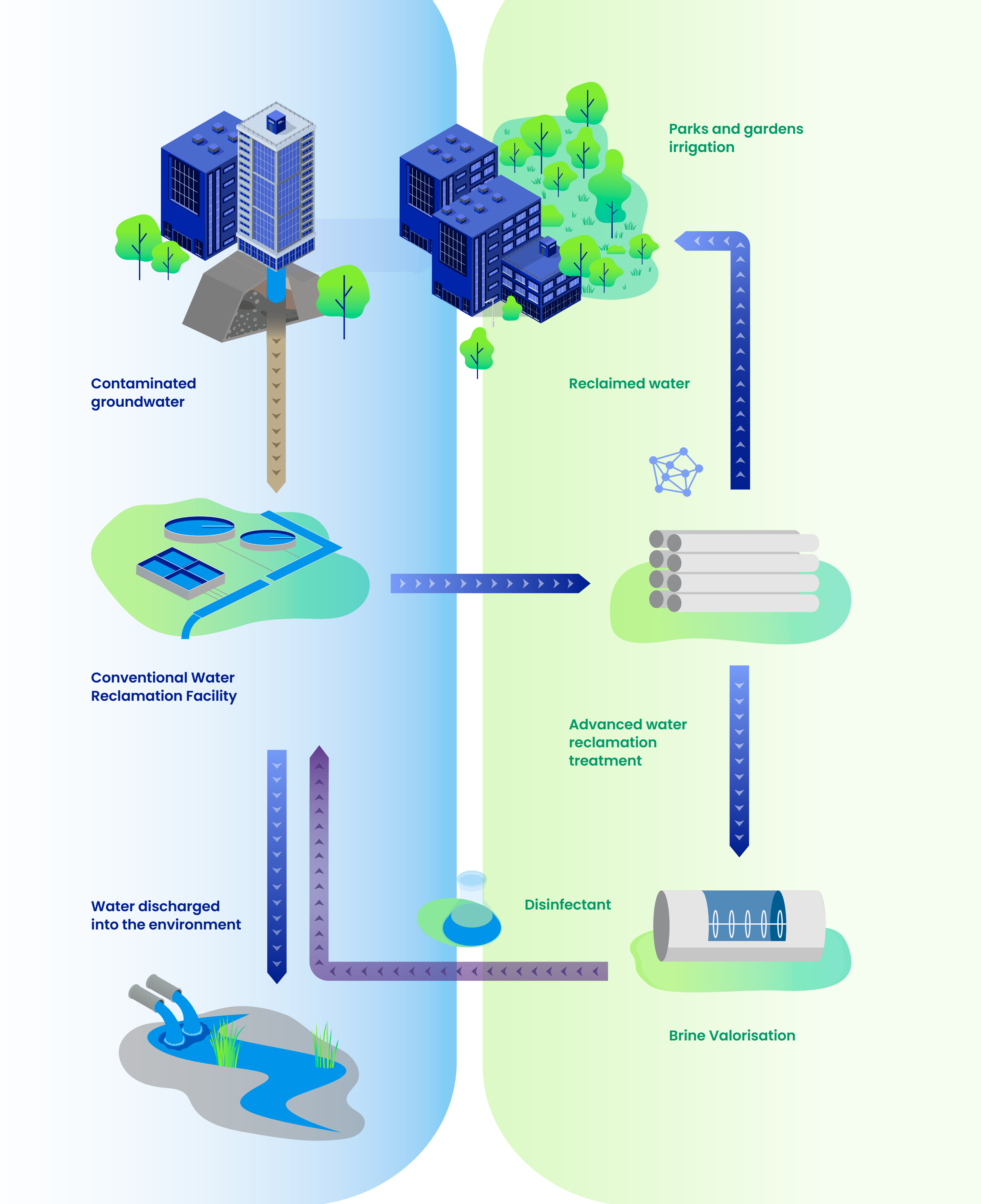

Figure 2. Current process of wastewater treatment vs. LIFE Conquer process. Source: own production.

The objectives of LIFE Conquer's technology are:

- Reduce the total water footprint of the urban irrigation system in the city of Murcia through the use of reclaimed water as a substitute for drinking and/or groundwater.
- Reduce the eutrophication potential.
- Reduce total energy consumption in Murcia's urban irrigation system.
- Reduce the purchase of sodium hypochlorite (NaClO) at EMUASA's wastewater treatment plants, thanks to the recovery of brine for self-consumption.

Image 1. LIFE Conquer pilot site, placed in the Zarandona water reclamation plant. Left: stage 1 (Smart NF). Right: stage 2 (Brine Valorisation).

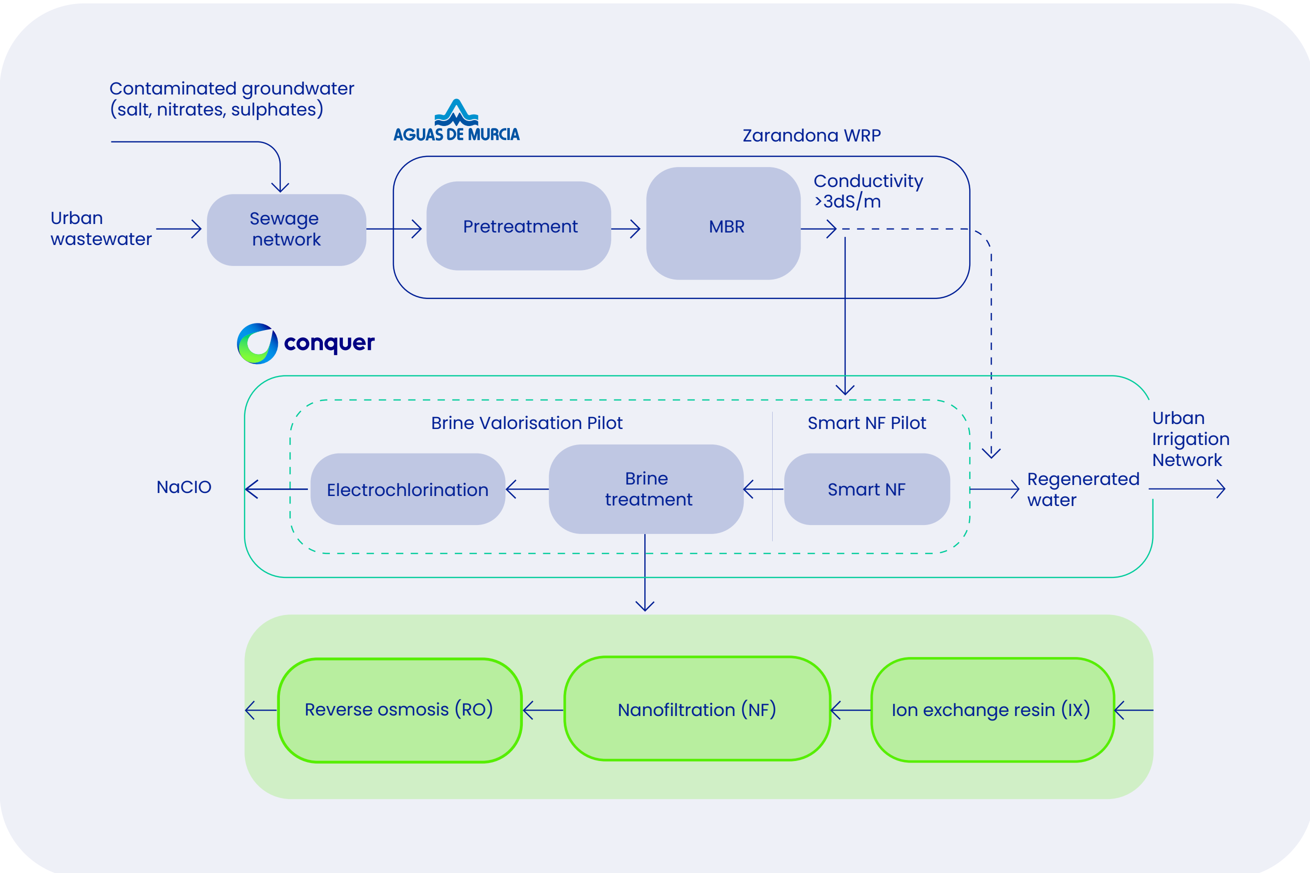

Figure 3. Diagram of the LIFE Conquer pilot.
Source: own production.

Stage 1: obtaining irrigation-suitable water through nanofiltration (NF)

The LIFE Conquer project begins its journey with the water discharged from the water reclamation plant (WRP) located at the Zarandona site. This water stream, loaded with nitrates and salts, feeds the first stage of LIFE Conquer: the **Smart NF pilot**.

Image 2. Pre-filter (blue) of the first stage of LIFE Conquer's technology.

In the first stage of this pilot site, **contaminated water is collected in a feed tank and passed through a pre-filter**, which removes any larger particles, and into the nanofiltration membrane system via a pumping system.

To produce reclaimed water rich in nitrates, **the Smart NF pilot features a nanofiltration membrane system** capable of separating molecules on a nanometric scale, with a size 60,000 times smaller than the thickness of a human hair.

Thus, **this system allows water and a large part of the nitrates, which serve as nutrients, to pass through the membranes, while rejecting most salts**, such as sodium, chloride, and other ions. This enables us to obtain two things. One is permeate water rich in nitrates and with low salinity, meeting the quality required for use in urban irrigation; the other, a reject stream with a high concentration of salts—that is to say, brine.

In this first stage of the system, a flow of 20 m³/h enters, producing a permeate flow of 16 m³/h and a rejection flow of the remaining 4 m³/h. The destination of these two effluents is very different: **the permeate is the reclaimed water that is directly injected into the urban irrigation network of the city of Murcia**, while **the rejection is the brine, which feeds the second stage of the LIFE Conquer solution**, a unit responsible for transforming brine into bleach: the Brine Valorisation pilot system.

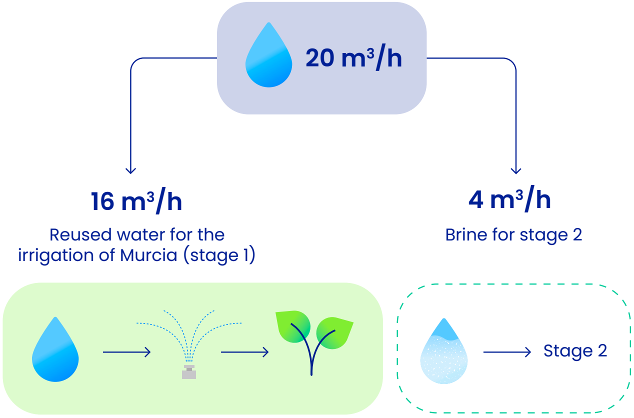

Figure 4. Effluents obtained in the first stage of LIFE Conquer. Source: own elaboration.

Stage 2: Brine Valorisation through electrochlorination

The second stage of the LIFE Conquer system, the Brine Valorisation pilot, consists of a **three-stage pretreatment train that conditions the brine before it enters an innovative three-dimensional electrochlorinator**, responsible for transforming sodium chloride into sodium hypochlorite or bleach.

Image 3. Second-stage pretreatment train of LIFE Conquer, from left to right: ion exchange resin, nanofiltration membrane, and reverse osmosis.

What does electrochlorination consist of, and why is pretreatment important?

Electrochlorination is a widely studied process for obtaining products of industrial interest. It **applies an electric current to a water source** to cause the sodium chloride (NaCl) present to oxidise, resulting in the **formation of sodium hypochlorite** (NaClO), which is commonly used as a disinfectant.

However, for this reaction to occur effectively, the water source must be free of impurities that could disrupt the reaction's equilibrium. In the case of the LIFE Conquer project, where brine is used as the feed source, other ions such as calcium, magnesium, and sulphates are present. These ions must be removed beforehand to ensure the water's suitability for the electrochlorination process.

The **pretreatment** begins with an ion exchange resin column to **eliminate calcium and magnesium**, followed by a **nanofiltration membrane system to remove sulphates**. It concludes with a **reverse osmosis membrane system**, which concentrates the chlorine and sodium ions, producing a brine with a high sodium chloride concentration.

The brine obtained after pretreatment passes through a 3D electrochlorinator, where, thanks to the application of an electric field, **sodium hypochlorite is formed**, a disinfectant widely used in wastewater treatment plants.

What is the difference between a conventional electrochlorinator and a 3D electrochlorinator?

Conventional electrochlorination systems consist of two plate-shaped electrodes (2D), anodic and cathodic, between which the oxidation of sodium chloride to bleach takes place. The LIFE Conquer project chose a novel rod-shaped (3D) electrode design to increase the active surface area for the reaction. The 3D electrochlorinator features 216 titanium rods, alternating between anode and cathode, thereby providing a larger reaction surface in a more compact unit.

Thanks to the implementation of the Brine Valorisation pilot project, which transforms brines into sodium hypochlorite, LIFE Conquer not only creates a useful product from a byproduct that is typically considered waste, but also reduces the demand for natural resources and minimises environmental impact.

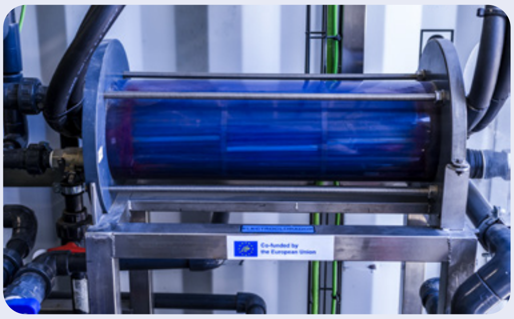

Image 4. 3D electrochlorinator designed for the second stage of the LIFE Conquer project.

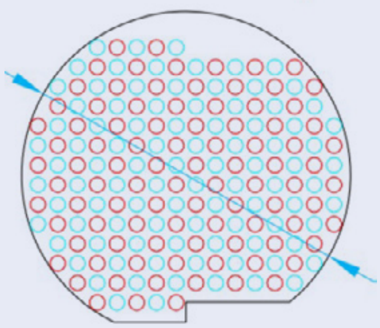

Image 5. Cross-sectional view of the 3D electrochlorinator, displaying the rods, which alternate anodes and cathodes.

What has the project achieved?

Global results of the LIFE Conquer project

- **Annual production of more than 140,000 m³ of reclaimed water** of suitable quality for urban irrigation use.
- **Injection of the reclaimed water produced into the urban irrigation network** of the city of Murcia, which is responsible for watering parks and green areas in the city.
- **8% reduction in drinking water** allocated for irrigation in the city of Murcia.
- **Reduction in eutrophication potential** by avoiding the discharge of water unsuitable for irrigation, equivalent to 5,000 kg of nitrogen per year.
- **Reduction in the waste or brine generated during the process of obtaining reclaimed water** by transforming it into a high-value product.
- **Production of 0.6 tons of bleach per year** for self-consumption at EMUASA's facilities.
- **Promotion of the use of reclaimed water for irrigation** among public administration professionals, technologists, and farmers.

Image 6. Information panel about the LIFE Conquer project in Jardín de las Tres Copas (Murcia), irrigated with reclaimed water.

- **Development of a replication plan** that includes six case studies.
- **Creation of a business model** that includes the commercialisation of the technology (stage 1 and 2, and stage 2) and the development of an economic analysis tool.
- **Dissemination of project results.**

Furthermore, during the operation of the LIFE Conquer plant, specific results were achieved for each of the two stages.

Results of the Smart NF pilot for reclaimed water production

- **Stable operation of the first stage of LIFE Conquer** for urban irrigation water conditioning. The plant is capable of operating continuously, ensuring supply to the urban irrigation network.
- **Recovery of 61% of nitrates**, which serve as nutrients for urban vegetation.
- **74% reduction of salt content in the water** to protect plants.

Results of the Brine Valorisation pilot for the transformation of brine into bleach

- **Optimisation of the pretreatment stages** for the waste produced in the Smart NF pilot.
- **95% reduction in calcium and 72% in magnesium** in the ion exchange resin stage.
- **Removal of 99% of sulphates** in the nanofiltration stage.
- **Concentration of sodium chloride** in the reverse osmosis stage.
- **Optimisation of the electrochlorination process** by using an innovative three-dimensional design for the transformation of sodium chloride into sodium hypochlorite.
- **Production of 29 g/L of sodium hypochlorite** in the electrochlorinator.

Replication plan

Although the LIFE Conquer project took place in the specific context of the Zarandona WRP, **the solution developed has significant potential for application in other geographical contexts and with water from other sources.**

For this reason, to ensure the continuity of the water reuse technology for irrigation proposed in LIFE Conquer, both a replication and business plan have been designed. These plans consider the two stages of the pilot process—nanofiltration to obtain reclaimed water suitable for irrigation and brine valorisation to produce a valuable byproduct such as sodium hypochlorite—independently.

Both plans were drawn up by **Aquambiente Circular Economy Solutions** (ACES), one of the project partners. ACES, part of Agbar (a Veolia group company), specialises in energy and material recovery from waste and byproducts.

The LIFE Conquer replication plan aims to evaluate, from a technical and economic perspective, the feasibility of replicating the solution in other plants with different geographical contexts and for diverse uses, providing guidance to facilitate its future implementation. **The six cases selected** were chosen based on the following parameters:

- **The selected location uses water contaminated with nitrates from a stable source** (river, groundwater, wells, etc.). This ensures that, if the LIFE Conquer solution is implemented, it can be sustained over time.
- The chosen location uses **water with excess salinity**.
- The chosen location is **near the site where reclaimed water is employed**, and there are means to transport this water.
- **Sodium hypochlorite is to be consumed at the pilot installation site.** This avoids the transport of corrosive chemical products.

After studying the technical and economic parameters of the various cases of interest, those of the brine collector, crop irrigation community, and French WWTP were said to be feasible.

Location	Chosen case	Case interest
Barcelona, Catalonia	Brine collector	Application of stage 2 (Brine Valorisation) through an extremely saline flow
Tarragona, Catalonia	Crop irrigation community	Water reuse for more sensitive crops and reintroduction of nitrates present in groundwater into crops
Girona, Catalonia	Golf course	Water reuse for lawn irrigation
Alicante, Valencian Community	WWTP	Repurposing brine to produce bleach for self-consumption
Barcelona, Catalonia	WWTP	Repurposing brine to produce bleach for self-consumption
France	WWTP	Repurposing brine to produce bleach for self-consumption

Chart 1. Chosen cases for the replication plan.
Source: own production.

Business plan

The LIFE Conquer business model takes into account both projects (excluding operation and maintenance [O&M]) and services (installation plus O&M) for water reclamation facilities. It acknowledges that the two stages constituting the LIFE Conquer solution can be used individually or in combination to create and offer to society a broader range of services.

Thus, this business plan establishes a clear strategy so that an innovative system aimed at water reclamation and brine treatment can be implemented through these **two application scenarios:**

1. **Production of reclaimed water and recovery of the brine produced:** the combination of stages 1 and 2.
2. **Brine Valorisation:** stage 2, with process modifications depending on the use case.

The two stages constituting the LIFE Conquer solution can be used individually or in combination to create and offer to society a broader range of services

Image 7. LIFE Conquer pilot site at Zarandona WRP.

In parallel, **an economic analysis tool has been developed** to streamline case evaluations and provide a foundation for future analyses. This tool simplifies the assessment of economic indicators, allowing for quicker determination of each case's feasibility.

The calculation of capital expenditures (CAPEX) and operating expenses (OPEX) utilises algorithms and equations derived from internal knowledge of technology scaling costs. This ensures that production capacity increases do not follow a linear pattern but instead reflect the economic advantages of scaling.

The potential market includes irrigation communities near water sources contaminated with nitrates, cities using a large amount of drinking water for irrigation, agricultural companies that could use treated wastewater, and wastewater treatment plants (WWTPs) with significant sodium hypochlorite (NaClO) consumption. The project will be directed at **public and private entities in the southeast and Levante regions of Spain**, focussing on salt removal and the use of nitrogen-rich wastewater. Additionally, it aims to offer local solutions to reduce the need for water and fertilisers, promoting a more circular consumption of NaClO.

Benefits and impacts

The impacts of the LIFE Conquer technology have been assessed from an environmental, economic, and social perspective using standardised methodologies such as life cycle assessment (LCA), life cycle costing (LCC), and social life cycle assessment (S-LCA).

Environmental assessment

From an environmental perspective, the addition of LIFE Conquer technology to transform water with high salinity and nitrates into reclaimed water suitable for irrigation, as well as the recovery of the resulting waste, has environmental impacts related to **reducing electricity consumption** for producing water suitable for irrigation and **minimising waste** from the reclamation process.

The environmental categories in which the greatest improvements have been achieved are global warming, ionising radiation, eutrophication, terrestrial ecotoxicity, and fossil resource scarcity, thanks to the production of reclaimed water and the consequent reduction in electricity consumption, as well as the recovery of the waste covered by the LIFE Conquer technology.

Image 8. Irrigation of a golf course.
Stock image.

Economic assessment

From an economic perspective, the addition of LIFE Conquer technology to transform high-salinity and nitrate water into reclaimed water suitable for irrigation, along with the recovery of the resulting waste, entails associated costs that can be divided into CAPEX and OPEX.

The economic evaluation concludes that adding the LIFE Conquer solution results in **a CAPEX increase of €0.15 per m³ of treated water and an OPEX increase of €0.53 per m³ of treated water.** The OPEX includes worker salaries, necessary reagents, electricity consumption, and other factors. This represents an additional cost at the Zarandona WRP of €0.68 to treat one cubic meter of high-salinity water contaminated with nitrates, converting it into water suitable for irrigation and recovering the waste.

Social assessment

From a social perspective, the LIFE Conquer project has achieved a **high level of acceptance** thanks to its innovative approach to water reclamation and reuse, as well as the commitment of an environmentally aware population. The quality of the water produced means it can be used to irrigate green spaces, thereby reducing pressure on aquifers and limiting the need for additional fertilisers.

Furthermore, LIFE Conquer **has created specialised and dynamic jobs in the water sector**, although challenges remain in terms of job security and community participation. Strengthening communication with the community and ensuring institutional support will be key to maximising its impact and expanding its success in similar contexts.

Next steps: project continuation

Although the project concluded in October 2024, **the plant will continue operating**, providing water suitable for urban irrigation and producing bleach.

The expansion of the production capacity of the Zarandona WRP will increase irrigation water production to over 350,000 m³ per year in the coming years.

Additionally, efforts will continue to replicate the LIFE Conquer solution in different geographic areas and for diverse uses, as well as to communicate and disseminate the project's results through various actions.

Image 9. Path among fields.
Stock image.

Conclusions

Murcia is one of the regions in Europe most affected by water scarcity due to its high agricultural activity and its reliance on the Segura River basin and the Tajo-Segura water transfer system for its water supply.

Given the pressing water shortage in the region, it is essential to develop and use alternative water sources. One of the most viable solutions is the reuse of groundwater; however, in areas with high salinity, these treatments may not suffice in producing water that meets the reuse requirements for irrigation. Although alternative treatments exist, they are energy-intensive processes that remove all the salts and nutrients necessary for irrigation.

LIFE Conquer has proven that reusing water for irrigation while adding value to the waste generated in the process is possible

The LIFE Conquer project has demonstrated the viability of an innovative system that is capable of reusing groundwater contaminated with nitrates and salts to produce high-quality reclaimed water for irrigation and that repurposes brine by converting it into sodium hypochlorite.

Thanks to LIFE Conquer, over 140,000 m³ of reclaimed water have been produced and injected annually into the urban irrigation system of Murcia. This volume is equivalent to 8% of the city's drinking water demand for this use, reducing the water footprint of the urban irrigation system by 8%.

Additionally, the pilot plant produces 0.6 tons of bleach per year for use in maintenance operations by EMUASA.

Although the project concluded in October 2024, the plant will continue to operate, supplying water suitable for urban irrigation and producing bleach.

The planned expansion of the Zarandona WRP's production capacity will increase irrigation water production to over 350,000 m³ annually in the coming years. Furthermore, the possibility of deploying the LIFE Conquer solution in other geographical contexts and for other uses will be explored, thus expanding its impact.

LIFE Conquer has proven that reusing water for irrigation while adding value to the waste generated in the process is possible.

Image 10. Recently irrigated lawn.
Stock image.

LIFE Conquer, a shared challenge among...

CETAQUA
CENTRO TECNOLÓGICO DEL AGUA

Cetaqua Barcelona is a private non-profit foundation established in 2007 by Aigües de Barcelona, the Universitat Politècnic de Catalunya-BarcelonaTech (UPC), and the Spanish National Research Council (CSIC). It is a public-private collaboration model created to ensure the sustainability and efficiency of the complete water cycle while considering local needs.

Role in the project: Cetaqua provides the technical expertise needed to validate the denitrification solution, interpret the data, and carry out technical, environmental, and economic assessment, as well as replication studies.

info@cetaqua.com

AGUAS DE MURCIA

Aguas de Murcia (EMUASA) is a joint services company, 51% owned by the Murcia City Council and 49% by Hidrogea, a private partner of Veolia. EMUASA manages the water cycle in the municipality of Murcia, providing service to approximately 439,712 people across the urban centre, rural areas, and 54 villages.

Role in the project: EMUASA's work encompasses a host of activities ranging from the collection of drinking water to wastewater treatment. It also manages the urban irrigation network and is committed to the goal of maximising water reuse.

aguas@emuasa.es

AQUAMBIENTE
Circular Economy Solutions

Aquambiente Circular Economy Solutions (ACES), part of Agbar (a Veolia group company), is a company specialised in energy and material recovery from waste and byproducts. ACES undertakes various activities, such as innovation projects, market studies, raw material characterisation, and promoting synergies with external organisations.

Role in the project: ACES leads the commercialisation of the project, assessing the feasibility of the solution in different geographical contexts within Europe and various end uses (e.g., crop irrigation), and developing the business plan.

benoit-fabien.lefevre@aquatec.es

conquer
Water reuse for irrigation

LIFE19 ENV/ES/000226

More information
www.life-conquer.eu

CETAQUA
CENTRO TECNOLÓGICO DEL AGUA

AGUAS DE MURCIA

AQUAMBIENTE
Circular Economy Solutions