# Valorisation of waste brines from the desalination industry through circular economy approaches

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**Desalination and Brine Management**

## Concept

Nowadays, freshwater scarcity is becoming more and more a severe global issue. It is expected to worsen as the global water demand will exceed 4000 billion $m^3$/year in 2030. Today desalination has become a popular and reliable solution. However, it is accompanied by a problematic matter: the production of brines. Brine, also known as "retentate" or "concentrate", is a solution that presents large amounts of total dissolved salts (TDS), that must be necessarily treated before its discharge into the environment according to strict regulations. When discharged, brine can be harmful to the environment due to its salinity, temperature and chemical substances. Nevertheless, it is worth noting how these brines present a high concentration of valuable raw materials (i.e. Magnesium, Calcium etc.). Such materials can be recovered from brines leading to:

(i) Reduction of EU's economic dependence on non-EU countries (e.g. import of magnesium from China);

(ii) Reduction of the final effluent discharged into the environment.

A solution that can reach both aforementioned goals consists in the implementation of Zero Liquid Discharge systems. ZLD systems are a set of processes combined in a suitable manner to minimize the volume of brines discharged to the environment by recovering valuable minerals. The ZLD combination enables to bring together the technological advantages of each process and restrain their limitations. Analyses of such systems will be the object of the PhD Project.

## Scientific approach

The PhD Project consists in the development of advanced simulative platforms that can simulate the functioning of innovative ZLDs (illustrated in the figure on the right). In particular, two treatment chains will be analysed: (i) a ZLD made up of four main units (Nanofiltration, Magnesium Reactive Crystallizer, Multi-Effect Distillation and NaCl Thermal Crystallizer) and (ii) an evolution of the first ZLD, characterized by the addition of the Eutectic Freeze Crystallizer and an Electrodialysis with Bipolar Membranes unit, allowing the recovery of more valuable products. Detailed analyses will be performed in order to evaluate the techno-economic feasibility of the systems. Such investigations will allow to identify the best operating conditions of each technology within the systems and the technolgies that contribute the most to the global economics. Such analyses will provide essential indications for the prototyping of an innovative crystallizer (for the recovery of magnesium hydroxide) and EDBM (Electrodialysis with bipolar membranes to produce acids and bases). Design and construction will be held at the University of Palermo. Firstly, the performances of the two single technologies will be tested alone. Subsequently, the two units will be integrated in Brine management chains and experimentally tested within the framework of three different European projects (Water Mining, Rewaise and SEArcularMINE).

## Research objectives

The main goal is to understand whether ZLD systems can become a pratical and feasible solution to the issues of brine disposal. The preliminary techno-economic analyses will supply indications on how to optimize the performances of ZLD systems and evaluate their feasibilty. The thorough experimental campaigns that will be carried out for the Magnesium Reactive Crystallizer and Electrodialysis with Bipolar Membranes will supply as much information as possible to evaluate their possible future application at industrial scale within the brine managment field.