Remine Water

Solar powered water reuse and resource recovery in mining

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LIFE17 ENV/ES/000315

CETAQUA WATER TECHNOLOGY CENTRE
Sandfire matsa
Łukasiewicz Instytut Metali Nieżelaznych
newheat

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01. OBJECTIVES

The main goal of the REMINE-WATER was to protect the environment from discharges of industrial process wastewater (e.g. high salinity or metals) and process wastes to contribute to the circular economy through the recovery of water, metals, salts and strong acids and their on-site valorization.

The main objectives of the project were to:

- Validate a treatment train integrating innovative technologies for brine treatment of processed water from mining and metallurgical industries.
- Reduce energy consumption and CO_2 footprint of brine treatment by the integration of solar thermal energy to the treatment train.
- Develop technologies to recover strong mineral acids and valuable metals from process mining water prior to its discharge to surface water.
- Assess the replicability and transferability of the demonstrated solution to other European mining and metallurgical sites considering technical, economic and environmental issues, as well as the legal and regulatory framework.

In order to guarantee the achievement of the main objectives of the project, a set of quantifiable specific objectives were defined:

- Reduction of 50% of the salinity and sulphate concentration of the wastewater river discharge from the mining and metallurgy industry.
- Reduction of 15% of the water consumption from mining and metallurgical industry by promoting on-site water reuse.
- Recovery of 90% of water from reverse osmosis concentrates discharged.
- Reduction of 95% of the salinity from reverse osmosis concentrates for water reuse.
- Reduction of 50% of operational expenditures compared to conventional thermal brine concentration.
- Recovery of 90% of sulphuric acid, 70% of copper and 40% of zinc, representing an increase of 1% of total metal production.
- Reduction of 70% of the CO_2 emissions (through the use of solar thermal-energy) compared to conventional thermal evaporation processes present in treated wastewater.

02. PROJECT DATA

LIFE REMINE WATER was a project financed by the LIFE programme (the EU's funding instrument for the environment and climate action). The total allocated budget has been 1,812,708 € (1,087,623 € subsidised by the LIFE programme). The project lasted 60 months, from October 2018 to October 2023. The consortium was made up of four partners: Cetaqua, Sandfire Matsa, IMN and NewHeat.

Project partners

CETAQUA
WATER TECHNOLOGY CENTRE

Cetaqua, Water Technology Center has been the coordinator of this project. Cetaqua is a model of public-private collaboration that was created to ensure the sustainability and efficiency of the water cycle while taking regional needs into account.

During the project, Cetaqua has been in charge of the design and development of the project pilots. Cetaqua has conducted the pilot operation, monitoring, analysis, and integration of results. Additionally, they have performed the technical, environmental, and economic analysis of the process, including Life Cycle Cost (LCC) and Life Cycle Assessment (LCA).

Łukasiewicz
Instytut Metali Nieżelaznych

The Institute of Non-Ferrous Metals (IMN) is a research centre from the Polish non-ferrous industry. The institute's complex activities cover all stages of metallic material production: from ore treatment to technologies for manufacturing modern products while meeting all environmental standards.

During the project, IMN assessed the replicability plan of the innovative treatment trains for mining industries and evaluated its transferability to other sectors.

Sandfire matsa

Sandfire Matsa is a sustainable, modern Spanish mining company which owns and operates three mines in the province of Huelva: the Aguas Teñidas and Magdalena mines located in Almonaster la Real, and the Sotiel mine located in Calañas, in the province of Huelva.

Their role in REMINE WATER consisted of assessing the suitability of the demonstration site and performing the installation of the pilot plants on its premises. Additionally, they operated the project pilots and evaluated the technical requirements for a full-scale implementation, considering the circular schemes principles.

newheat
renewable heat supplier

Newheat develops, builds and operates heat production plants, exclusively produced from solar thermal technologies for the needs of industrial processes.

The role of Newheat in the project consisted of designing and monitoring the pilot solar thermal power plant. In addition, they have elaborated a business model of the use of solar thermal energy in the mining industry.

03. TAKING THE MINING INDUSTRY FROM LINEAR TO CIRCULAR

Water scarcity is one of the major global challenges of our time, representing a threat not only in the ecosystems but a direct impact on economic growth. The climate change and the continuous droughts that countries of the South of Europe suffer from are forcing improvements in water efficiency and sustainability.

The mining sector is an important water consumer in Europe, as water is a critical component in the operation of a mine. In spite of the improvement in wastewater treatment processes and the implementation of partial reuse of inner water flows to reduce the water footprint, water is still discharged after ensuring its quality. In this context, there is a need to implement full water reuse schemes, minimise brine discharges and reduce the dependency of external water sources.

Moreover, accelerating technological innovation cycles and rapid growth in emerging markets have resulted in growing demand for metals and minerals. Specifically, climate-neutrality and digitalization scenarios defined for 2030 and 2050 in the EU Green Deal require an intensive consumption of critical and strategic raw materials. In the mining operation, valuable metals are removed through precipitation as sludge for further management as waste. In a circular scheme, mining wastewaters represent an opportunity to exploit mining wastewaters as a potential secondary source of valuable resources.

The main goal of Remine Water was to transform the current process into a circular process (Figure 1). Remine Water has implemented this by developing a system that allows water to be reused and the by-products contained in mining wastewater, such as acids, metals and minerals to be recovered.

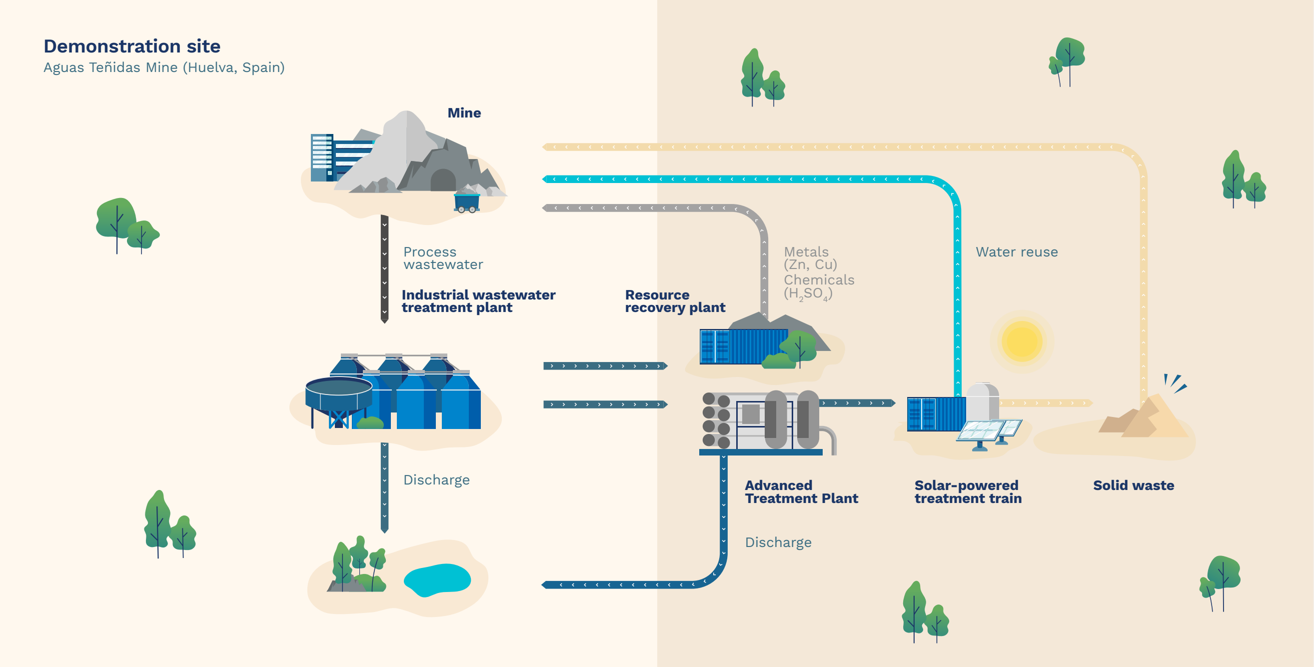

Figure 1. Transformation of a linear operation mining scheme into a circular process in REMINE WATER.

04.
CASE STUDY

The demonstration site of the project was on the mine of Aguas Teñidas, property of Sandfire Matsa, located in the town of Almonaster la real, in Huelva province (Southwest of SPAIN). This mine produces copper, zinc and lead concentrates.

Their wastewaters are treated in the water treatment plant located on its premises (Figure 2). Their conventional treatment consists of two stages: in the first treatment line, water comes from a big pond where different wastewaters are mixed (process and contact waters, metal-containing leachates, etc). The objective of this step is to remove thiosulphates present on the wastewater. In the second treatment line they remove sulphates in the form of ettringite and gypsum. However, their effluent water still has a very high sulphate concentration and they are seeking to reduce it to meet future discharge requirements.

In this framework, the REMINE WATER project has developed two innovative treatment trains. The first one aimed to minimise brine discharges and improve the quality of output water to be reused internally or discharged if needed. The second one had the goal of recovering valuable raw materials from wastewaters (Figure 3).

Figure 2. Overview of Matsa conventional wastewater treatment plant and REMINE WATER pilot.

Figure 3. Overview of the REMINE WATER innovative treatments trains.

WATER RECLAMATION PLANT

This plant was composed of two stages (Figure 4). The first one consisted of a sulphate removal system and the second one of a Zero Liquid Discharge (ZLD) scheme. The sulphate removal system treated between 4 - 6 m^3/h of neutralised process waters. The train was composed of a softening plant to remove water hardness (calcium and magnesium), followed by a pH adjustment unit, sand filtration and nanofiltration membranes to reject sulphates. The zero liquid discharge scheme consisted of concentrating brines and recovering water with different sequential treatments: reverse osmosis membranes treated the nanofiltration permeate to obtain high quality water which could be reused directly by the mine.The reverse osmosis rejection was conducted to the ElectroDialysis-Brine Concentration (ED-BC) system. The ED-BC concentrate output stream was treated by a Low Temperature Evaporator (LTE), coupled to a solar plant that supplied thermal energy (Figure 5). This last step produced a second stream of quality water to be reused and a concentrated brine solution that was stored in a basin.

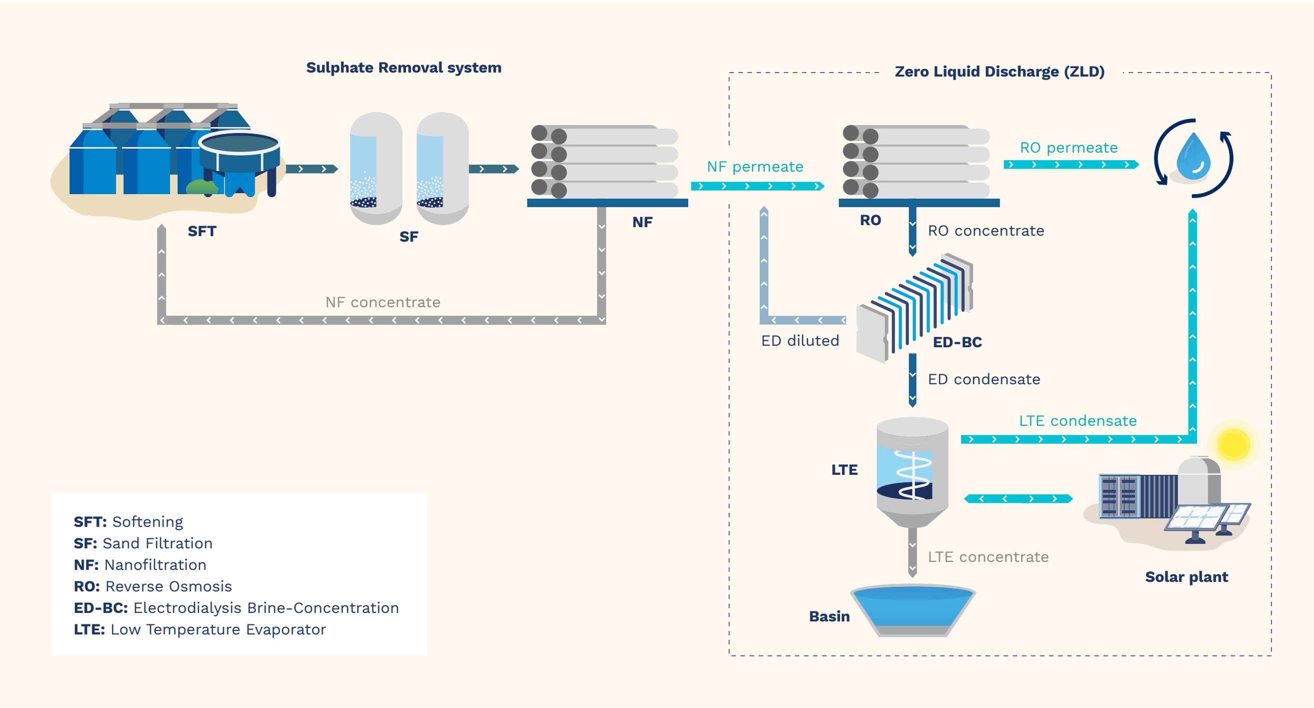

Figure 4. Sulphate removal system & ZLD plant scheme.

Figure 5. Overview of the solar plant.

RESOURCE RECOVERY PLANT

The goal of the resource recovery plant (Figure 6) was to recover metals present on the dump leachates, mainly copper (Cu) and zinc (Zn), to employ them either in the mine or in other industries, favouring a circular economy scheme. The plant processed 0.1 m^3/h of leachates.The first step consisted of a chemical oxidation and iron and aluminium precipitation followed by a pH adjustment. The outlet stream was conducted to the ion exchange resins to selectively remove Cu and Zn. Sulphuric acid (H_2SO_4) was applied to regenerate the resins and recover the Cu and Zn. This acidic solution was treated by nanofiltration membranes to recover sulphuric acid in the permeate stream and recover Cu and Zn in the concentrate solution. Finally, Cu was separated from Zn through its electrodeposition in the 3D electrodeposition unit, while zinc remained in solution and was recovered as zinc sulphate ($ZnSO_4$). Sulphuric acid was applied to dissolve again the deposited Cu to obtain a copper sulphate concentrate ($CuSO_4$).

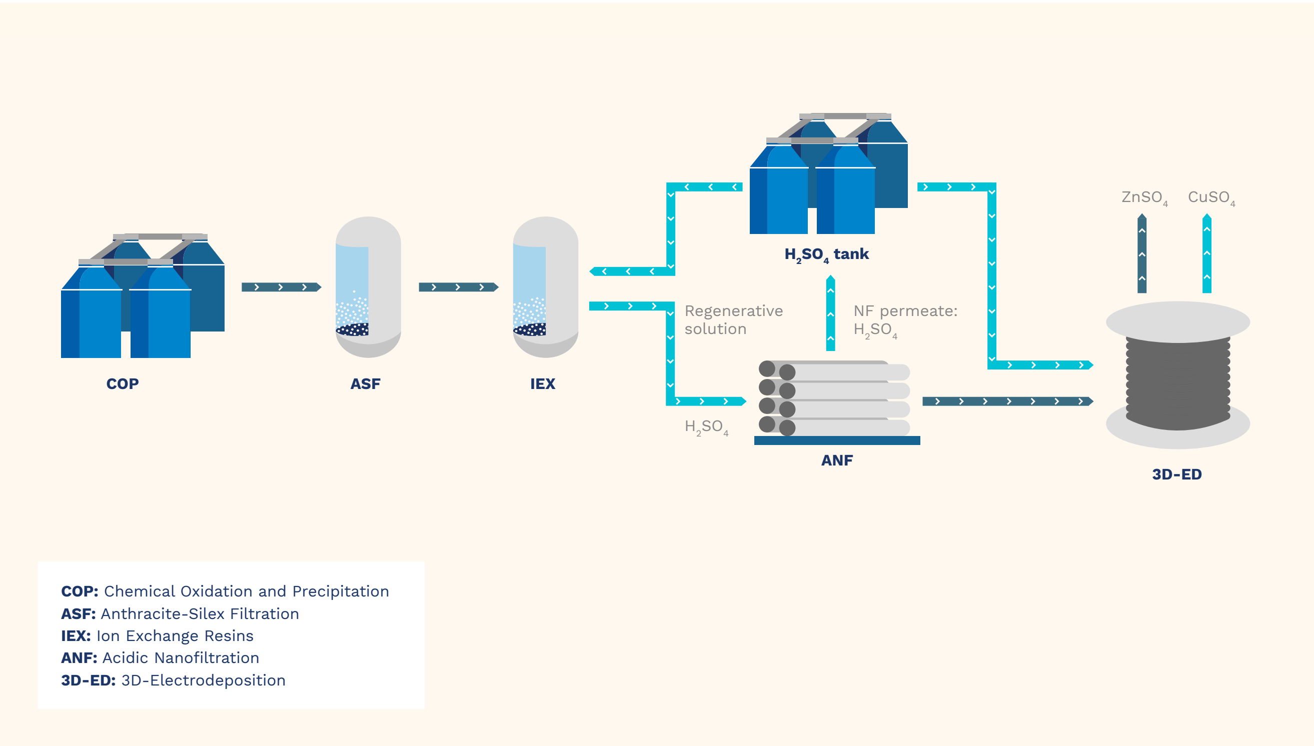

Figure 6. Resource recovery plant scheme.

05. ACHIEVED RESULTS

The REMINE WATER has validated a treatment train integrating innovative technologies for brine treatment through the construction and operation of a water reclamation and resource recovery plants. The main obtained results are:

- **Reduction of 60% of the salinity and sulphate concentration of the wastewater river discharge** in the implementation of a full-scale plant. According to the results of the study about the implementation of a circular economy inside Matsa, mixing a proportion of a reverse osmosis permeate with a proportion of the output of their conventional water treatment plant will result in a high quality water able to be reused in the mineral processing plant.
- **Reduction of 50% of the freshwater consumption** in a full-scale plant by promoting on-site water reuse and taking advantage of the high quality water produced in the reverse osmosis.
- **Recovery of 95% of water from reverse osmosis concentrates** through the implementation of the zero liquid discharge scheme. During the project it has been demonstrated that salts are concentrated from ~5 g/L total dissolved solids (TDS) in the reverse osmosis concentrate stream to ~100 g/L in the produced brine in the evaporator.
- **Reduction of 99% of the salinity from reverse osmosis concentrates for water reuse**. The recovered water at the end of the ZLD train, specifically, in the evaporator condensate, is a secondary source of high quality water available to the mine, with a TDS concentration lower than 0.01 g/L.
- **Recovery of subproducts for internal reuse implying economic savings**. The obtained product in the softening step made of calcium carbonate and magnesium hydroxide can be used to raise the pH in some steps of their conventional treatment plant, thus replacing the use of lime to some extent.
- **Reduction of electrical energy consumption and 64% less CO_2 emissions** in the evaporator, compared to conventional thermal evaporation processes, by the integration of solar thermal energy to the treatment train. In addition, this replacement results in a 50 % reduction in the operational expenditures of this unit.

Furthermore, other technologies were developed in the resource recovery plant to recover strong mineral acids and valuable metals from process mining water. The main outcomes from are the following:

- **Recovery of 50% of sulphuric acid in acidic nanofiltration step**. In these conditions, the obtained sulphuric acid can be reused in the same treatment train for resin regeneration in ion exchange or copper dissolution in electrodeposition.
- **Recovery of 95% of copper and 50% of zinc in ion exchange resins**. Both elements are concentrated four times in the acidic nanofiltration. Finally, zinc is separated from copper in the electrodeposition unit. As a result, the concentrated product has a concentration of ~28 g/L of Zn and ~80 g/L of Cu, in the form of sulphates. These two products can be used as reaction reagents in the flotation step of the mineral treatment plant. Before the implementation of this treatment train, these resources were wasted in the sludge produced in the conventional wastewater treatment plant.

Finally, the replicability assessment to other European mining and metallurgical sites of the two treatment trains have identified potential sites in Spain and in Poland where these circular schemes could be implemented, considering technical, economic and environmental issues, as well as the legal and regulatory framework. Furthermore, possible industries where the treatment plants could be transferred have been identified, such as the fertiliser industry, for brine treatment, or hydrometallurgy for metal recovery. A preliminary design of the treatment plant requirements and a first economic estimate have been drawn up.

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