LIFE SOL-BRINE & LIFE BRINE-MINING

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General problem of Brine Discharge & Brine Treatment
Brine discharge problem

• Brine $\rightarrow$ solution of high salt concentration (mainly NaCl)
• Produced $\rightarrow$ desalination plants, industry (chemical, coal mine, textiles, food etc)
• Brine discharge $\rightarrow$ Tones of salts and water are released to surface water bodies, sea or WWTP

Problems:
- Pollution of surface water bodies and sea (flora and fauna changes, limiting the possibility to use river or lake water for agricultural, industrial and municipal purposes creating social, environmental, economical problems)
- Salination of soils (agricultural problems)
- Degradation of underground water bodies
- Accumulation of chlorides and sulfates
Brine Treatment-Salt Recovery

• Tones of recovered salts could be reused by industry (some of them are in the EU list for Critical Raw Materials e.g Mg)
• Other valuable-high market price materials could be recovered apart from salts (such as biomolecules from food industry brines)
• Decrease of energy consumption and CO₂ emissions (less energy is used for the recovery of salts from brines compared to their conventional production)
• Millions of m³ water could be reused for agricultural, industry and municipal purposes
• Avoid water scarcity
• Better status of soil and water bodies
Innovative Projects for Brine Management to recover water and salts
Strategic Steps to be followed for Brine Management

1. Definition of the materials that can be recovered from brine
2. Integration of new and mature technologies to recover water and resources from the brine
3. Estimation of environmental footprint
4. Definition of existing and new markets for the products
5. Overcome policy barriers → suggest solutions
6. Initiatives to improve social acceptance of systems and recovered materials
7. Build/operate innovative systems
Innovative Circular Systems for Brine Management

- **Walnut** (TRL9): 2021
- **Life BRINE MINING** (TRL4): 2010
- **Sol - Brine** (TRL7): 2019
- **Zero Brine** (TRL4): 2017
- **Water Mining** (TRL9): 2020
“Development of an advanced innovative energy autonomous system for the treatment of brine from seawater desalination plants”

Area of implementation: Tinos Island, Greece

- Project Budget: 1,209,689.00 €
- EC Funding (LIFE+): 604,844.00 €
- Duration: 39 months
- Start date: 01/10/2010
- End date: 31/12/2013

Municipality of Tinos Island (Project Coordinator)

National Technical University of Athens

Culligan Hellas S.A.
Innovative aspects

- **Brine production**: from the desalination plant of Tinos Island
- **Total brine elimination**: The system has been designed in line with the Zero Liquid Discharge principle
- **Water Recovery**: (> 90%)
- **Production of useful end-products**: (a) water of high quality and (b) dry salt. Products with market opportunities.
- **Energy autonomous operation**: Solar thermal collectors are used for delivering hot water and a PV for electricity. All energy requirements are covered exclusively through the use of solar energy.
- **Use of state-of-the-art technology**: Custom designed vacuum evaporation technology (evaporator and crystallizer) and solar dryer.
Sol Brine System

Evaporator

Crystallizer
Sol Brine System
Sol Brine System

Site Visit
Sol Brine-EU Green Awards

The Best Life Project of last 25 years
LIFE Brine-Mining Project

Area of implementation: Poland

Project Budget: 6,383,847 €
EC Funding (LIFE+): 3,508,365 €

Duration: 58 months
Start date: 01/09/2019
End date: 30/06/2024
Partners

Coordinating beneficiary

National Technical University of Athens

Beneficiaries

GLOWNY INSTYTUT GORNICTWA
LENNTech
NEVIS-NOVEL Environmental Solutions S.A.
SEALEAU B.V.

Silesian University of Technology
POLSKA GRUPA GORNICZA
THERMOSSOL STEAMBOILERS S.A.
Titan Salt B.V.
Titan Projects B.V.
Coal mines closure

&

need for coal mine brine treatment
Decarbonization in Europe

European Green Deal

2030
55% reduction in EU GHG emissions compared to 1990

2050
net-zero emissions

Energy transition to a climate – neutral economy

Coal mines closure

The need for saline water treatment will continue to exist, since even after their closure, coal mines have to be continuously dewatered
The problem in Poland
&
the project target area
The problem in Poland

- Poland is the dominant producer of hard coal in EU
- Coal mines generate vast amounts of saline wastewater
- Direct or indirect drainage of these streams to water bodies
- Ecological Status of rivers: moderate
- Vistula River: 55% of fresh water in Poland
- Economic losses from Vistula salinization: 150-200 million $ per year (losses in the transportation and the industrial and agricultural sector)
Coal mine brine discharge in the project’s target area

- PGG is the owner of most of coal mines in Poland
- Million tonnes of brine are produced per year from the mining operation
- The high salinity brine is discharged in artificial ponds for the precipitation of salts and solids
- However, a great amount of salts end up to the Vistula River, causing the river degradation

The Ziemowit coal mine, which belongs to PGG
The project target area

The Goławiecki Stream and the Small Vistula River

The 2 national monitoring points of the area

The 3 artificial ponds in the Ziemowit mine. In each pond, coal mine brine from different depth of the mine is discharged

Overflow of ponds to Goławiecki sidestream

Estuary of the Stream to the Vistula River
Coal mine brine discharge in the project target area

- High content of chlorides, sodium ions and sulfates
- The Goławiecki Stream’s conductivity reaches the level of seawater
- High level of $K^+$, $Br^-$, $Sr$, $Mn^{+2}$, $B$, $HCO_3^-$: all these ions are associated with produced wastewater from coal mine operations
The pilot system units
Project area implementation

Map of the Brine-Mining site in the area of the Ziemowit mine

Photo of the Brine-Mining containerized technologies in the area of the Ziemowit mine

The project is co-funded by the EU LIFE Programme
Technologies Applied

- **Ultrafiltration**: Removal of the brine suspended solids
- **Precipitation**: Precipitation of the minerals (Mg, Ca) using chemical solutions
- **Nanofiltration**: Separation of monovalent ions (Cl\(^-\), Na\(^+\), K\(^+\)) from divalent ions (SO\(_4^{2-}\))
- **Electrodialysis**: Concentration of NaCl in the NF permeate from 9% to 15%
Technologies Applied

- **Reverse Osmosis**: From the RO, clean water is recovered while the concentrate is mixed with the ED inflow.

- **Evaporation - crystallization**: The evaporator concentrates NaCl from 15% to solid form.
LIFE Brine-Mining pilot system installation

Ultrafiltration

Precipitation tanks

Nanofiltration, Electrodialysis and Reverse Osmosis

Evaporator

The project is co-funded by the EU LIFE Programme
The pilot system performance
Process Flow Diagram of the Prototype System
Precipitation Reactors operation performance

97% Mg removal in Precipitation Reactor I

Precipitation Reactor 1 performance July - September 2022

96-97% Ca removal in Precipitation Reactor II

Precipitation Reactor 2 performance July - September 2022

The project is co-funded by the EU LIFE Programme
Nanofiltration and Electrodialysis operation performance

>97% Mg and >97% SO₄ removal in Nanofiltration

2 times condensation in Electrodialysis

The project is co-funded by the EU LIFE Programme
Reverse Osmosis operation performance

>98% removal in all ions

Reverse Osmosis performance July - September 2022

The project is co-funded by the EU LIFE Programme
Pilot system operation performance

Raw brine → Ultrafiltration: 97% Mg\(^{2+}\) removal

Precipitation Reactor 1: 97% Mg\(^{2+}\) removal

Precipitation Reactor 2: 96-97% Ca\(^{2+}\) removal

Nanofiltration: > 98% SO\(_4^{2-}\) removal

Electrodialysis: > 86% Ca\(^{2+}\) removal

Evaporator: Solid NaCl

Reverse Osmosis: Clean water

TDS=8%

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The Brine-Mining Circular Economy Concept & Expected Results
LIFE Brine-Mining: Circular Economy Concept

LIFE Brine-Mining: From coal mine brine to marketable minerals, salts and water

Recovery of minerals, salts and water from coal mine brine desalination. Use in the agricultural, the municipal and the industrial sector. Rise in the revenues of the coal mine from the recovered materials exploitation.

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1. Prevention of brine discharge
   Avoid discharge of 8,872,500 m³ brine per year into surface water

2. Recovery of clean water
   Recovery of 7,328,685 tones of clean water per year

3. Production of minerals/salts
   546,800 tones of minerals/salts will be produced per year
LIFE Brine-Mining full-scale implementation expected results

4. Salts of high purity

- Production of 39,293 tones Mg(OH)$_2$: 91% purity
- Production of 58,559 tones CaCO$_3$: 98% purity
- Production of 29,913 tones CaSO$_4$: 91% purity
- Production of 435,000 tones NaCl: 98% purity
Project’s Benefits

Economic Benefits

Job opportunities will be offered to new professionals.

The recovered materials will be promoted to the industrial market, boosting the coal mine income.

At the same time, the recovered materials prices will be lower than the ones produced conventionally, making them more attractive to the market.

The coal mine sector will save money by paying less fees to the government, due to less discharged brine in the aquatic environment.

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Project’s Benefits

Social Benefits

- Incentives for local job opportunities, as more mines can follow the Ziemowit mine initiative
- The recovered clean water can be used for municipal purposes, like irrigation of playgrounds
- Rise of the environmental profile and status of the area, where the mine is located
- Public health protection

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Thank you for your attention

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LIFE BRINE-MINING website:
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