

# ***LIFE SOL-BRINE & LIFE BRINE-MINING***



Life BRINE  MINING

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# ***General problem of Brine Discharge & Brine Treatment***

# Brine discharge problem

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

## Problems:

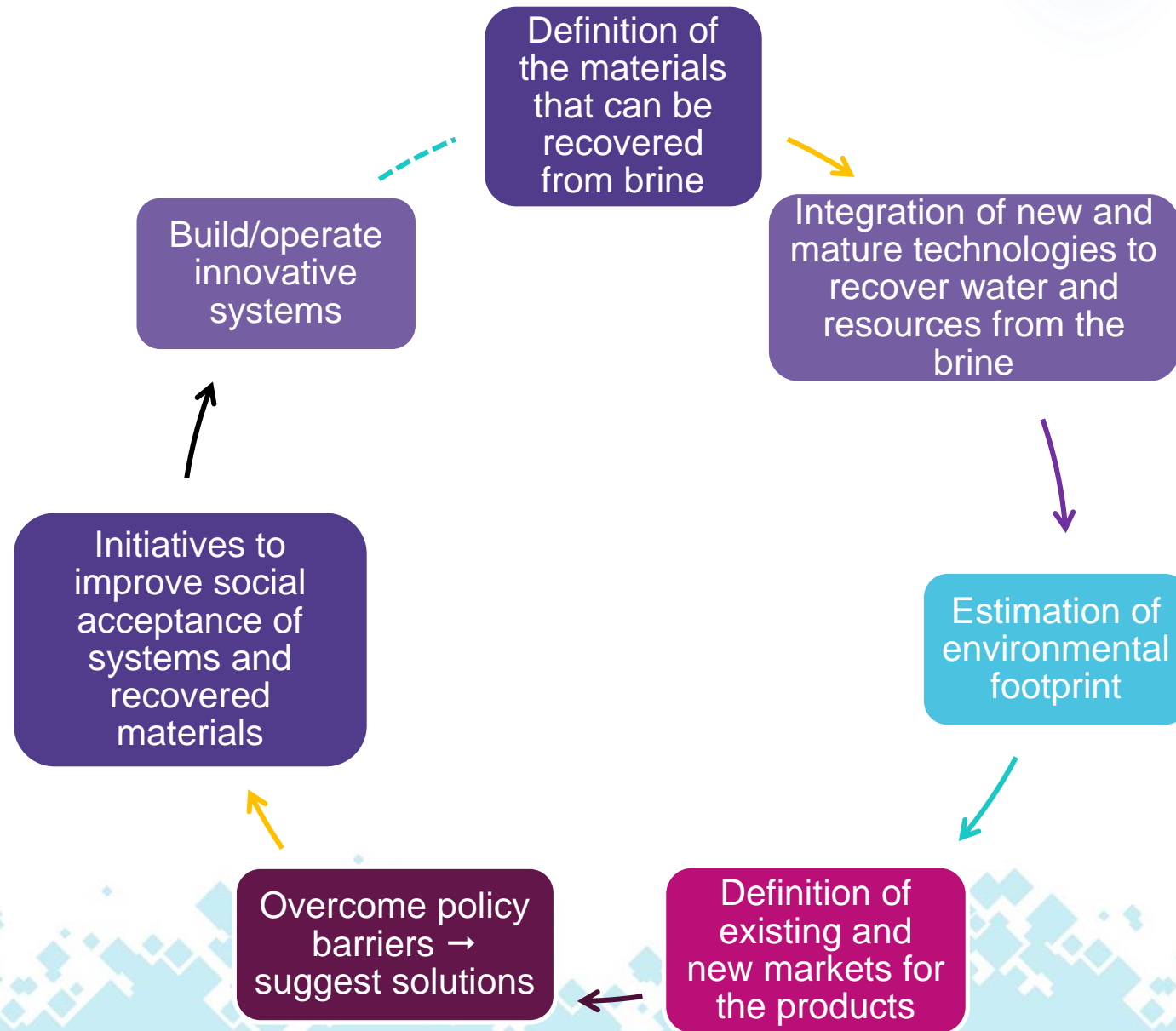
- Pollution of surface water bodies and sea (flora and fauna changes, limiting the possibility to use river or lake water for agricultural, industrial and municipal purposes creating social, environmental, economical problems)
- Salination of soils (agricultural problems)
- Degradation of underground 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 CO<sub>2</sub> emissions (less energy is used for the recovery of salts from brines compared to their conventional production)
- Millions of m<sup>3</sup> 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





# Innovative Circular Systems for Brine Management



# Sol Brine-General Information

*“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.**

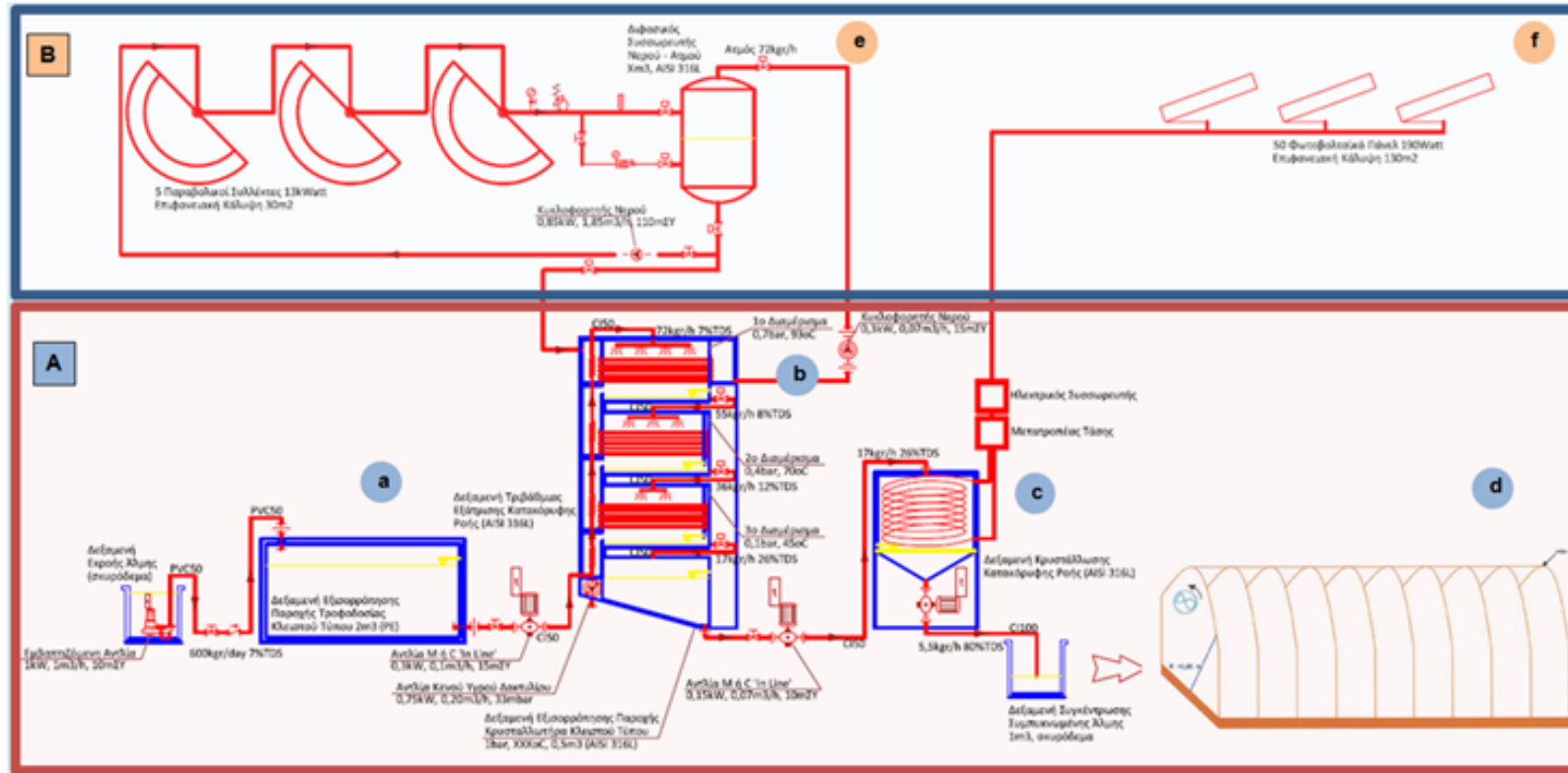




# Innovative aspects

- **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.

# Single Line Diagram



# Sol Brine System



*Evaporator*



*Crystallizer*



# Sol Brine System



*Dryer*



*CSP*



# 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



Co-funded by  
the European Union

# Partners

## Coordinating beneficiary



National Technical  
University of Athens



Silesian University  
of Technology

## Beneficiaries



GLOWNY INSTYTUT  
GORNICTWA



LENNTECH



NEVIS-NOVEL  
Environmental  
Solutions S.A.



SEALEAU B.V.



POLSKA GRUPA  
GORNICZA



THERMOSSOL  
STEAMBOILERS S.A.



Titan Salt B.V.



Titan Projects B.V.



Co-funded by  
the European Union



***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



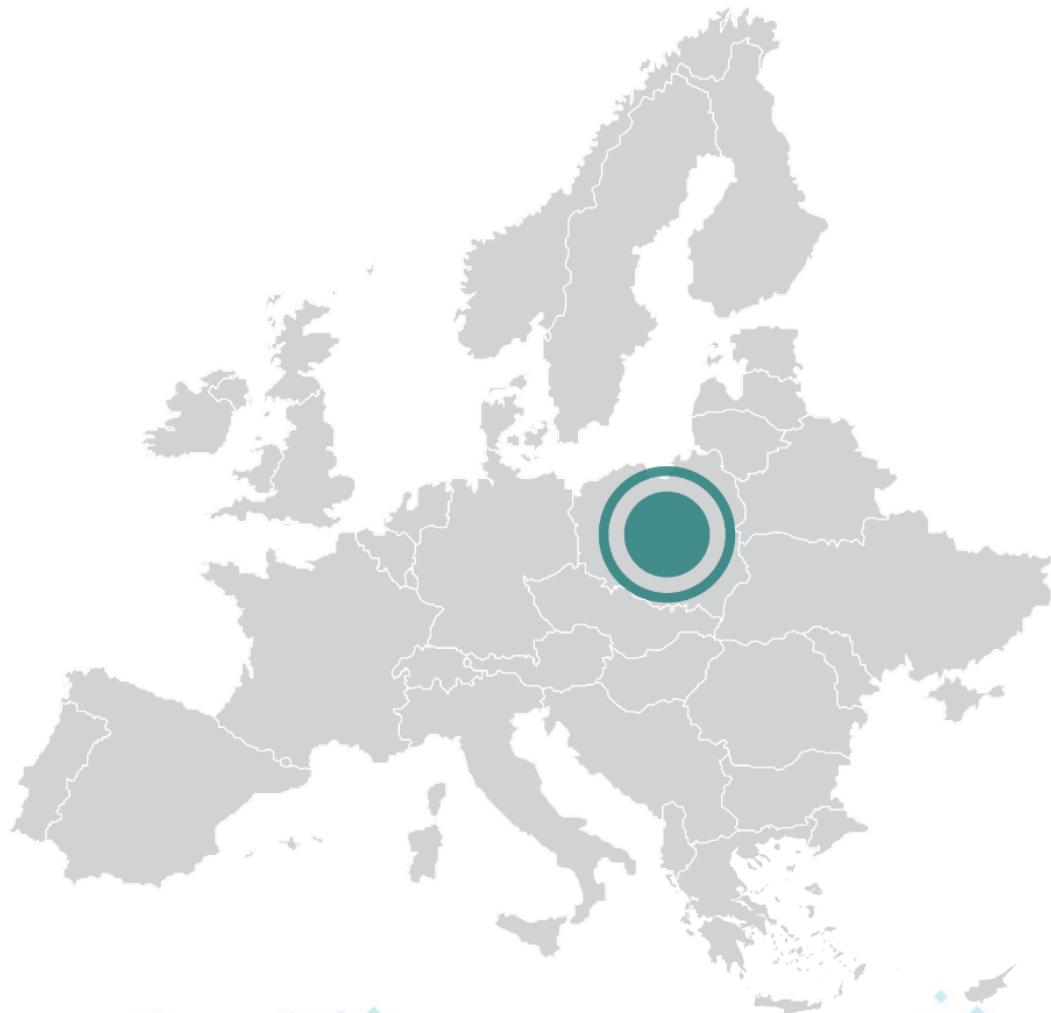
The need for saline water  
treatment will continue to  
exist, since even after their  
closure, coal mines have to  
be continuously dewatered



***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

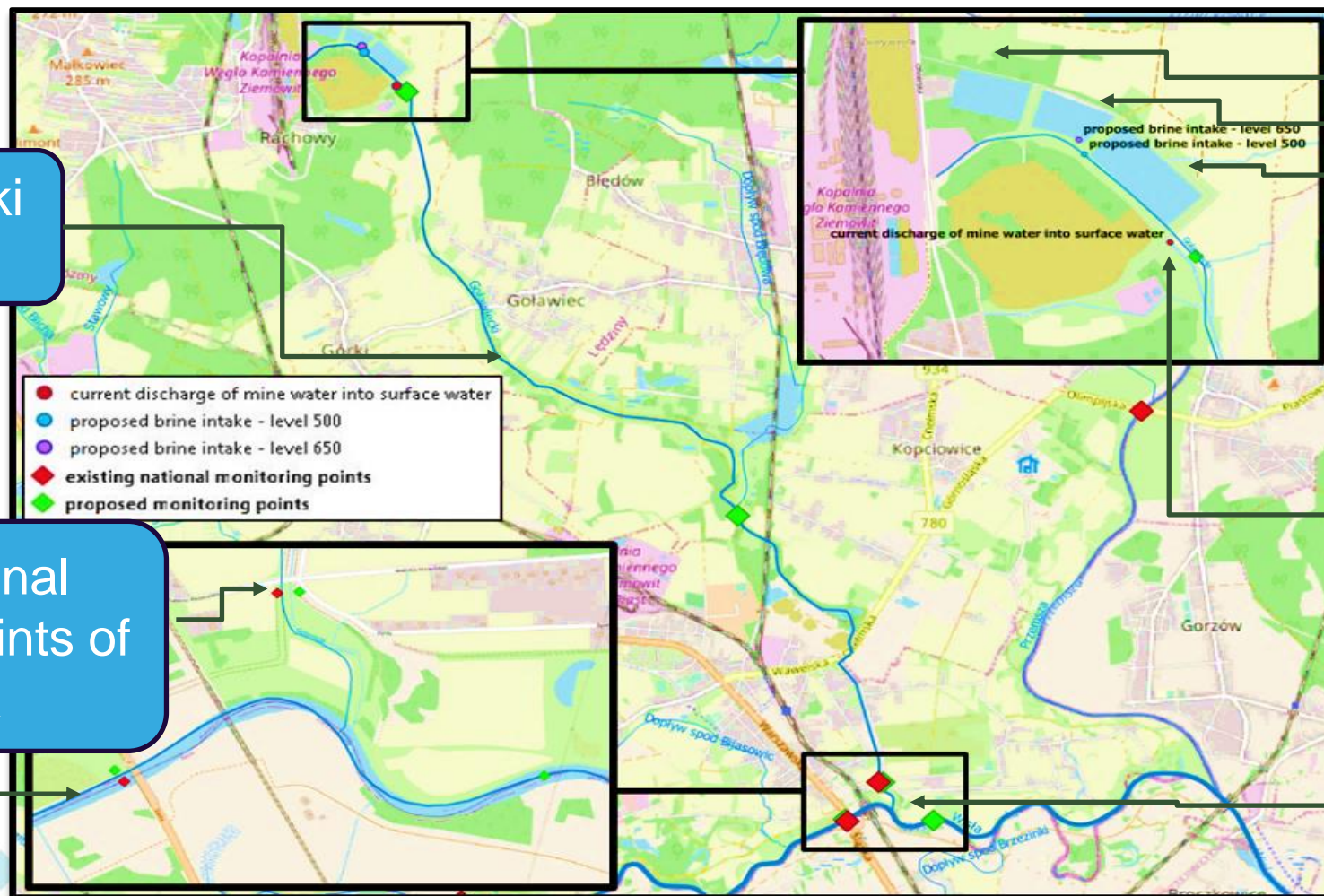
The Goławiecki Stream

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



The project target area: The Goławiecki Stream and the Small Vistula River

# Coal mine brine discharge in the project target area

## Result of coal mine brine discharge in the Stream and the River

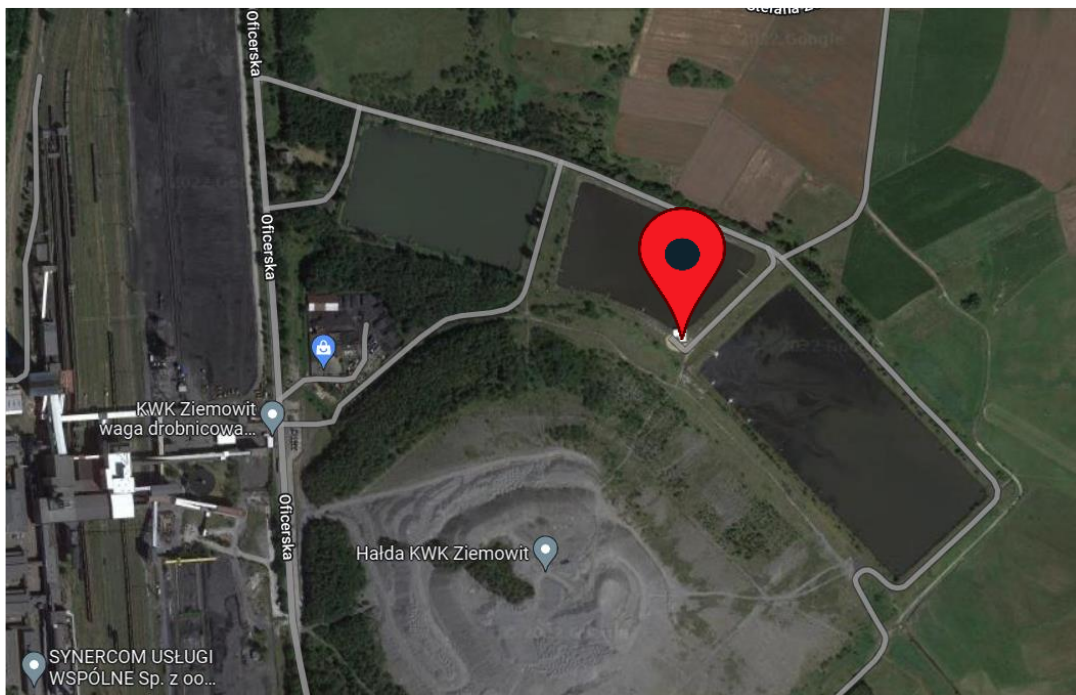
- ❑ National Monitoring Report (2019): Bad Water Condition
- ❑ High content of chlorides, sodium ions and sulfates
- ❑ The Goławiecki Stream's conductivity reaches the level of seawater
- ❑ High level of  $K^+$ ,  $Br^-$ ,  $Sr$ ,  $Mn^{+2}$ ,  $B$ ,  $HCO_3^-$ : all these ions are associated with produced 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**

# Technologies Applied

- ❑ **Ultrafiltration:** Removal of the brine suspended solids
- ❑ **Precipitation:** Precipitation of the minerals (Mg, Ca) using chemical solutions
- ❑ **Nanofiltration:** Separation of monovalent ions ( $\text{Cl}^-$ ,  $\text{Na}^+$ ,  $\text{K}^+$ ) from divalent ions ( $\text{SO}_4^{-2}$ )
- ❑ **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

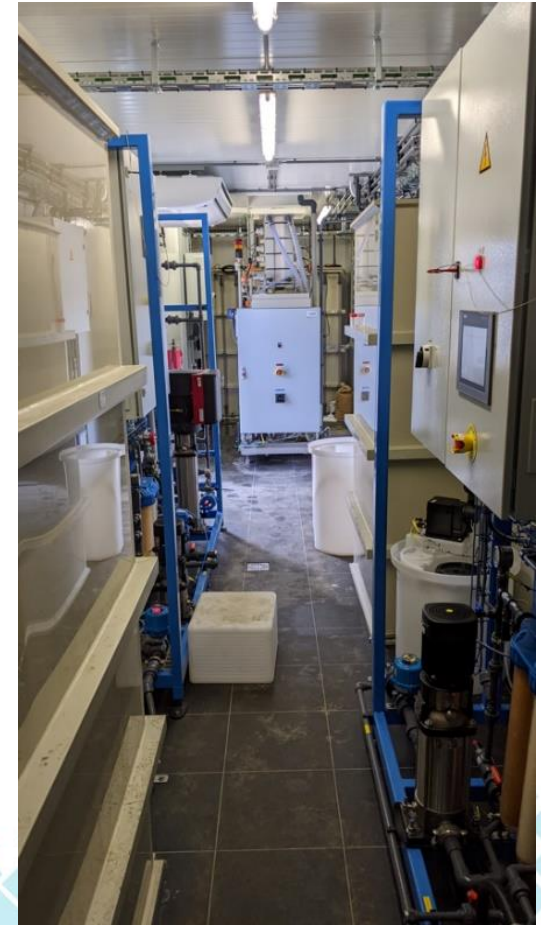
Ultrafiltration



Precipitation tanks



Nanofiltration,  
Electrodialysis and  
Reverse Osmosis



Evaporator



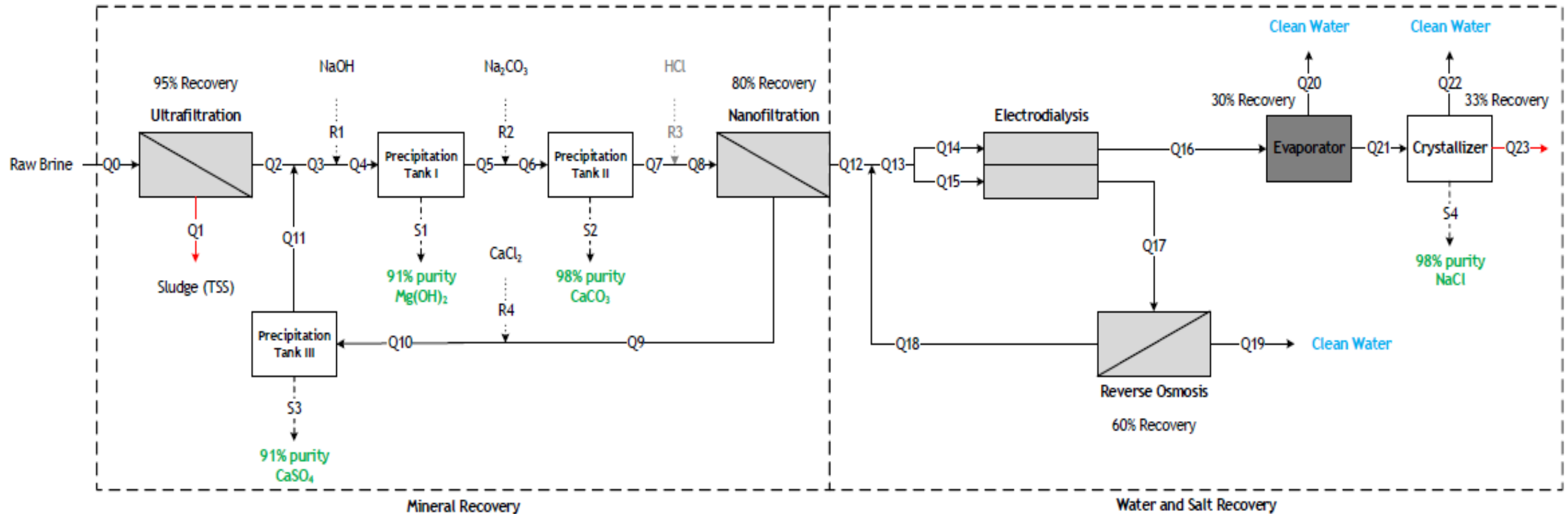
The project is co-funded by the EU LIFE Program



# The pilot system performance



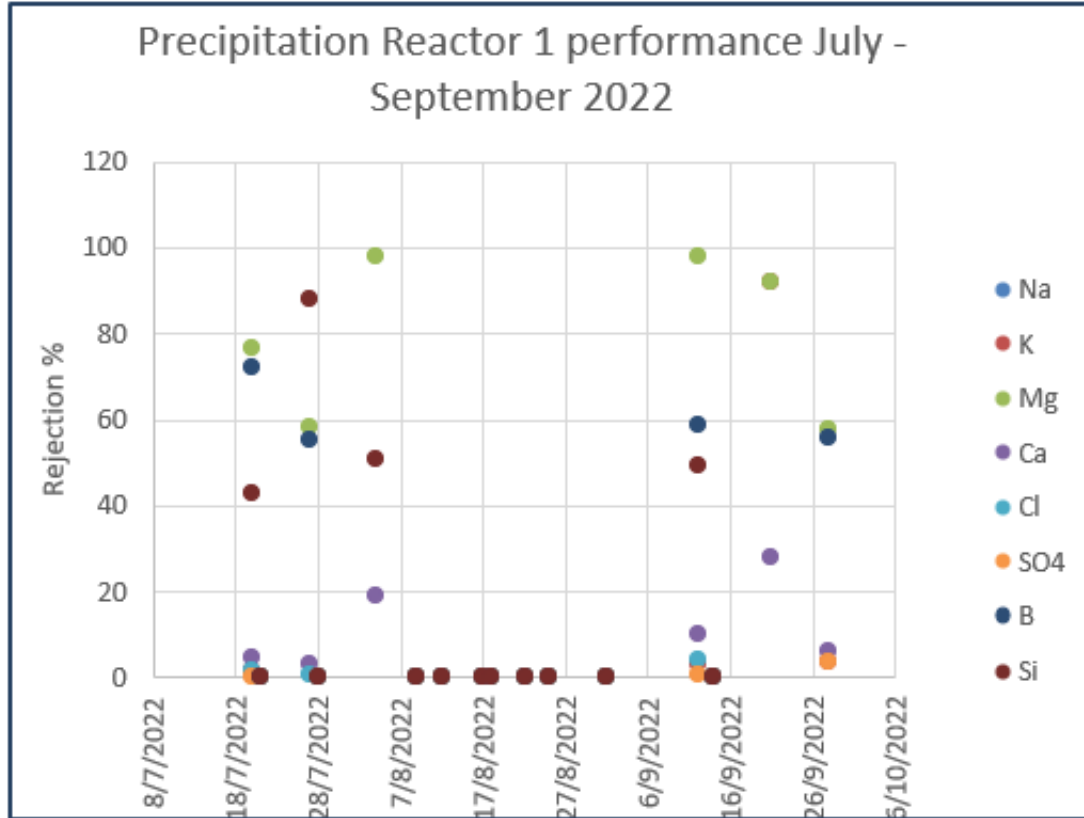
# Process Flow Diagram



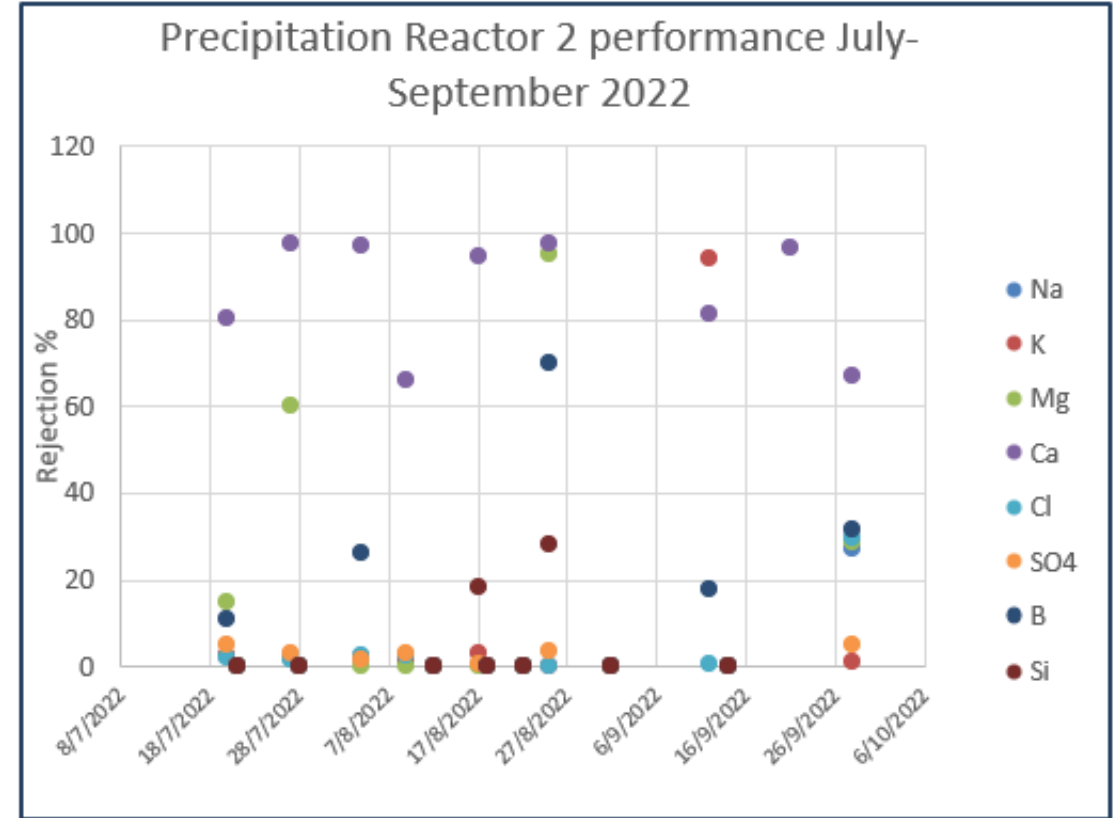
Process Flow Diagram of the Prototype System

# Precipitation Reactors operation performance

## 97% Mg removal in Precipitation Reactor I

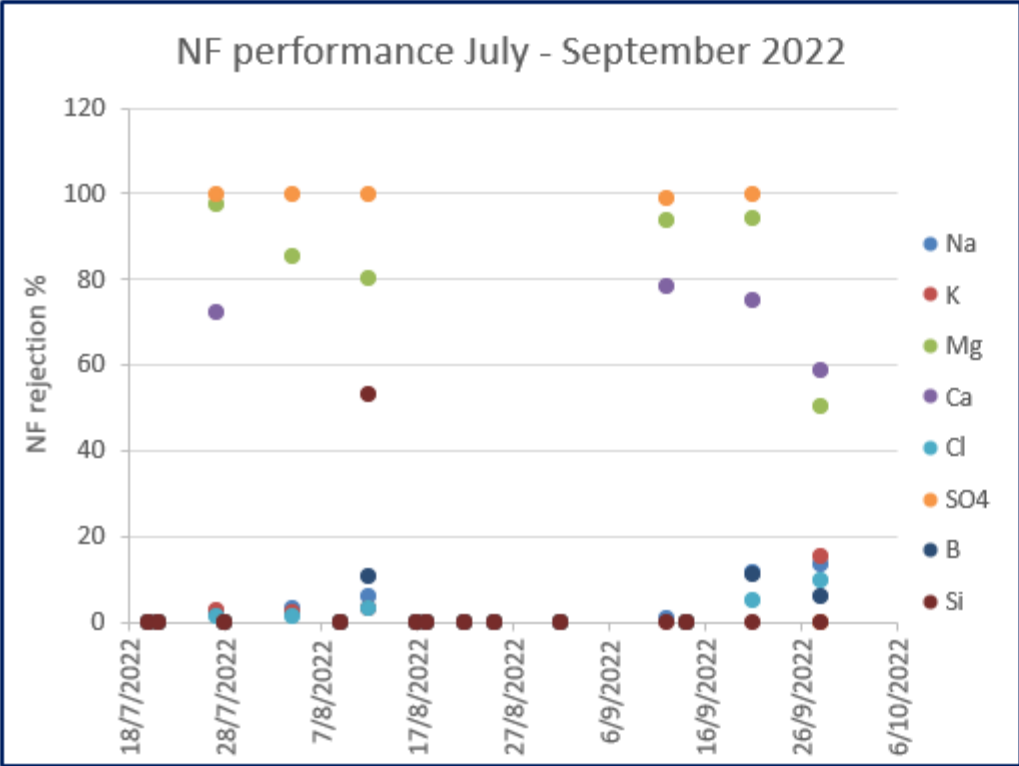


## 96-97% Ca removal in Precipitation Reactor II

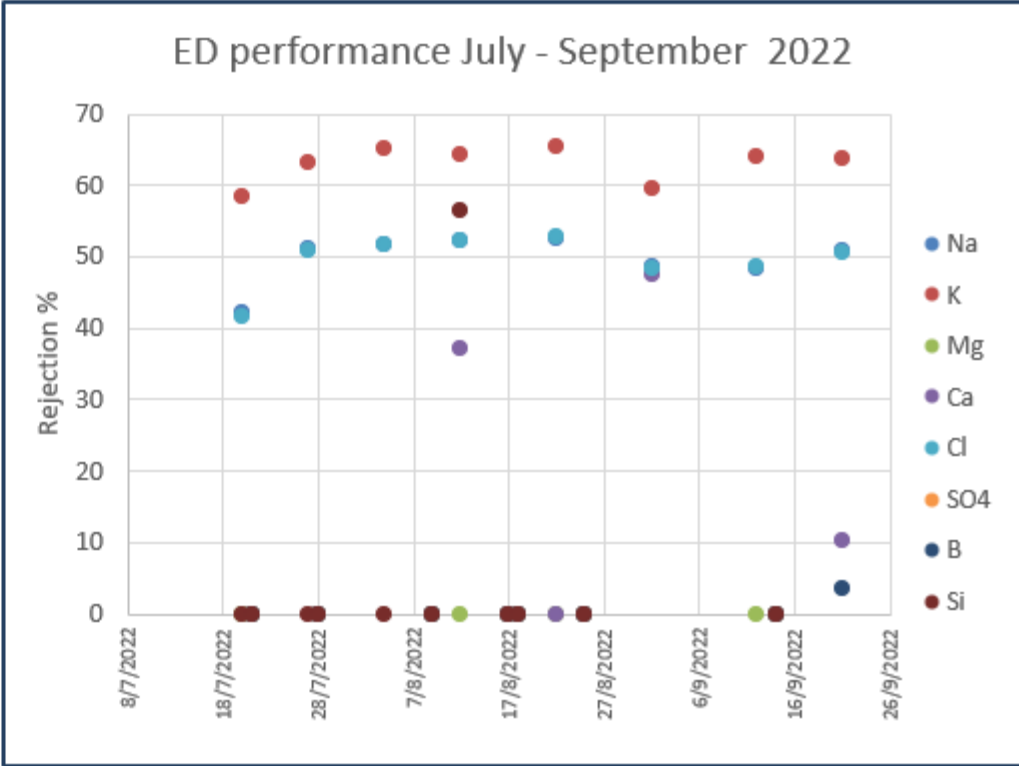


# Nanofiltration and Electrodialysis operation performance

>97% Mg and >97% SO<sub>4</sub> removal in Nanofiltration



2 times condensation in Electrodialysis

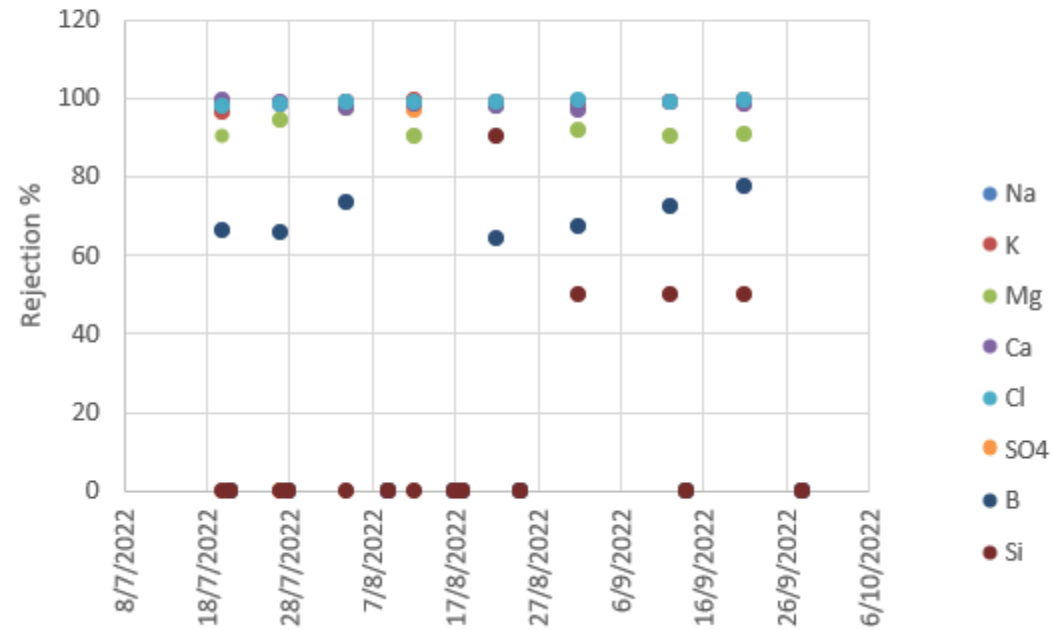




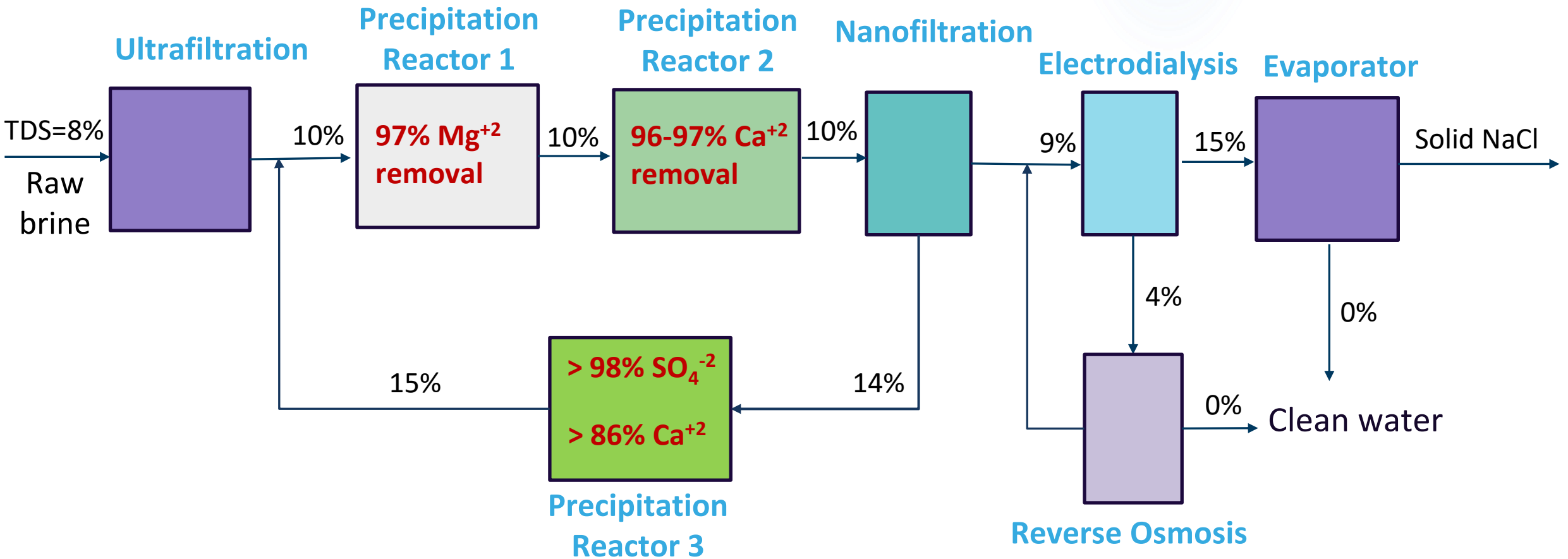
# Reverse Osmosis operation performance

>98% removal in all ions

Reverse Osmosis performance July - September  
2022



# Pilot system operation performance



# **The Brine-Mining Circular Economy Concept & Expected Results**

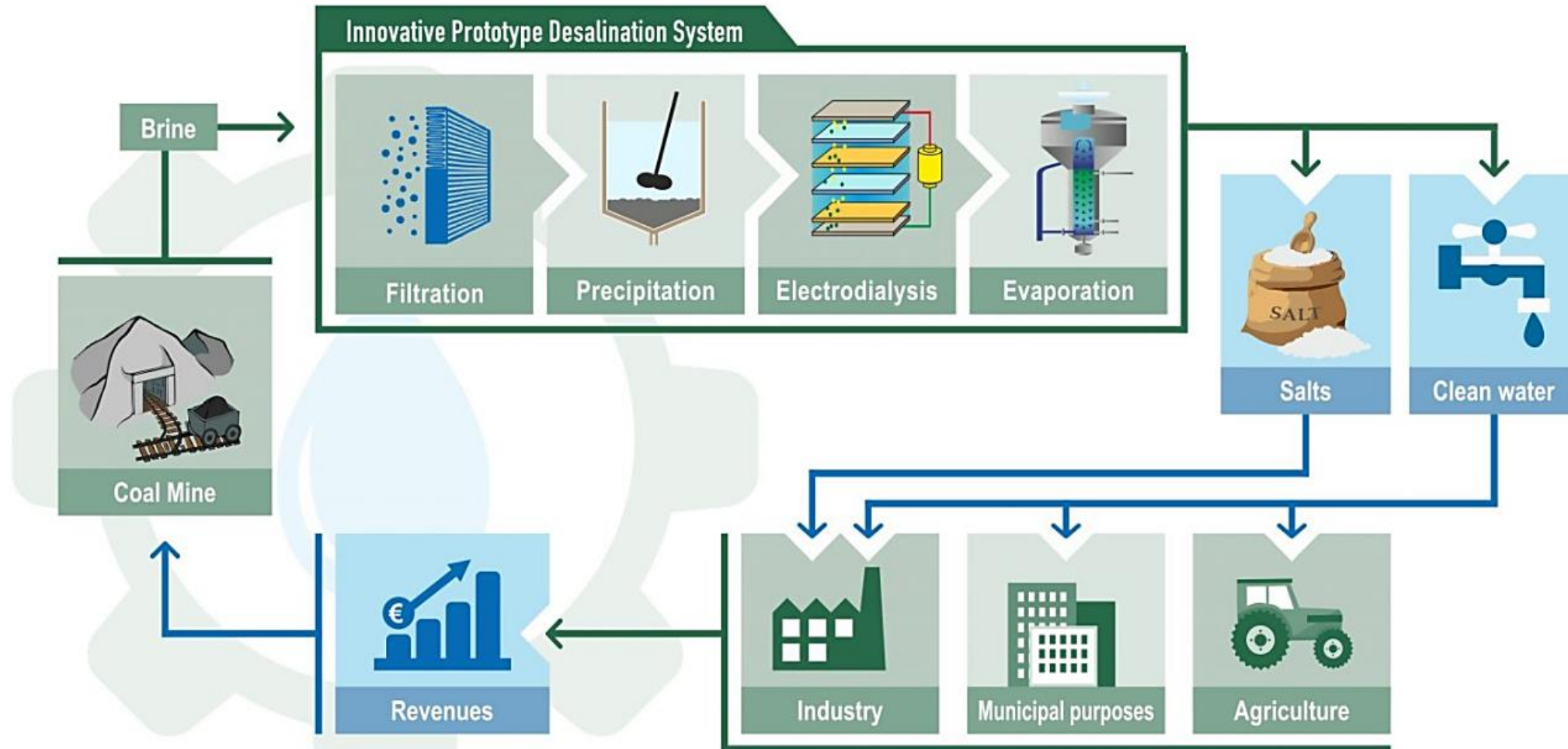


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# LIFE Brine-Mining: Circular Economy Concept

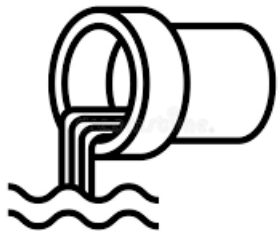
LIFE Brine-Mining: From coal mine brine to marketable minerals, salts and water



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

# LIFE Brine-Mining full-scale implementation expected results

## 1. Prevention of brine discharge



Avoid discharge of  
8,872,500 m<sup>3</sup> brine per  
year into surface water

## 2. Recovery of clean water



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

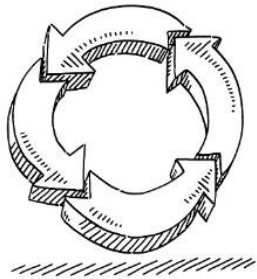
## 3. Production of minerals/salts



546,800 tones of minerals/salts  
will be produced per year

# LIFE Brine-Mining full-scale implementation expected results

## 4. Salts of high purity

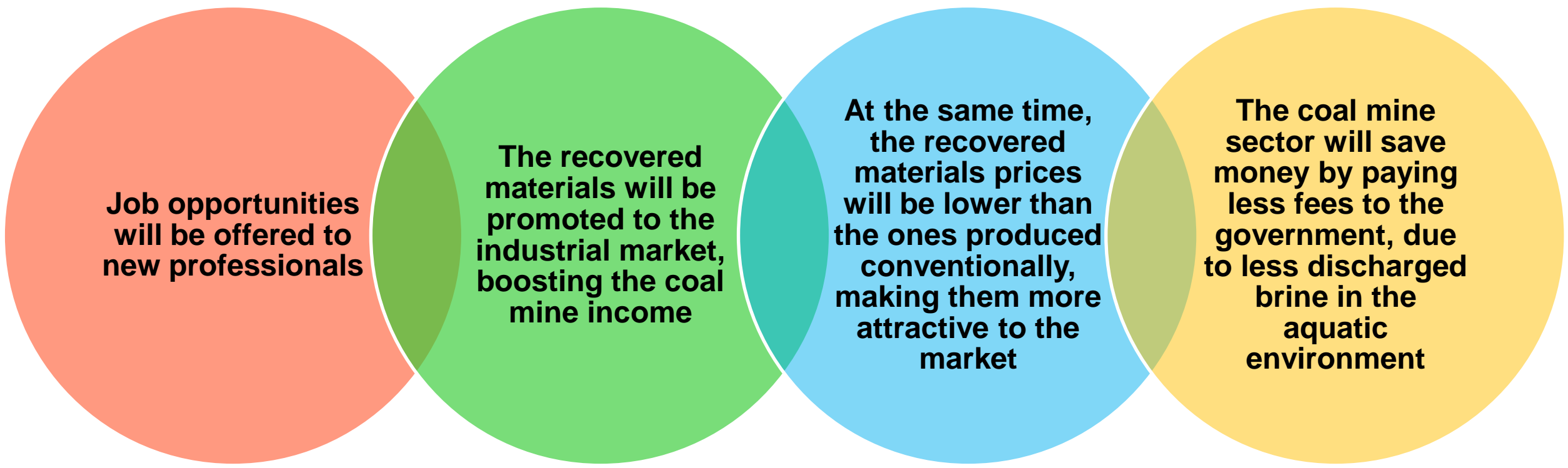


- ❑ Production of 39,293 tones  $\text{Mg}(\text{OH})_2$ : 91% purity
- ❑ Production of 58,559 tones  $\text{CaCO}_3$ : 98% purity
- ❑ Production of 29,913 tones  $\text{CaSO}_4$ : 91% purity
- ❑ Production of 435,000 tones  $\text{NaCl}$ : 98% purity



# Project's Benefits

## Economic Benefits



**Job opportunities  
will be offered to  
new professionals**

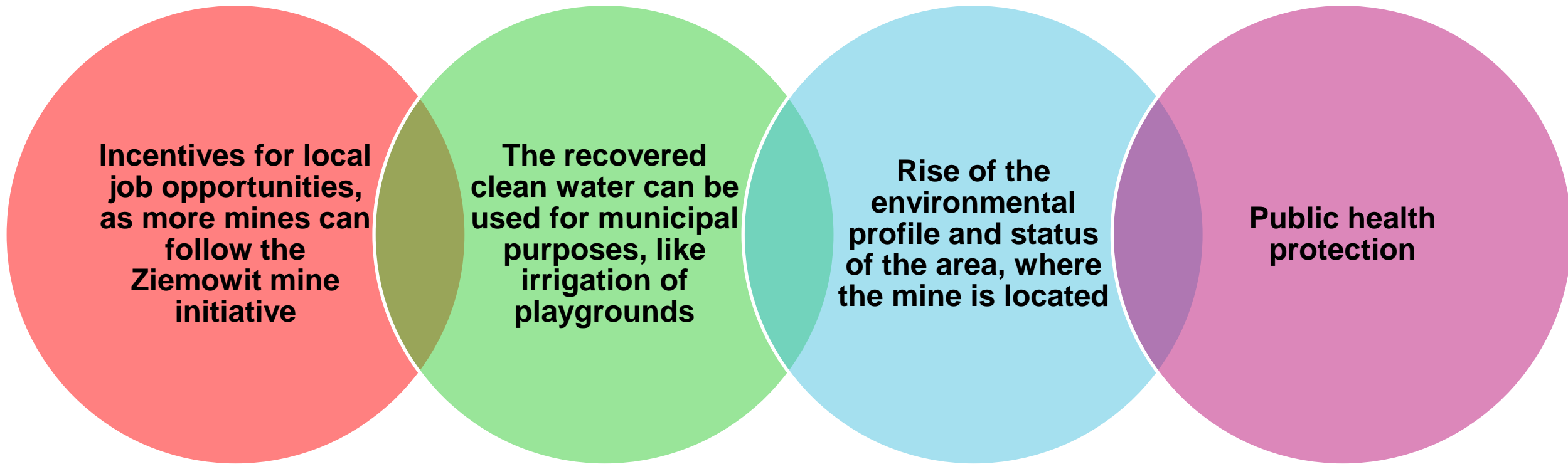
**The recovered  
materials will be  
promoted to the  
industrial market,  
boosting the coal  
mine income**

**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**

# Project's Benefits

## Social Benefits





# ***LIFE SOL-BRINE & LIFE BRINE-MINING***

Thank you for your attention



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**LIFE BRINE-MINING website:**  
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