ZERO BRINE

Online Training:

Recupero di minerali da salamoie esauste

Organized by:

Università degli Studi di Palermo

Presenters:

Prof. Giorgio Micale

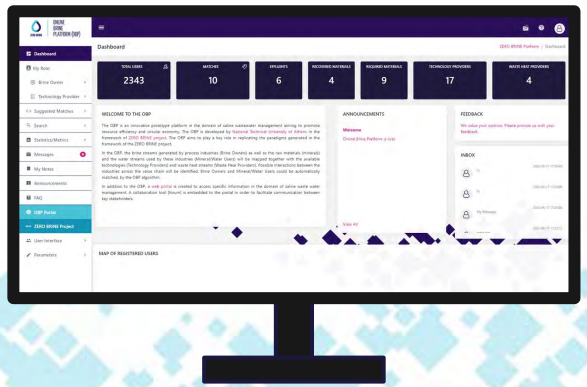
Dr. Serena Randazzo

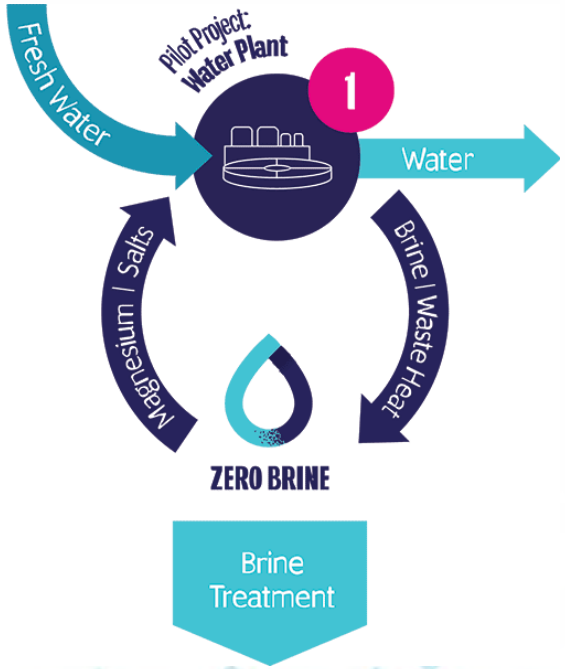
Dr. Fabrizio Vassallo

Ing. Carmelo Morgante

Agenda

- **10:00 – 10:30** - Welcome and introduction to the **ZERO BRINE** project
- **10:30 – 11:00** - The **Netherlands Case Study** (Treament of brines from the water softening industry)
  - Presentation of case study
  - Discussion of results achieved
- **11:00 – 11:15** - Virtual tour of **UNIPA's BEC** (Brine Excellence Centre)
- **11:15 – 12:00** - **Online Brine Platform**
- **12:00 – 12:15** - Wrap-up





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What is BRINE?

Brine is a high-concentration solution of salt (usually sodium chloride) in water

which can be generated in different industries

a few are:

Desalination Industry

Wastewater treatment Industry

Coal Mining Industry

Industrial Wastewater ◆ Resource Recovery ◆ Circular Economy

Can BRINE be harmful?

Brines, when discharged into the environment, can be harmful for the receiving ambient due to:

-Difference in **salinity**, **temperature** and **density**;

-**Chemicals** for the control of **bio-fouling**;

-**Chemicals** for the control of **scaling**;

-**Corrosion**;

-**Cleanings**.

...in the case of desalination

Salinity

In the case of Seawater Reverse Osmosis (SWRO) plants waste brines produced can present a salt concentration in the range **65000-85000 ppm**.

Temperature

The **mixture brine-cooling water** discharged by thermal plants is between **5 to 15 °C warmer** than ambient seawater, whereas the **temperature** of the **RO concentrate is similar to ambient** values.

Density

As a consequence of both the effects (salinity and temperature) three cases are possible:

1. The **wasted brine sinks** in the receiving water body (its **density is higher**)
2. The **brine is as dense as** the receiving body
3. The **brine is lighter** than the receiving water, so **it buoyancies**.

Current brine management methods

Proposed strategies for brine disposal in coastal sites:

- Pre-mixing with seawater (usual for thermal plants);
- Use of a dense jet diffuser.

Proposed strategies for brine disposal in in-land sites:

- deep well injection;
- disposal into surface water bodies;
- irrigation of plants tolerant to high salinities;
- disposal to municipal sewers;
- evaporation ponds (concentration into solid salts).

Brine = New Resource source?

Potential resources to be exploited from brines:

- **Recovery of salts:**

  -for the production of commercial food-grade salt;

  -for the production of commercial industrial salt;

  -for the production of high value compounds (e.g. Magnesium, Lithium and other Trace Elements);

- **Recovery of the energy contained in the brine through:**

  -Osmotic processes (e.g. Pressure Retarded Osmosis);

  -Electrochemical processes (e.g. Reverse Electrodialysis & Capacitive Mixing);

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Mineral Recovery from waste brine = Implementation of Circular Economy

The **circular economy** is a **model of production and consumption**, which involves sharing, leasing, reusing, repairing, refurbishing and recycling existing materials and products as long as possible. In this way, the **life cycle of products is extended.**

Economic ← **Advantages** → **Environmental**

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PROJECT

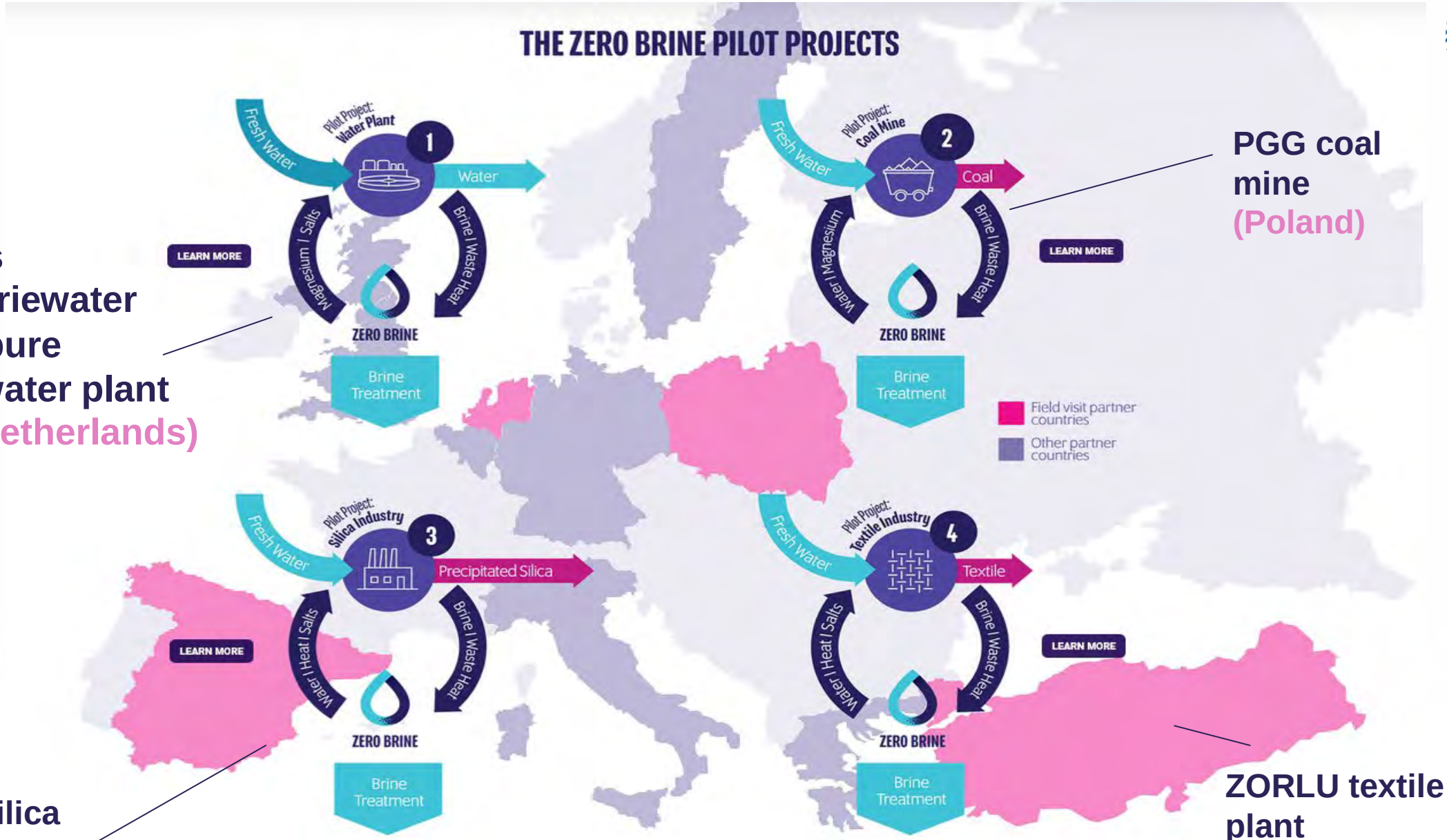
ZERO BRINE is a four-year Innovation Action (IA) financed by the European Commission and coordinated by TU Delft.

It runs under the collaboration of 22 partners from research institutes, SMEs, construction companies and end-users from 10 countries.

AIM:

to prove that **minerals**, such as magnesium, and clean water can be **recovered** from industrial processes for reuse in other industries, thus facilitating the implementation of the **Circular Economy.**

ZERO BRINE



Evides Industriewater Ultra-pure Demiwater plant (The Netherlands)

PGG coal mine (Poland)

IQE silica plant (Spain)

ZORLU textile plant (Turkey)

Presentation of Case study 1

Industry Water (Evides,Netherlands)

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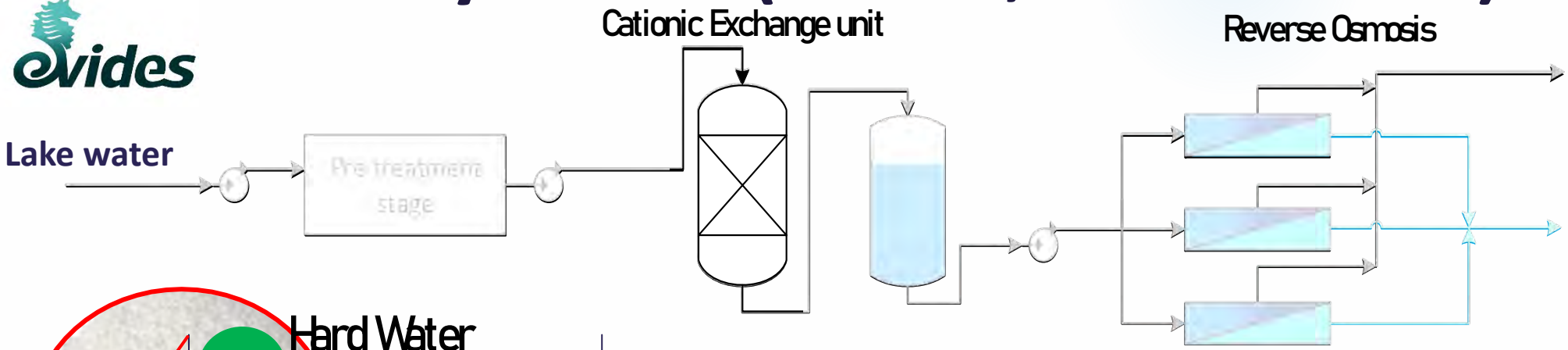
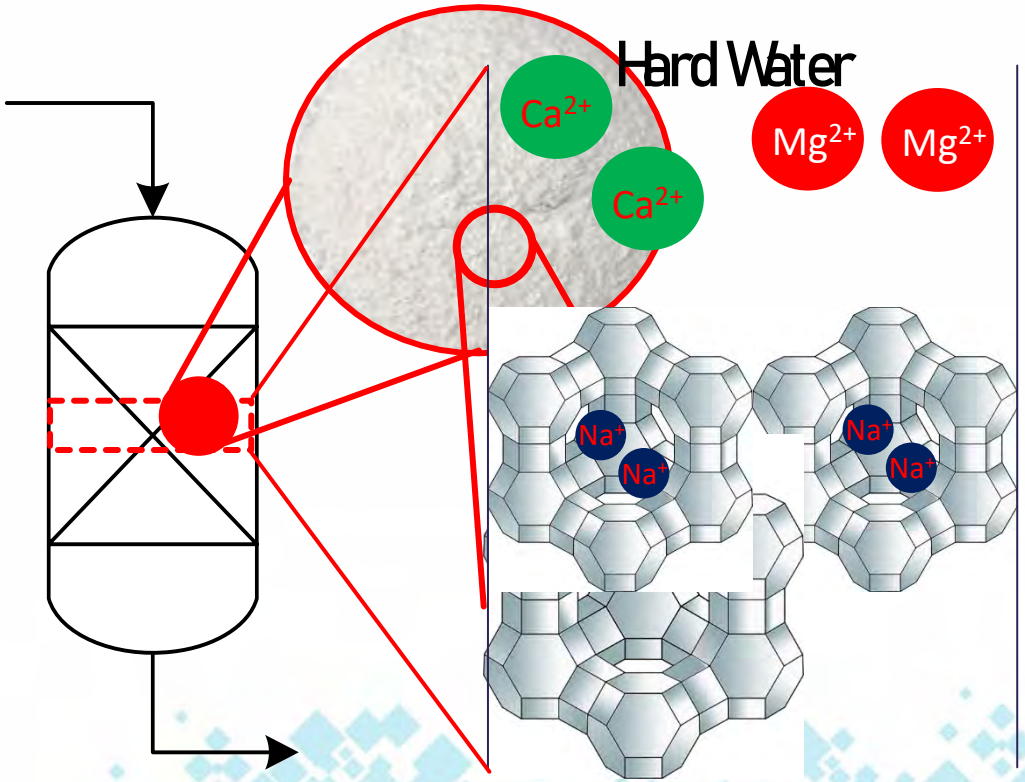
Evides

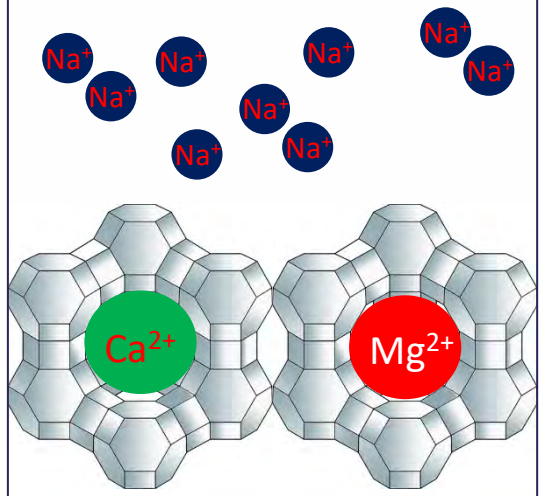




Softened Water

Regeneration Step

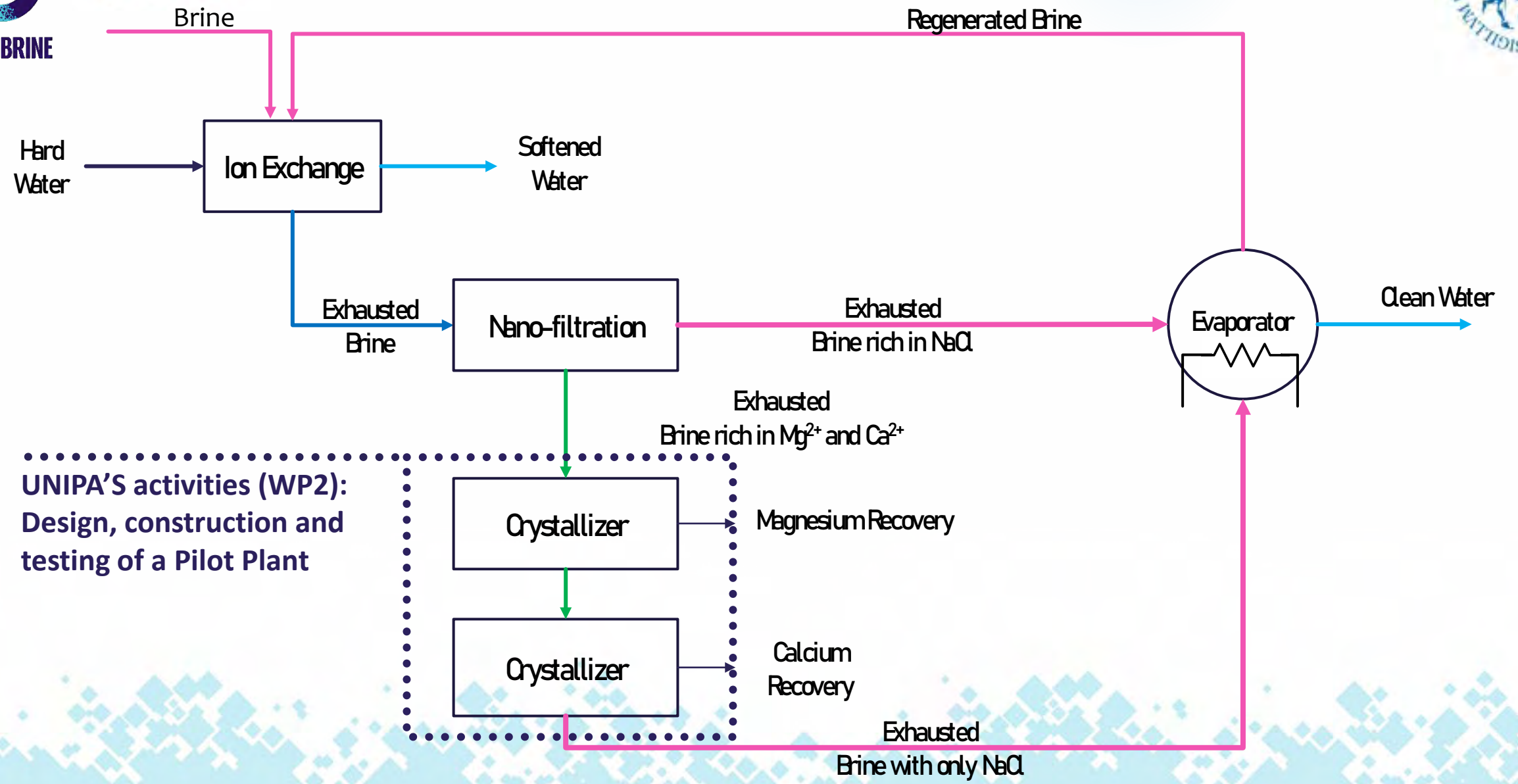
Aqueous solution of high concentration of NaCl (Sodium Chloride)



Exhausted Brine

Industrial Wastewater ◆ Resource Recovery ◆ Circular Economy

Industry Water (Evides,Netherlands)



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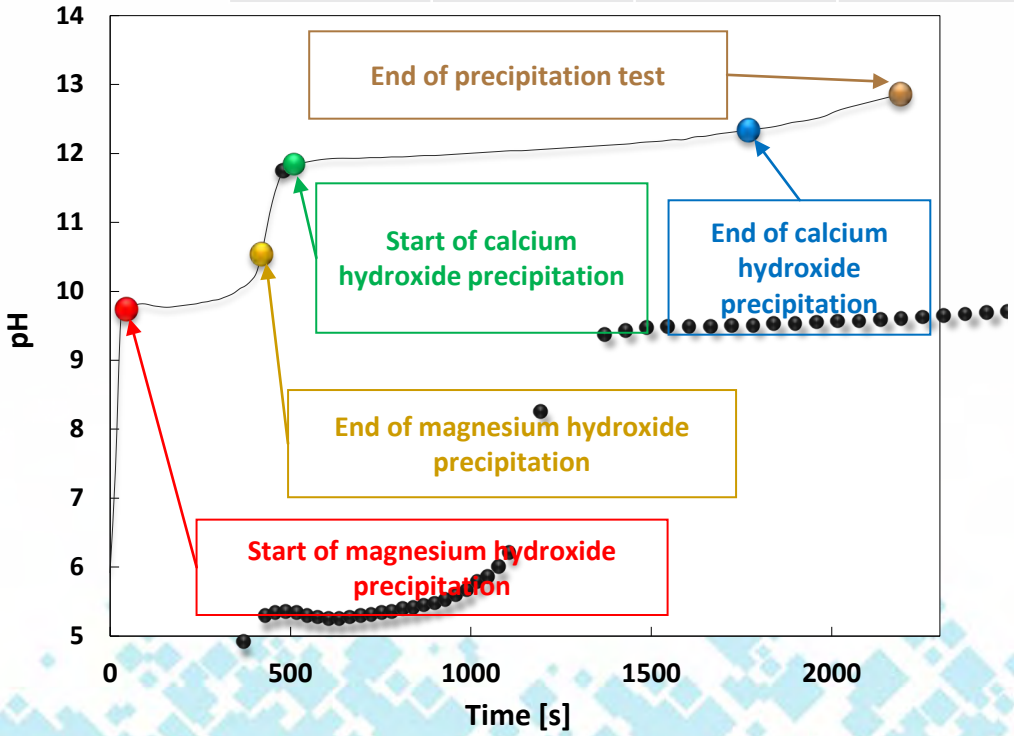
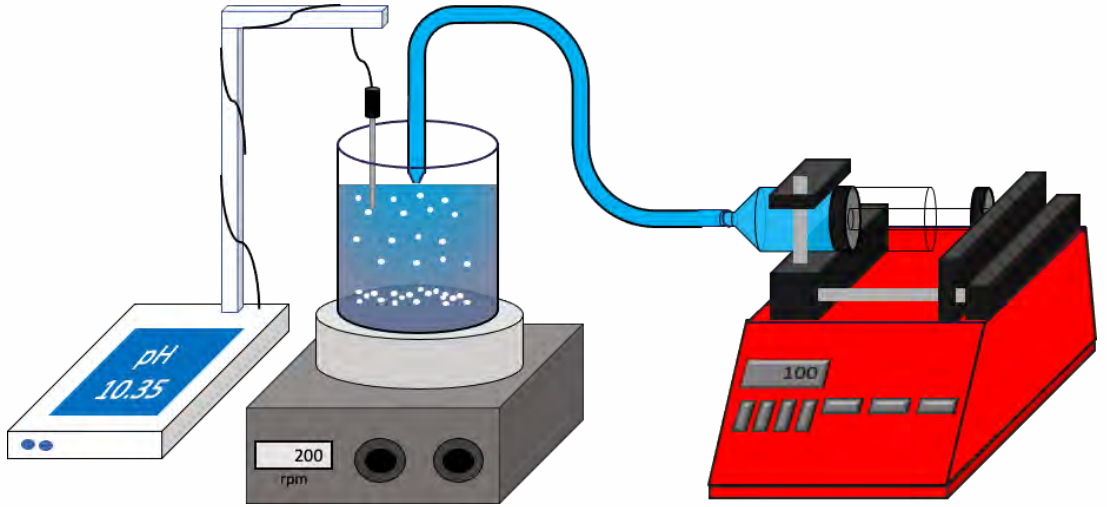
Discussion of results

Pilot Plant

Assessment test for the recovery of Mg and Ca

IEX Spent Brine			NaOH solution	
pH	Mg^{2+} [g/L]	Ca^{2+} [g/L]	Concentration [M]	
			Mg step	Ca step
6	3.08	24.12	1	4





	Ca^{2+} [g/L]	Mg^{2+} [g/L]	pH
1° step (filtrate)	22.53	0.02	10.4
2° step (filtrate)	0.00	0.00	13.00

$Mg(OH)_2$	Purity	>98%
	Precipitation yield	>99%
$Ca(OH)_2$	Purity	>98%
	Precipitation yield	>99%

Commissioning Pilot plant

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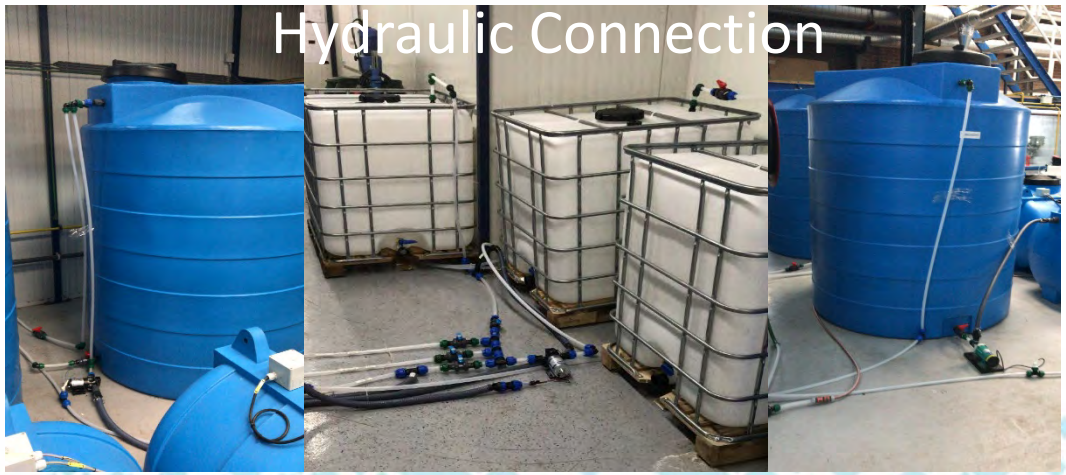
Commissioning MF-PFR


Cloth Installation


Shipment


Hydraulic Connection


Commissioning Drum filter

Industrial Wastewater ◆ Resource Recovery ◆ Circular Economy

- Evides

ffer Tank
vides Site
Brine)

Brine transport to
ZERO BRINE site

Buffer Tank
in ZERO BRINE site
(Brine)

Lenntech

5

7

NaOH

UNIPA –
Crystallizer
Stage 1

8

NaOH

UNIPA –
Crystallizer
Stage 2

9

10

NTUA - Evaporator

Condensate

Clean
Water

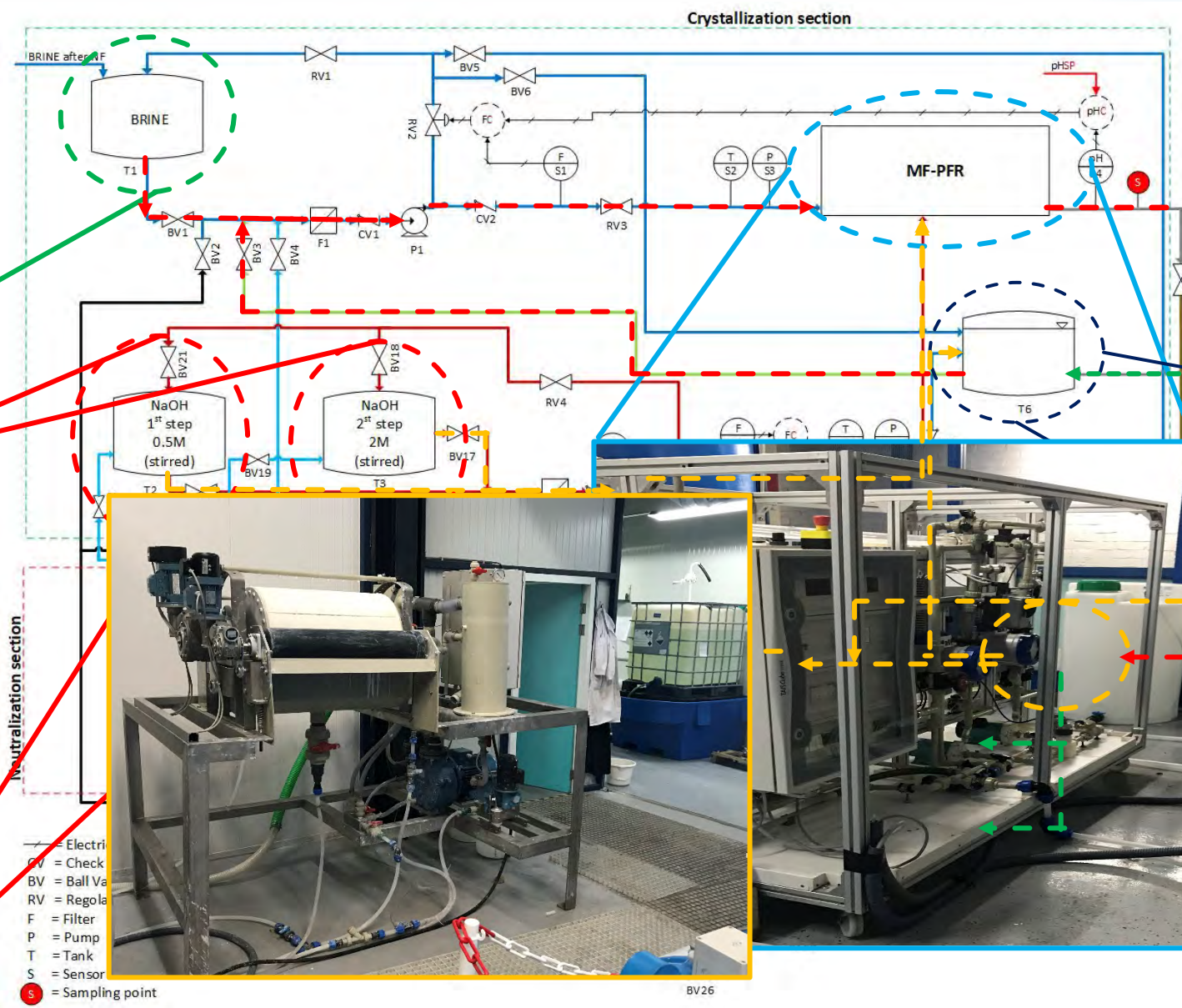
Raw Material

End Product

Process Stream

Buffer Tank

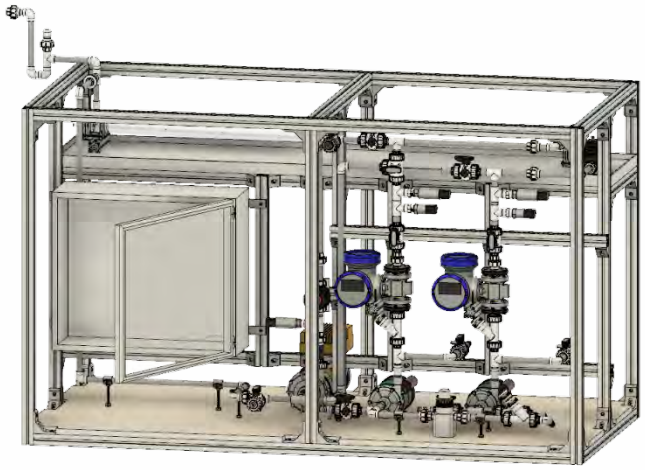
Pilot unit



Industrial Wastewater ◆ Resource Recovery ◆ Circular Economy

Pilot unit

Pilot unit testing in Plant One (The Netherlands)



Possible operative conditions:

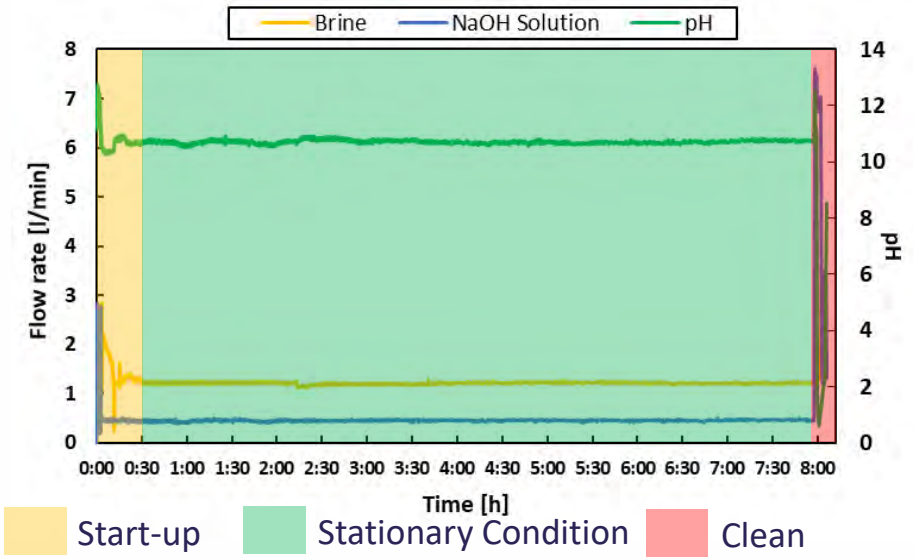
- Flow rate brine range 0.5-5 l/min
- Flow rate Alkaline solution 0.2-2 l/min
- Magnesium concentration 1-3 kg/m^3
- Sodium hydroxide concentration 0.5-2 M

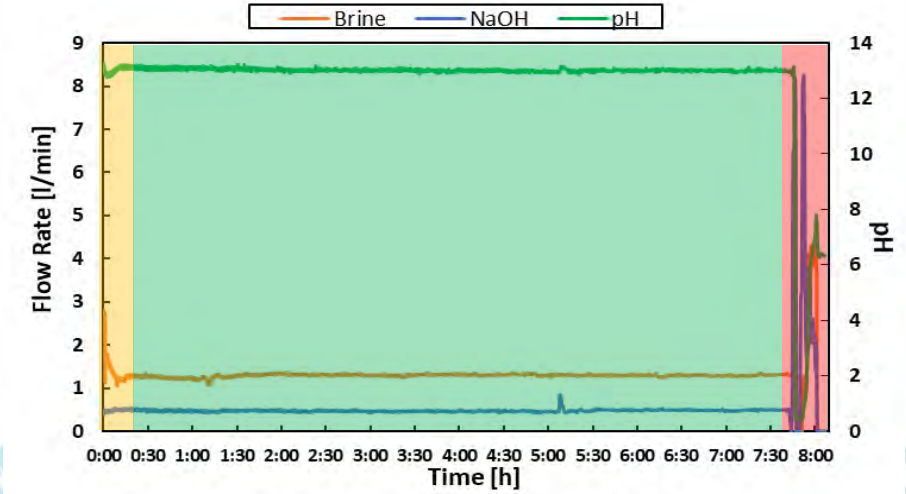
Several long run tests (duration of 8 hours)

Average composition of brine adopted for the precipitation tests									
Brine coming from NF	pH	Conductivity	Concentration of main cations in solution [g/l]				Concentration of main anions in solution [g/l]		
		[mS/cm]	Na^+	K^+	Ca^{2+}	Mg^{2+}	HCO_3^-	Cl^-	SO_4^{2-}
(A)	7.23	62.87	8.80	0.21	10.8	1.34	0.33	30.36	0.11
(B)	7.03	74.24	8.29	0.24	12.6	1.76	0.11	41.21	0.55
(C)	7.00	91.40	11.49	0.24	15.8	2.51	0.14	46.38	0.65

F. Vassallo, D. La Corte, N. Cancilla, A. Tamburini, M. Bevacqua, A. Cipollina, G. Micale, « A pilot-plant for the selective recovery of magnesium and calcium from industrial waste brines», submitted to Desalination

Pilot unit
Pilot unit testing in Plant One (The Netherlands)





First step of precipitation
Magnesium Hydroxide precipitation:

- Flow Rate Brine, 1.22 l/min
- NaOH Solution, 0.4 mol/l
- Flow Rate NaOH Solution, 0.44 l/min
- pH= 10.8

Second step of precipitation
Calcium Hydroxide precipitation:

- Flow Rate Brine, 1.22 l/min
- NaOH Solution, 2 mol/l
- Flow Rate NaOH Solution, 0.48 l/min
- pH= 13.1

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Pilot unit

Pilot unit testing in Plant One (The Netherlands)

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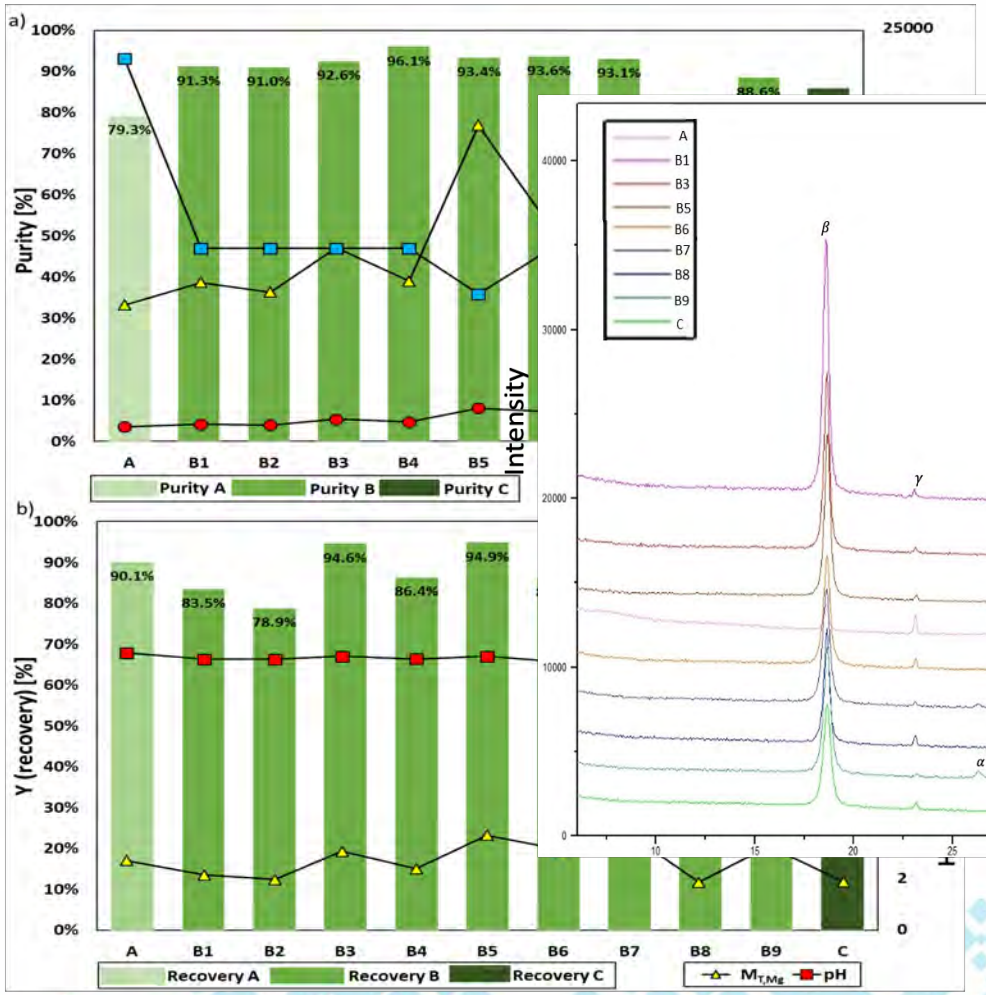
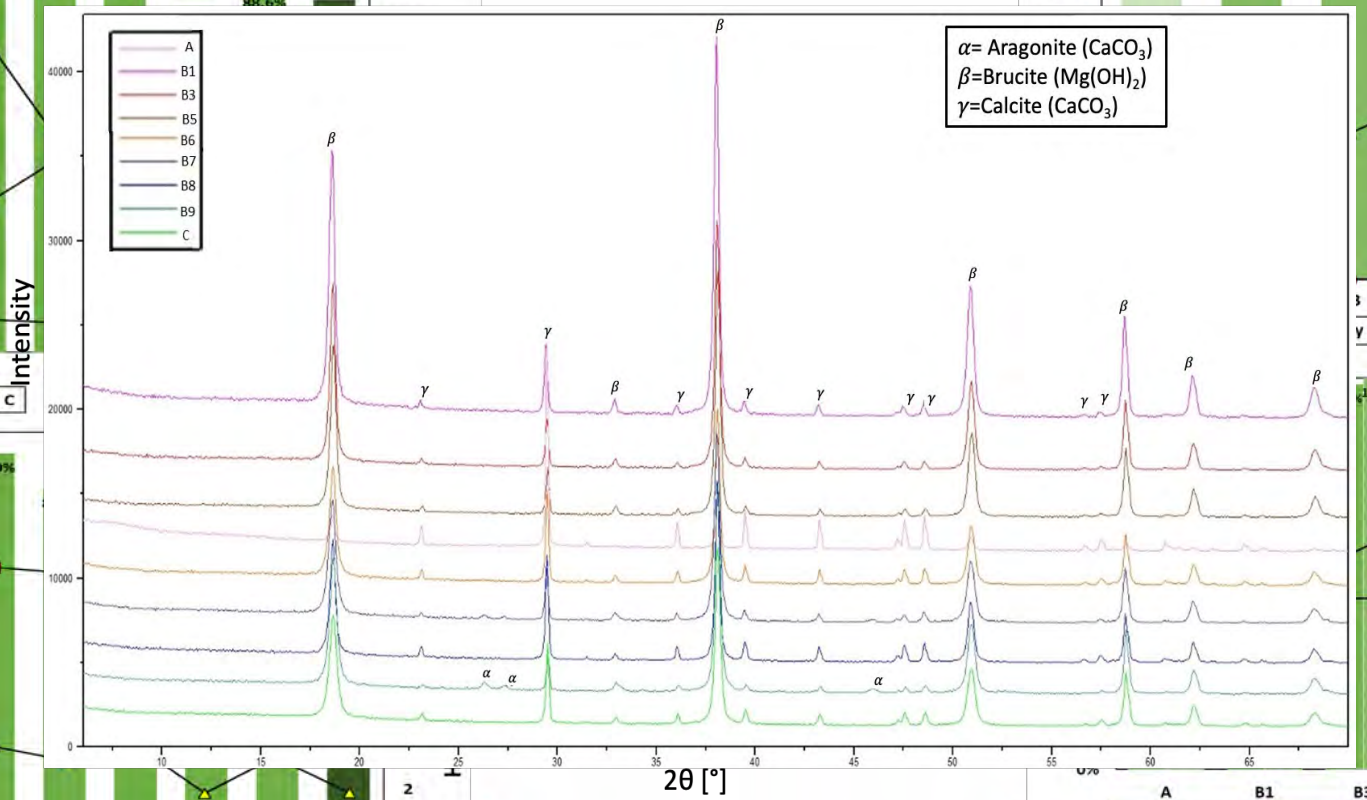
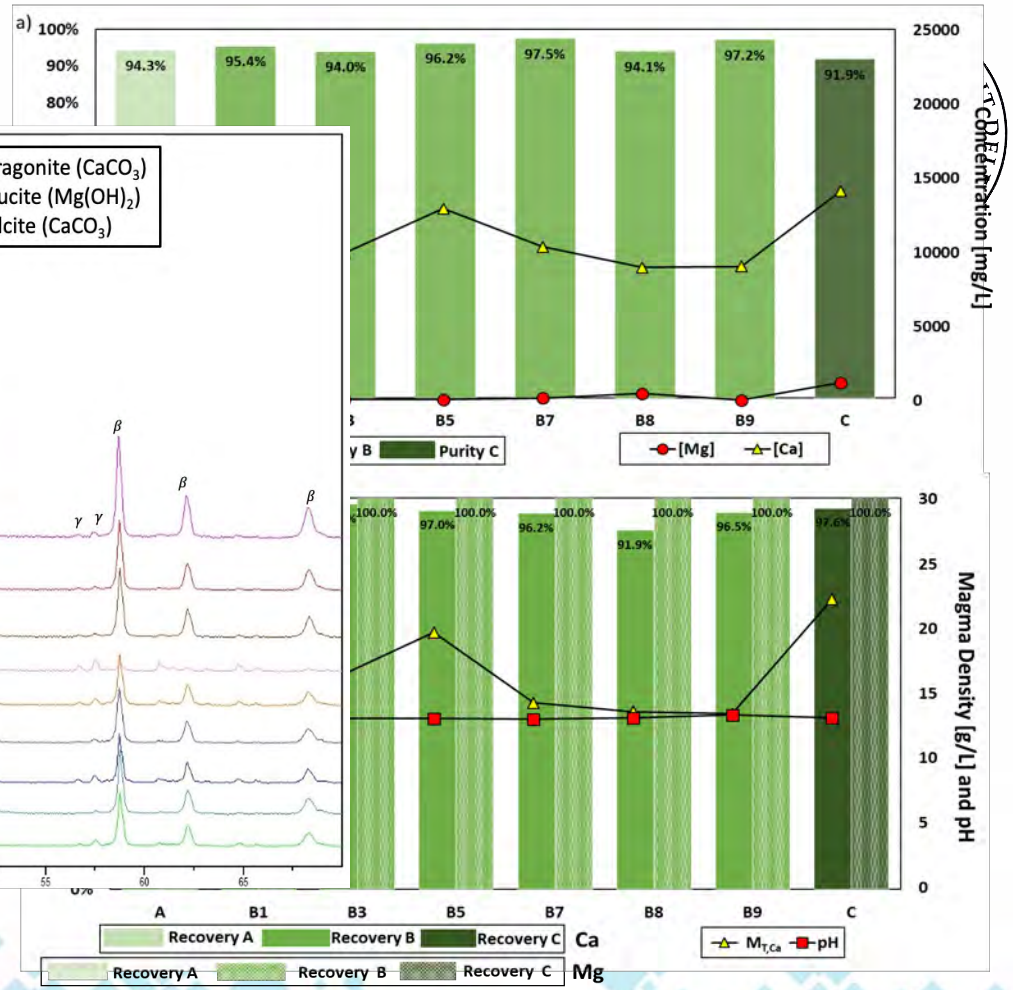
Magnesium precipitation step

Calcium precipitation step







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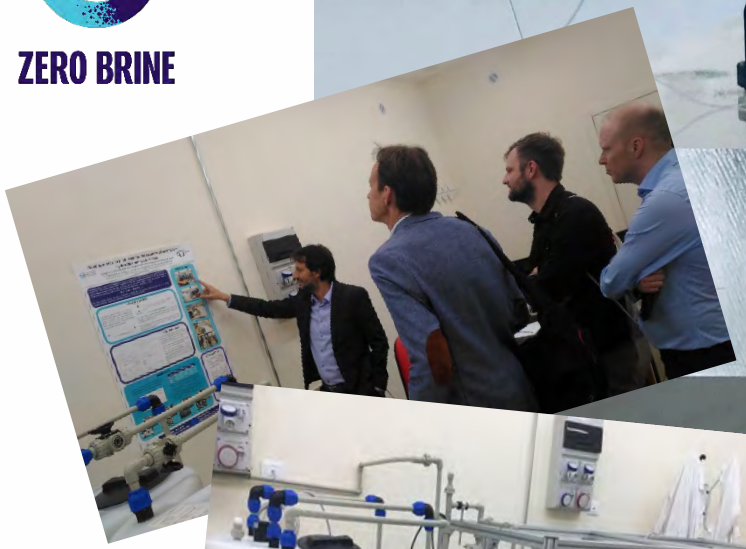
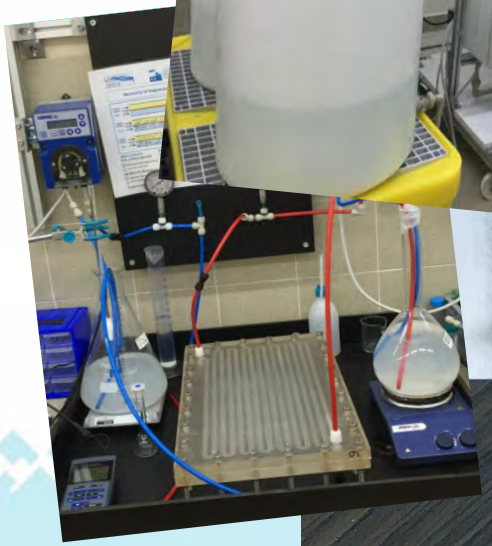
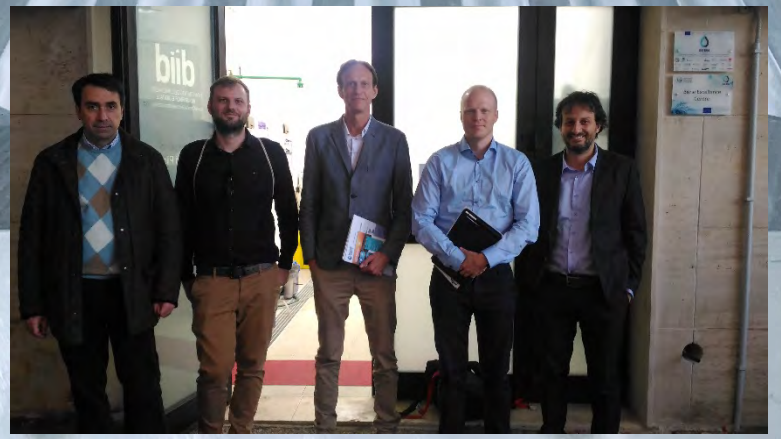
Virtual tour of **UNIPA's BEC**
(Brine Excellence Centre)







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Online Brine Platform Section

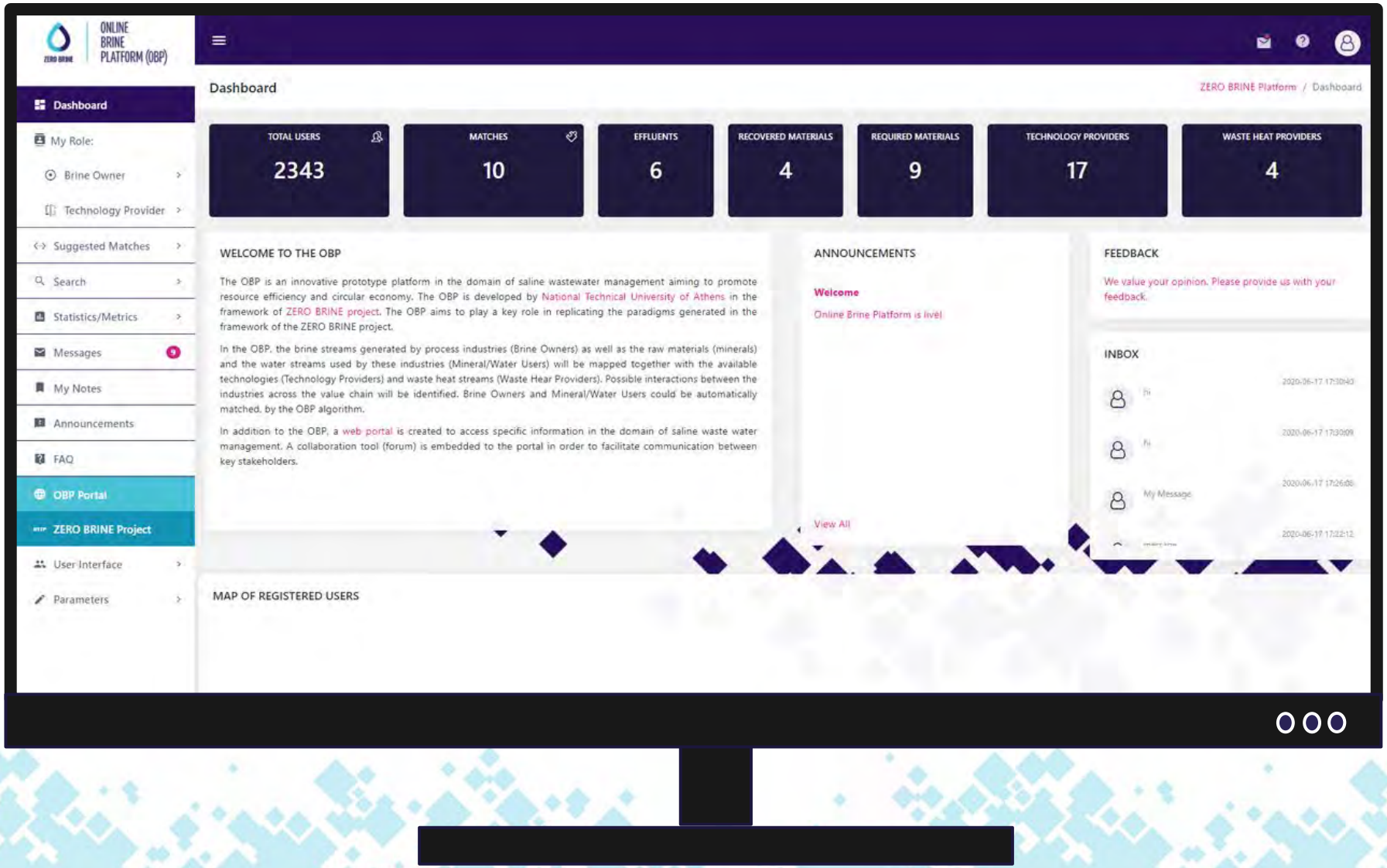
Sharing the platform

- to **promote** or **facilitate** the **renting, swapping, lending, sharing, gifting** or **bartering of the resources**, to connect the (by-) product owners with the individuals or firms → collaboration is formed among them.

Such a sharing platform **allows multiple users to use similar resources** or (by-) products thereby reducing demand

→ Online Brine Platform

Online Brine Platform



Industrial Wastewater ◆ Resource Recovery ◆ Circular Economy

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Learn more about the

University of Palermo

Click here

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Thank you for your attention