ZERO BRINE

D10.4 Report on Field Visits to Pilot Projects

October 2020

Draft

The ZERO BRINE project (www.zerobrine.eu) has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 730390.

Deliverable 10.4	Report of Field Visits to Pilot Projects
Related Work Package	WP10 – Dissemination & Communication
Deliverable lead	Revolve Media
Author(s)	Stuart Reigeluth, REVOLVE Vanessa Vivian Wabitsch, REVOLVE Danielle Kutka, REVOLVE
Contact	vanessa@revolve.media danielle@revolve.media
Reviewer	Roelof Moll, TU Delft
Grant Agreement Number	730390
Funding body	Horizon 2020 Framework Programme
Start date	1.6.2017
Project Duration	48 months
Type of Delivery (R, DEM, DEC, Other)[1]	R = Report
Dissemination Level (PU, CO, CI)[2]	PU = Public
Date Last update	14 October 2020
Approved by	Roelof Moll, TU Delft
Website	www.zerobrine.eu

Revision no.	Date	Description	Author
0.1	29 May 19	M24 draft deliverable submitted	REVOLVE
0.2	15 Nov. 19	M30 update to working draft	REVOLVE
0.3	15 May 20	M36 update to working draft	REVOLVE
0.4	7 Oct 20	Revised upon external review comments (M41)	REVOLVE
0.5	14 Oct 20	Update links	REVOLVE

The ZERO BRINE project has received funding from the European Commission under the Horizon 2020 programme, Grant Agreement no. 730390. The opinions expressed in this document reflect only the author's view and do not reflect the European Commission's opinions. The European Commission is not responsible for any use that may be made of the information it contains.

[1] **R**=Document, report; **DEM**=Demonstrator, pilot, prototype; **DEC**=website, patent fillings, videos, etc.; **OTHER**=other

[2] **PU**=Public, **CO**=Confidential, only for members of the consortium (including the Commission Services), **CI**=Classified

Executive Summary

As a subtask to capacity building (Task 10.6), field visits to the ZERO BRINE pilots are an essential part of the communication strategy to further disseminate and exploit the ZERO BRINE circular economy solutions for industrial wastewater to key stakeholders. The visits are an opportunity for knowledge sharing of the ZERO BRINE technologies and the resource potential and circular business opportunities of brine-intensive industries to industry and end-users. The site visits are also a great opportunity to invite policy-makers to learn about these solutions and identify the policy gaps and key recommendations that will be specified in the policy briefs, helping advance circular solutions in the field of industrial wastewater. The field visits also build connections with media to foster wider interest in the project and disseminate its aims and results. As a key pillar of capacity building, the field visits raise the overall awareness of the pilot's objectives, contributions to the circular economy, and form interactive, educational activities that support the development of knowledge and skills-sharing in the circular economy.

In concurrence with the field visits, factsheets are developed to provide an in-depth overview of the respective pilots' aims, technologies employed, and resources recovered and are a core feature of the ZERO BRINE media kits.

This deliverable was submitted in M24 as a draft; due to the coordination of the field visits depending on the operations of the respective pilots, it was decided with the Project Officer and Executive Project Coordinator to update the draft deliverable in six-month increments (M30, M36 and M42) with a final deliverable due by M48.

Contents

1. Overview of Field Visits

The field visits target academic, corporate, and public partners and press. In order to optimise stakeholder engagement and attendance to the ZERO BRINE pilot site visits, organisation of these visits are strategically coordinated with other key stakeholder events when possible.

To attract the interest of specialised press in the fields of water, water reuse, circular economy, technology and innovation and industrial processing, and to encourage the effective dissemination and exploitation of ZERO BRINE, REVOLVE has partnered with key print and digital media outlets. Through media partnerships, quality content is curated and interest in project news is secured, increasing the dissemination potential so that audiences follow ZERO BRINE's progress throughout the project's duration and increase the exploitation of the technology and results. For this reason, press relations are a key component of the ZERO BRINE communication strategy throughout the project.

The timeline of the ZERO BRINE field visits is dependent on the successful operations of the pilots. The timeline for the field visits is:

Field Visit NL –Demineralised Water Plant pilot at Plant One in Botlek area, Rotterdam Port (Site 1)
23 May 2019
14:00-16:00 - EVIDES site press excursion
16:00-18:00 - Plant One test facility - EU Salt excursion + press

Field Visit PL – Coal mine water pilot at Bolesław Śmiały coal mine, Łaziska Górne
8 October 2019
9:30 – 12:00 Visit coal mine + tour of pilot
12:15 - Visit to Silesian University Technology (SUT) presentations
15:00 - Brine Excellence Center (BEC) visit at SUT

Field Visit ES-IQE Chemical site
Due to confidentiality and safety concerns, a public site visit was replaced with an internal visit for a small group of consortium partners.

Field Visit TR: ZORLU Textile site
14-16 October 2020 (M43-46)
The possibility for a digital field visit will be discussed with partners as an alternative to a physical trip, due to COVID-19.

In parallel with the field visits, ZERO BRINE is developing 4 media kits per pilot including factsheets, infographics, interviews, photos and videos for each demonstration site.

a. Demineralised Water Plant Pilot (NL)

Based in the Botlek industrial area of Rotterdam port, the EVIDES Demineralised Water Plant (DWP) is a central facility that supplies water to 25 companies for use in industrial processing. Due to increasing quality standards, reliability expectations, and to deal with the increasing salinity of the feed water, sourced from the Brielse Meer, the pilot will use waste heat from nearby factories to eliminate brine effluent while recovering high purity calcium, magnesium, NaCl solution and sulphate salts. For practical concerns, an amendment (M36) has transferred the operational management of the pilot to TU Delft due to the pilot's operations on the premises of Plant One testing facility.

i. Visit Overview

The chloralkali sector has a high potential for the application of circular economy solutions for the recovery of salts from brine. To promote this potential and target key industry stakeholders in the salt industry, a broader collaboration was established in the context of the EU Salt Annual Meeting and General Assembly, organised by the European Salt Producers' Association (22-24 May 2019) in Rotterdam. On 23 May, the conference programme 'Circularity with a pinch of salt' included a session on material reutilisation where ZERO BRINE's Innovation Manager, Dimitris Xevgenos, presented the project and the application of circular economy approach to the chloralkali sector. To offer an example of circular processes in industrial applications, the presentation highlighted the pilot installation at the Evides Demineralised Water Plant (DWP) in Rotterdam, which provided the context for the site visit for EU Salt participants (salt and industry experts) in the afternoon that same day.

In addition to the EU salt participants, specialised press were invited to join the ZERO BRINE pilot, located at Plant One Rotterdam, a sustainable tech and innovation test facility.

Lenntech representative, supplier of the nanofiltration unit, explains the initial trial runs.

As the Plant One test facility is located a few hundred meters away from the Evides Demineralised Water Plant's operational facility, the visit included a stop at the Evides DWP to learn about the current technology and to contextualise the pilot plant at Plant One. At Evides, attendees were welcomed by Jan Willem Mulder, Manager Process and Technology at Evides Industriewater. The visit included an overview of the industrial activities of the surrounding industrial cluster and an explanation of the current technology. Participants were then guided to see the technology and learn about the current purification process and to ask questions. Other representatives from TU Delft were also present to answer questions and supplement the presentation by Evides.

EU Salt participants joined the press group at the pilot demonstration at Plant One, where all field visit participants were welcomed with an introduction by Roelof Moll and a representative from one of the technology partners, Lenntech. After viewing the pilot installation, participants were welcomed to a large conference room where short presentations on ZERO BRINE and the work being done at the pilot sites were presented by Dimitris Xevgenos (SEALEAU) and work package 2 (Sites 1 and II) Lead, Henri Spanjers (TU Delft), and Executive Project Coordinator Roelof Moll (TU Delft).

Following the presentations, questions were fielded from participants by project partners. These questions focused on the problems of releasing brine effluents into the Port, the energy use for the pilots in the context of the Life Cycle Analysis, and the value of the sources being recovered from the brine and what possibilities there are for their market use.

Coordination of the site visit was conducted by TU Delft and REVOLVE.

ii. Outreach and Results

A total of 45 participants took part in the field visit to the Plant One test facility, the majority of participants comprising salt and industry experts.

The Demineralised Water Plant pilot factsheet was developed in M24 by REVOLVE with the guidance of TU Delft and Evides, to disseminate to the attendees (see Annex). This factsheet is included in the online media kit, and was promoted in the press release on the pilot and visit. This factsheet will be updated by M43 pending the analysis of project results and will also be aligned with a press release on the final results.

As the pilot demonstration was still awaiting a final component from one of the technology partners during the site visit, no professional video work was conducted. Professional video footage of the pilot was taken during M33 resulting from ZERO BRINE's Site I nomination for the Industrielinqs Water Innovator of the Year 2020. The b-roll footage includes the Site I operations and explanation of the technology by Henri Spanjers, Lead of TU Delft Industry Water group and WP2. The video material will be processed into the technology video when final results are ready (M43).

During the visit, REVOLVE took photos, short video clips, and promoted the activities on social media, tagging the relevant media and attending partner companies. The top tweet during the visit made a total of >1700 impressions and had 34 engagements.

The top tweet from ZERO BRINE during the site visit.

The photos were integrated into the online media kit and in the ZERO BRINE photo galleries on the project website.

The attending media included technology and water-focused, Dutch-speaking print and digital media (De Ingenieur / WaterForum), digital, European water outlets (Water News Europe), and international, water-focused print and digital media (Global Water Intelligence / World Water).

The breakdown of the audience and subscribers of the attending media:

- De Ingenieur
    - >4,770 Twitter followers
    - Online: 56,000 monthly users
    - Print/Digital Subscribers: 22,000
    - Online Newsletter: 25,000
    - Audience: Educated following, interested in engineering
- WaterForum
    - >4,020 Twitter followers
    - Online: 12,000 monthly users
    - Online Newsletter: 9,000
    - Audience: Drinking, wastewater management, knowledge centers, universities, national/local governments, industrial/sewage treatment, water tech/engineering companies.
- Water News Europe
    - >1,200 Twitter followers
    - Online: 1,500 monthly users
    - Online Newsletter: >300
    - Audience: Water professionals, policy makers and water companies

- Global Water Intelligence
    - >15,200 Twitter followers
    - Online: 187,000 annual users in over 200 countries, 938,000 page views/year
    - Publication: Over 10,000 subscribers
    - Audience: EPC contractors, utilities, equipment/tech suppliers, engineers, and researchers

- World Water (Water Environment Federation)
    - >27,600 Twitter followers (WEF)
    - Online: 13,000 users/month, 116,000 page views/month (WEF)
    - Print Publication: 4,967 subscribers
    - Digital Publication: 21,649 subscribers
    - Audience: Engineers, government/municipal offices, consultants, contractors, planners, executives in water industry

As follow-up to the site visit, a dedicated press release was sent to all stakeholder segments in the ZERO BRINE mailing lists with a link to the online media kit. Overall, the Dutch demi water pilot was featured in 14 press articles from a variety of international and national presses and in four languages: French, Dutch, Korean, and English. Below is a comprehensive list of the various articles produced and their outreach, provided by Meltwater analytics:

Bouw proefinstallatie ZERO BRINE-project start in januari in Plant One, 27 Sep 2018, WaterForum; Reach: >1,085

Unieke kringloop in de Rotterdamse haven, 11 Jan 2019, Rijksdienst voor Ondernemend Nederland; Reach: >245,000

Industriële kringloop in de Rotterdamse haven, 14 Jan 2019, Engineers Online; Reach >17,800

Demin Water Pilot Advances Industrial Circularity & Critical Raw Material Recovery, 23 May 2019, Water Online; Reach: >77,400

ZERO BRINE – From industrial saline waste water to clean water and minerals, 24 May 2019, Holland Circular Hotspot; Reach >439

Zero Brine: Kick-off innovative brine treatment in Port of Rotterdam, 30 May 2019, Water News Europe; Reach: >2,225 (webpage analytics)

Evides demonstrates circular economy, 18 June 2019, Filtration+Separation; Reach: >6,330

[네덜란드] Evides, 산업폐수 정화로 순환경제 실현, 20 June 2019, Korean Water Journal; Reach: >4,250

Kickstarting industrial circularity in the Port of Rotterdam, 19 Nov 2019, PR Pro; Reach: >1,022

Kickstarting Industrial Circularity In The Port Of Rotterdam, 19 Nov 2019, Water Online; Reach: >54,800

NIEUWE INDUSTRIËLE WATERZUIVERING IN BOTLEKGEBIED, 19 Nov 2019, De Ingenieur; Reach: 49,400

Waste brine aids circular economy, 20 Nov 2019, Filtration+Separation; Reach: >4,035

Zero Brine launches first pilot in Rotterdam, 5 Dec 2019, Filtration+Separation; Reach: >7,370

Kickstart circularité industrielle dans le port de Rotterdam, 7 Dec 2019, BTP News; Reach: >3,580

Based on the Meltwater data, above press articles is estimated to have reached 474,736 people.

b. Coal Mine Pilot (PL)

The pilot at Bolesław Śmiały Coal Mine in Łaziska Górne, Poland, demonstrates that coal mine water, considered a waste by the current mining industry, can be the source of valuable raw materials, such as concentrated brine, magnesium hydroxide, and high-quality RO permeate while halving the energy consumption compared to the current treatment method. Currently, coal mining largely contributes to the nearly 400 million tonnes of salt discharged into Polands' freshwater rivers, causing significant environmental strains and estimated to cause industry, agriculture, and water losses of up to $250 million per year. The pilot at the PGG Bolesław Śmiały Coal Mine can treat up 400 L/hr of wastewater with 82.8% salt recovery as well as calcium and magnesium rich retentate that allows for the recovery of magnesium hydroxide.

i. Visit Overview

On 8 October, participants from industry and media were welcomed to the Bolesław Śmiały Coal Mine by the general director of PGG – the owner and operator of the mine. Attendees were offered bottled drinking water recovered from mining wastewater produced from of the current technology's on-site desalination plant. Additional context was provided on the history of the mine and its activities as one of the oldest and deepest mines in Poland. A description of the pilot and its significance for the industry was given by Professor Marian Turek and Dr. Krzysztof Mitko of the Silesian University of Technology (SUT).

To disseminate the ZERO BRINE project and details on the local pilot to industry and experts within the field of circular economy, the field visit was organised a day before the International Brokerage Event Horizon 2020 for Circular Economy and Transforming Industry, which took place on 9 October in Warsaw, which was attended by REVOLVE.

Panoramic view of Bolesław Śmiały.

Due to the size of the pilot demonstration, participants were split into two groups. Both groups had the opportunity to tour the mine's grounds and see a panoramic view of the operations, the town of Łaziska Górne and nearby power plant, as well as visit the ZERO BRINE pilot installation for an explanation of the processes and technologies from the researchers from SUT.

Researcher and participants during pilot visit.

Following the coal mine pilot visit, a short trip to the Silesian University of Technology allowed for presentations to further contextualize the impact of the ZERO BRINE technologies. Presentations were given from Grzegorz Gzyl from the Central Mining Institute on the impact of water discharges on surface water in the Upper Silesian Coal Basin, as well as an overview of ZERO BRINE by the project's Executive Coordinator Roelof Moll, the problems of brine and the ZERO BRINE solutions by Marian Turek, and the Technological innovation of ZERO BRINE by Luuk Rietveld, ZERO BRINE's Scientific Coordinator. The series of presentations were followed by a question and answer session addressing questions such as the likely impact of the evaluation of the Water Framework Directive on putting pressure on the coal mining industry to address its brine discharge.

ii. Outreach and Results

Around 40 participants joined the full-day field excursion including industry experts from The Central Mining Institute (GIG), The Institute of Mining Technology (KOMAG), and SUEZ.

The Coal Mine Pilot factsheet (developed in M28) was given to participants in English and Polish on the key aims of the pilot, its context and business opportunities (see Annex). This factsheet is also included in the online media kit. The pilot will be operational until M35; after the data is analysed, the factsheet will be updated with the final results by M43. In M29 photos were also added to the media kit in the lead-up for the press release and a promotional Twitter video was also released showing highlights of the visit.

Footage from the pilot visit and additional interviews were held with consortium partners and industry experts for use in the technology videos and additional communication outputs.

During the visit, photos, short video clips, were taken and activities were communicated on social media to the ZERO BRINE followers, tagging the relevant media and attending partner companies. The top media tweet on the visit made a total of >3300 impressions and had 19 engagements.

The top media tweet from ZERO BRINE on the site visit.

The attending media included technology and water-focused, Dutch-speaking print and digital media De Ingenieur, European water outlet Water News Europe, and Reuters Television Poland, and Turkish press Daily Sabah.

Below is an overview of the attending media, the articles published as a follow-up to the field visit, and where possible, information on the subscribers/sectors for a clearer indication on the readership:

- REUTERS
    - Poland In article 'Coal mine treats its wastewater protecting environment' reached 34.1k people (Meltwater)
    - TVN24 article 'Coal mine in Poland desalinates wastewater to protect environment' reached 9.13 M people (Meltwater)

- De Ingenieur
    - Article 'Proef in Polen met zuiveren zout mijnwater' reached 49.4k people (Meltwater)
    - >4,770 Twitter followers
    - Online: 56,000 monthly users
    - Print/Digital Subscribers: 22,000
    - Online Newsletter: 25,000
    - Audience: Educated following, interested in engineering

- Water News Europe
    - Article 'Poland: Pilot recovers salt and clean water from coal mine wastewater' reached 3.1k people (online)
    - >1,200 Twitter followers
    - Online: 1,500 monthly users
    - Online Newsletter: >300
    - Audience: Water professionals, policy makers and water companies

- Daily Sabah
    - Print circulation: 7,000 subscribers
    - Article 'Circular economy: A path to eco-friendly business' reached 1.05 million people (Meltwater)

As follow-up to the site visit, a dedicated press release was sent to all stakeholder segments in the ZERO BRINE mailing lists with a link to the online media kit. Overall, the Polish coal mine pilot was featured in 16 press articles from a variety of international and national presses and in five languages: French, Polish, Spanish, Dutch, and English. Below is a comprehensive list of the various articles produced and their outreach, provided by Meltwater analytics:

Przemysł cyrkularny w praktyce? Zgłoszenia na wyjazd studyjny do kopalni węgla Bolesław Śmiały, 26 Sep 2019, Teraz Srodowisko; Reach: >46,200

Coal mine in Poland desalinates wastewater to protect environment, 9 Oct 2019, TVN24; Reach: >9.13M

La nouvelle exploitation minière.. Une mine de charbon polonaise récupère des ressources précieuses à partir d'eaux usées, 11 Oct 2019, BTP News: Reach: >3,580

The new mining - Polish coal mine recovers valuable resources from wastewater, 11 Oct 2019, Smart Water Magazine; Reach: >6,240

Coal mine treats its wastewater protecting environment, 11 Oct 2019, PolandIn; Reach: >34,100

Polish coal mine recovers valuable resources from wastewater, 15 Oct 2019, FutureENVIRO; Reach: >164

Una mina de carbón polaca recupera valiosos recursos de las aguas residuales, 15 Oct 2019, FutureENVIRO; Reach: >744

Prezes PGG w Komisji Europejskiej: łańcuchy wartości spółek górniczych potrzebują ochrony, 21 Oct 2019, SLASKIBIZNES; Reach: >51,000

On coal and water in Poland, 22 Oct 2019, REVOLVE; Reach: >563

Polish Coal Mine Recovers Valuable Resources from Wastewater, 28 Oct 2019, Water Active; Reach: >489

Poland: Pilot recovers salt and clean water from coal mine wastewater, 29 Oct 2019, Water News Europe; Reach: >3,605 (webpage analytics)

Kombinacja kilku technik zapewni wydajny odzysk surowców z Solanki, 6 Nov 2019 Teraz Srodowisko; Reach: >28,000

Proef in Polen met zuiveren zout mijnwater, 11 Nov 2019, De Ingenieur; Reach: >49,400

PGG zamierza przestać zrzucać solankę do rzek. Obiecujący pilotaż w kopalni Bolesław Śmiały, 14 Nov 2019, SLASKIBIZNES; Reach: >42,200

Circular economy: A path to eco-friendly business, 19 Nov 2019, Daily Sabah; Reach: >1.05M

Circular economy: A path to eco-friendly business, 19 Nov 2019, World News Monitor; Reach: >35,400

Based on the Meltwater data, the total outreach of the press articles is estimated to have reached 1,256,905 people.

c. Silica Plant (ES)

The pilot plant at IQE in Zaragoza, Spain, in operation until M39, aims to demonstrate the technical and economic feasibility of implementing a circular economy scheme in the silica industry to recover water, sodium sulphate, waste heat, acids and alkalis. Nanofiltration and crystallisation and electrodialysis with bipolar membranes (EDBP) were evaluated, yielding 75% water recovery suitable for on-site reuse. Using regenerated membranes allows higher water recovery and reduces energy compared to commercial RO membranes. A preliminary cost analysis shows the technology is economically feasible and implementable at industrial scale. Final technical and economic viability will be determined after results from the crystallisation stage, with final analysis of results expected by M43.

i. Overview

Due to confidentiality reasons, a public field visit was not permitted to the site. In lieu of a full coordinated visit, REVOLVE will work in close collaboration with IQE and Eurecat to develop a

technology video that offers an equal experience of learning and engagement, supplemented with a further opportunity for engagement with industry and media stakeholders. One such possibility could include an interactive Q&A session following the official publishing of the press release in tandem with the technology video, to be launched between M44-45 following the results in M43.

To share insights into the operation of the ZERO BRINE technology within the silica factory, a factsheet was developed in M35. An interview with an expert from Eurecat on the silica site will be developed by M43 following the results of the analysis. Furthermore, IQE provided video material for the development of a video, which will also be produced by M45.

Photos of the pilot are available on the project website (here).

An Outreach and Results section will be added to this deliverable by M48 with final impact figures concerning the interactive Q&A session, video and press release.

d. Textile Factory (TR)

The pilot by TUBITAK at the ZORLU textile factory in Lüleburgaz – Kırklareli, Turkey focuses on the development of the innovative brine treatment system for textile industry to recover concentrated salt solution for using in textile dyeing process baths. Alternatively, salt recovery for other sectors i.e. leather salting process is also considered throughout the study. The expected results from textile industry brine recovery system was pre-assessed to be 50 kt/year reduction water consumption due to achievement of additional water reuse, recovery of 400 tons of NaCl/year for production processes, reduction of 200 t/year CO_2 emissions also due to NaCl recovery and attainment of waste heat recovery from the enterprise.

i. Overview

The field visit was tentatively scheduled for M41; however, due to travel restriction in light of COVID-19, a delay to the field visit activities will be foreseen to discuss with partners the best means to do so – possibly through a digital visit. The final decision of this will be planned by M46, in case there is an opportunity for an in-person field visit next Spring. The overview of activities will be included in the M48 update to the deliverable.

The factsheet on the Turkish pilot was developed in M40. An interview will be conducted with TUBITAK on the pilot by M46 and for integration in the pilot video, which will either be scheduled in tandem with an in-person field visit, or part of the work carried out to prepare for a digital visit.

Photos of the pilot are available on the project website (here).

The Outreach and Results of the field visit activities will also be included in the M48 update.

CONCLUSIONS

To be added in M48 report.

REFERENCES

NA

ANNEX

a. MEDIA KITS

i. **Demineralised Water Plant Factsheet (NL)**

ii. **Coal Mine Pilot Factsheet (PL)**

iii. **Silica Factory Pilot Factsheet (ES)**

iv. **Textile Factory Pilot Factsheet (TR)**

ZERO BRINE

ZERO BRINE PILOT DEMONSTRATION

DEMINERALIZED WATER PLANT (DWP) OF EVIDES IN BOTLEK, ROTTERDAM, THE NETHERLANDS

Context

ZERO BRINE advances circular economy business model solutions to reduce industrial saline wastewater streams by recovering and reusing the minerals and water from the brine. Demineralized water is an essential commodity in the Botlek area, the industrial district of the port of Rotterdam, because it is required for many production processes. Reverse osmosis (RO) has become one of the main processes for producing demineralized water, but reverse osmosis alone is not enough to produce water of the required purity from the available water (fresh surface water), and several pre- and post-treatment processes are used. At the Evides DWP, one of the largest demineralized water production facilities in Europe, wastewater is treated by reverse osmosis combined with ion-exchange softening, among other technologies (see Graph 1).

Objective

At the Demi Water Plant (DWP) of Evides in the Botlek industrial area, ZERO BRINE demonstrates the circular economy approach to treat industrial wastewater through redesigning the current brine treatment process from linear to a circular model recovering all the resources (see graph 1). A large-scale demonstration plant is tested at PlantOne, a test facility focused on sustainable technology and innovation in the Energy Port and Petrochemical cluster of Rotterdam Port, by using the waste heat from one of the factories in the port. The objective is to recover Ca- and Mg-salts as well as demineralized water from the discharges of the water-softening unit. The quality of the recovered products will be aimed to meet local market specifications.

Technology

The demonstration plant comprises two sites combining residual heat and wastewater streams with the aim to eliminate brine effluent (zero brine discharge). At Evides (Site 1) the aim is to treat the regeneration solution of the ion exchange (IEX) unit (spent regenerant) and to recover valuable minerals and salts as well as water from this flow. This is done by nanofiltration, crystallization and evaporation of IEX (see Graph 2). Site 2 is an innovative design that aims to treat the reverse osmosis concentrate of DWP. Additionally, nyex is used to remove the anions and charged organic matter (see Graph 3).

Business opportunities

Industrial saline impaired effluents (brines) are an environmental challenge and an economic opportunity. The following materials with potential commercial value are recovered on the two sites that will be used in the same factory by Evides or in the industrial area Botlek.

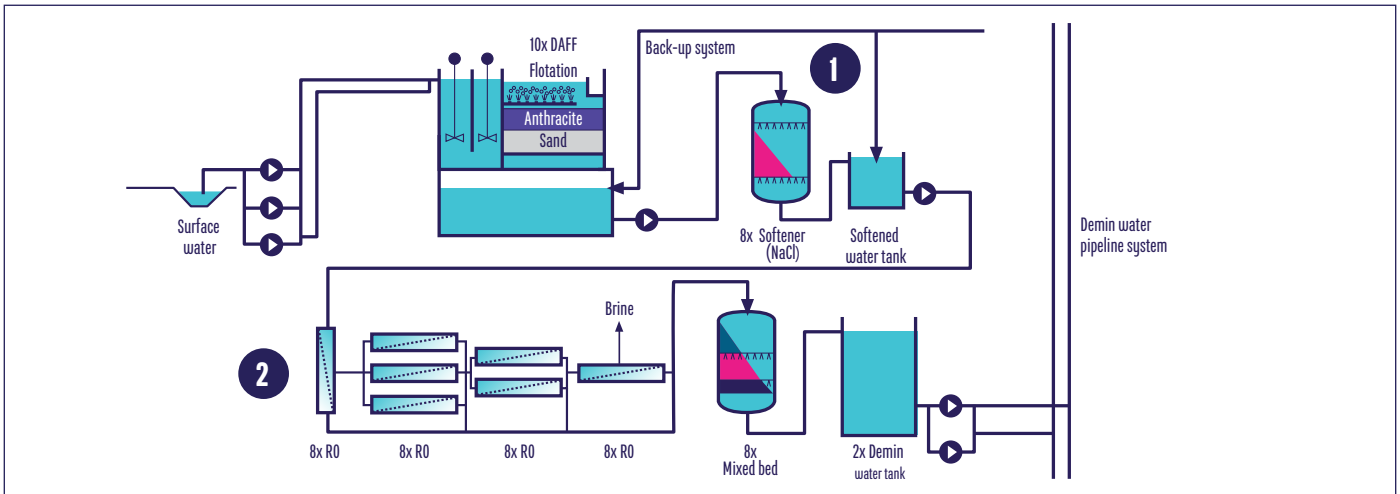
Site 1

- High purity magnesium & calcium
- Clean Water
- NaCl regeneration solution

Site 2

- Sulphate salts
- NaHC03
- Clean Water
- NaCl regeneration solution

Graph 1: Schematic view of the current processes at the DWP plant at Botlek



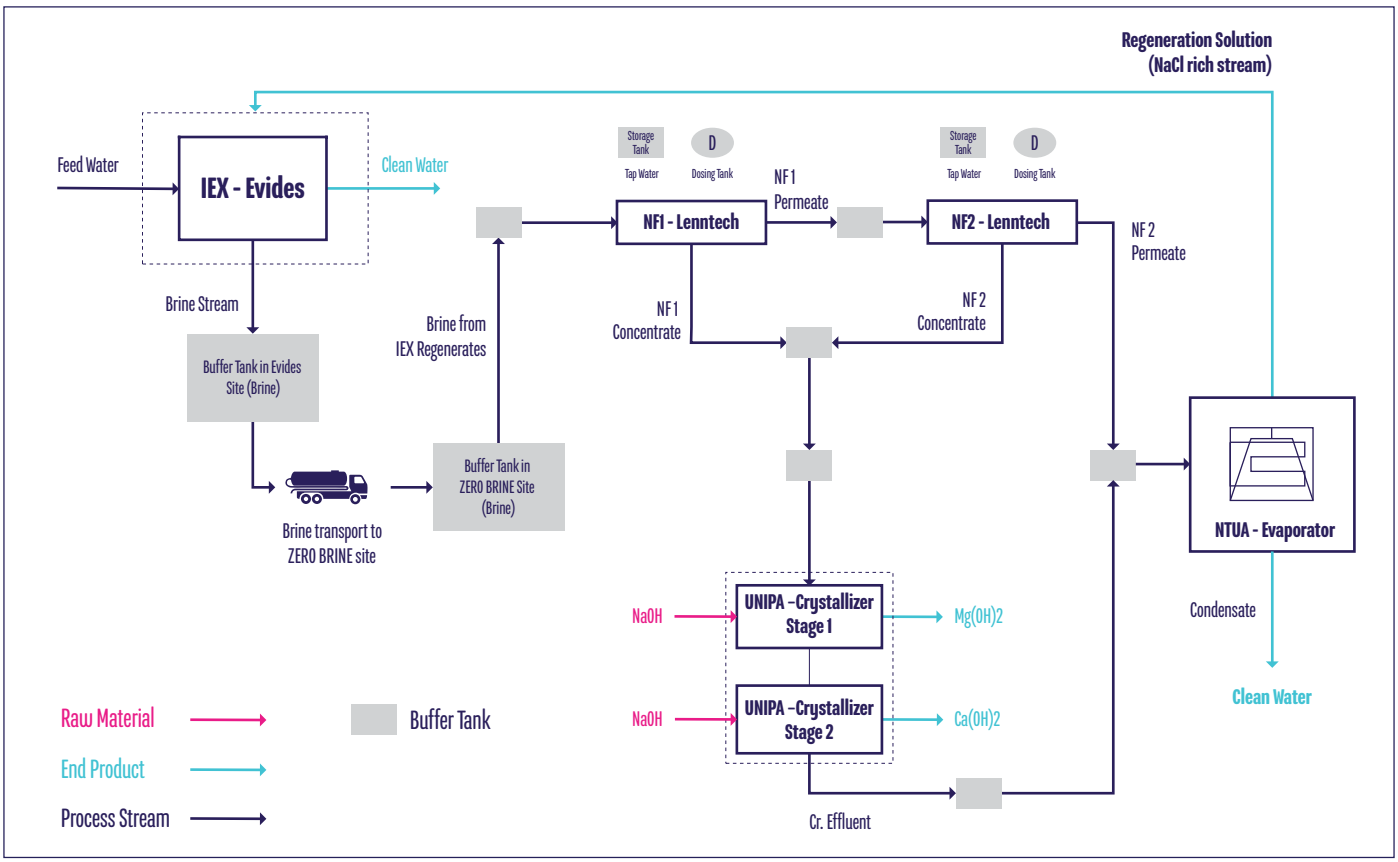
1 Site 1: Technologies

Demonstration of Nanofiltration (NF) – Crystallizer (MF-PFR) Evaporation for treatment of Ion Exchange (IEX) Regenerates

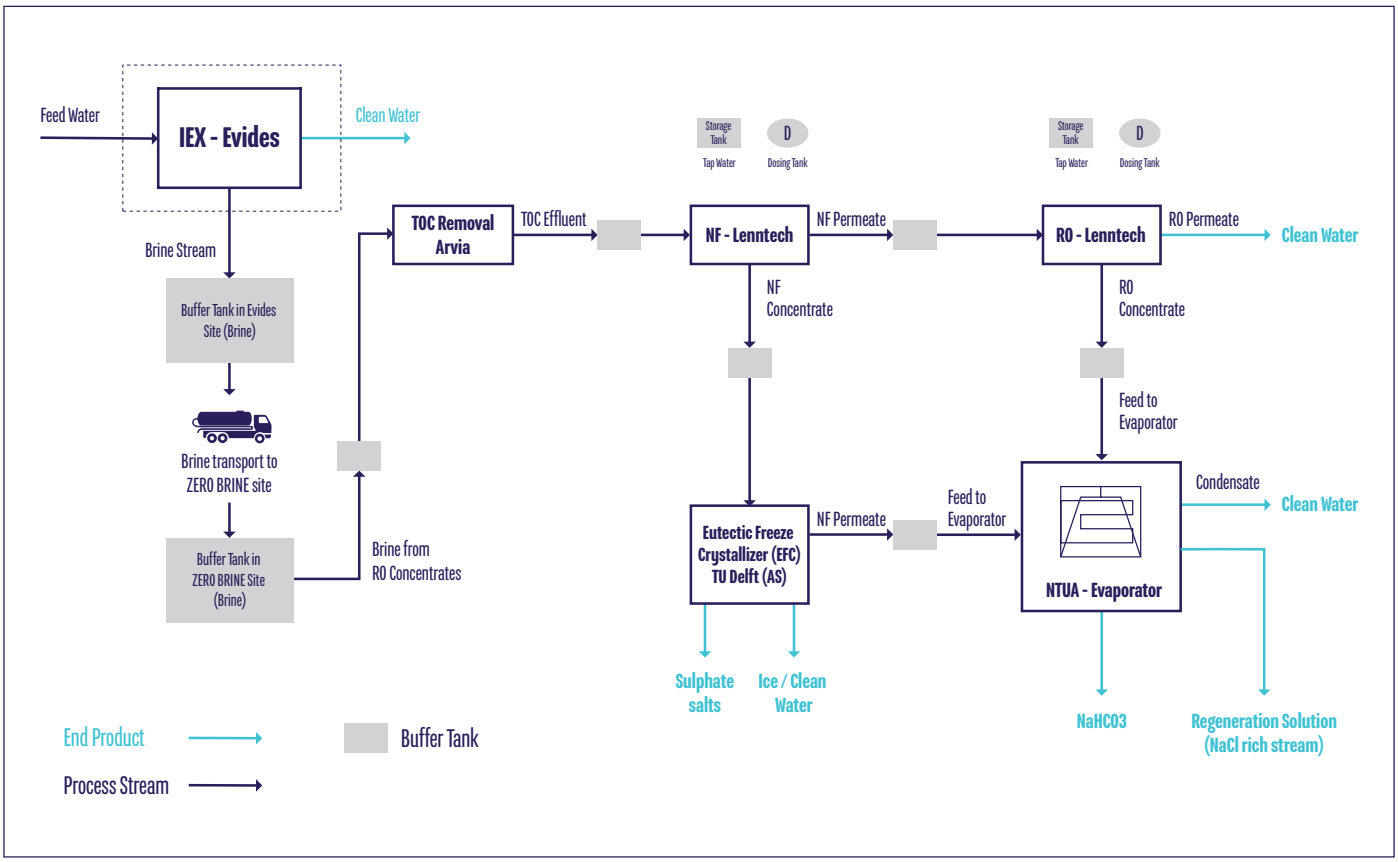
2 Site 2: Technologies

Nyex (TOC Removel) – Nanofiltration – Reverse Osmosis (RO) – Evaporation Eutectic Freeze Crystallization (EFC) for treatment of RO Concentrates

Graph 2: Site 1



Graph 3: Site 2



The ZERO BRINE project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 730390.

ZERO BRINE

ZERO BRINE PILOT DEMONSTRATION
BOLESŁAW ŚMIAŁY COAL MINE IN ŁAZISKA GÓRNE, SILESIA, POLAND

Context

Saline wastewaters are a concern of many industries. The coal mining industry is particularly affected: every year Poland discharges around 4 million tonnes of sodium chloride (salt) into rivers, coming mainly from coal mines. This causes environmental damage and economic strains due to pollution fees. ZERO BRINE is turning this problematic issue into a source of income by recovering valuable resources such as water, salts, and minerals for reuse in other industries, creating potential jobs and societal improvements. The pilot plant is operated and overseen by the Silesian University of Technology (SUT) that is located nearby in the small city of Gliwice.

Coal mines are an important sector in the EU. Overall, coal is produced in 11 EU countries, having a major contribution to the energy security in nearly half of the Member States. In addition, coking coal is identified by the European Commission (EC) as one of the 27 critical raw materials since its supply risk is high. Coking coal also has a high economic importance due to its use in the metallurgy sector. As such, coal production will remain a very important sector in the future.

The coal mining industry is deeply affected by the environmental and economic problems with saline wastewater disposal. Every year, the mining sector discharges around 4 million tonnes of salt into the rivers in Poland. Poland's two longest rivers (Vistula and Odra) are under significant pressures from mining activities. For many years, excessive salt concentration has been found in the Vistula River, with 94% of the chlorides originating from hard coal mining activity. The Vistula River contains about 55% of the total fresh water resources in Poland and covers about 60% of the water needs in the country (including the river basin). The rising salination of the Vistula River is the cause of losses in industry, agriculture and water transport, which are estimated to be $100-250 million per year.

One possible solution is to use coal mining wastewater as the source of raw materials, thus turning the problem into a business opportunity. Poland only has one industrial-scale desalination plant in Czerwionka-Leszczyny, owned by PGWiR, which produces around 70,000 t/year of salt from coal mine water. The plant operates on coal mine water originating from operational "Budryk" mine and from an inactive mine, "Dębieńsko". The plant does not use chemical treatment. The low salinity coal mine water is pre-concentrated by reverse osmosis (RO). Then, after mixing with more saline coal mine water, it is subjected to further concentration by vapour compression (VC), and salt is obtained in a VC crystallizer. Unfortunately, this technology exhibits high energy consumption as well as limited salt recovery due to the presence of bivalent contaminants such as magnesium and calcium, which are not removed from the feed stream. The existing technology also does not allow the recovery of valuable raw materials, such as magnesium hydroxide.

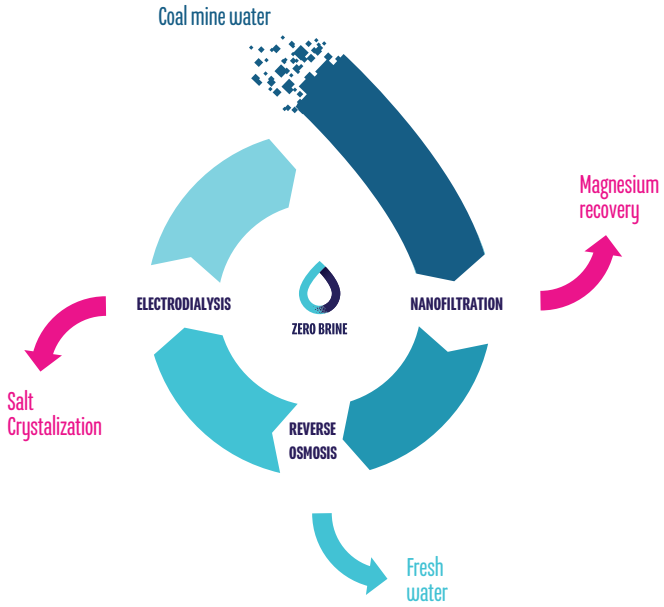
Decrease energy consumption by **50%**

Faster processing time than existing technologies

Recover materials such as **salt or concentrated brine, magnesium hydroxide**

Impact

ZERO BRINE aims at providing a technological solution of the saline wastewater problem for the coal mining industry. The ZERO BRINE technology is expected to decrease the energy consumption in the production of concentrated brine by 50% (target: 22 kWh/m3 of brine treated), compared to the vapour compression technology already used in Czerwionka-Leszczyny. The technology will also allow the recovery of raw materials: evaporated salt or concentrated brine, which both have multiple applications in the chemical industry, as well as magnesium hydroxide, which is a valuable commodity in the refractory materials industry. The ZERO BRINE team has already confirmed the interest of Poland's refractory materials manufacturer in new sources of high-purity magnesium hydroxide. Moreover, the same technology can be applied to other branches of industry which generate saline discharges.



Business opportunities

The problem of saline wastewaters is not unique to only one mine or one company – it has been a systemic issue throughout the whole industry for years. At the moment, 18 hard coal mines are still operational in Poland, provided below by coal mine industry: Jastrzębska Spółka Węglowa JSW Group (4 coal mines), Polska Grupa Górnicza (8 coal mines), Tauron Wydobycie (3 coal mines), Przedsiębiorstwo Górnicze Silesia (1 coal mine), Węglokoks (1 coal mine), Lubelski Węgiel Bogdanka S.A. (1 coal mine). All of those companies might be interested in turning their big environmental problem into a potential source of income.

An important business opportunity is the production of salt. The average production in Poland is around 4.3Mt/y, with salt-in-brine accounting for around two-thirds of production. Some 63% of salt-in-brine produced domestically is consumed in two synthetic soda ash plants (operated by Soda Polska Ciech). Around 21% of salt-in-brine is used in the production of evaporated salt and 16% in chlor-alkali production (by Anwil Nitrogen Plant, PCC Rokita and Organika-Zachem Chemical Works).

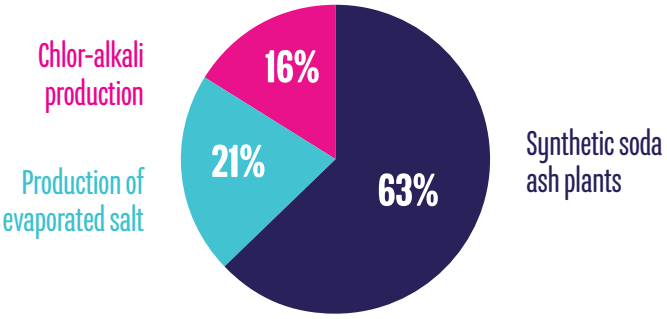
The magnesium hydroxide is of interest for the refractory materials industry. In 2006, the production of refractories in Poland reached nearly 300,000 tonnes, around 28% of which were unshaped materials. The main manufacturers in Poland include ZM Ropczyce S.A., PMO Komex (part of Alcerol-Mittal), PCO Z˙arów S.A., Vesuvius Skawina.

The business opportunities of ZERO BRINE are not limited to Poland. Because of how similar in composition the coal mine waters are to the sea water, the proposed technology could also be applied in the desalination industry – a sector which will become increasingly important due to the increasing water stress.

Turning waste into a potential source of income for operational coal mines

Salt production: **4.3 MT/y**

Usage of salt-in-brine:



Magnesium hydroxide is used in refractory materials industry - which reached **300,000 tonnes** in 2006

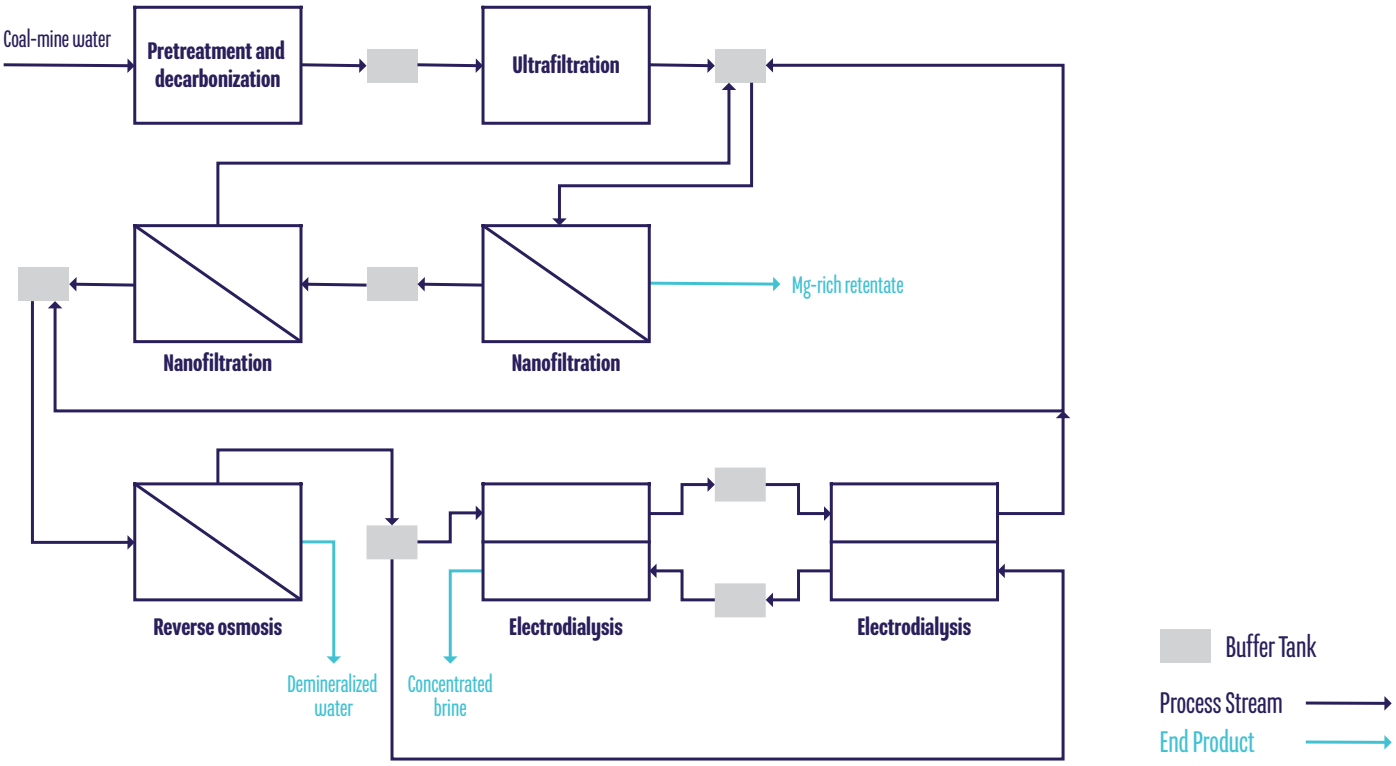
The ZERO BRINE project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 730390.

Technology

The feed – coal mine water – after being pre-treated with decarbonization and ultrafiltration, is subjected to a two-pass nanofiltration. Nanofiltration is a membrane method, which allows separation of univalent ions – such as sodium and chlorides – from bivalent ions – calcium, magnesium, sulphates. The nanofiltration unit thus splits the coal mine water into two streams: salt-rich permeate and calcium and magnesium-rich retentate. The retentate can be used n the recovery of magnesium hydroxide. Magnesium is a critical raw material officially listed by the European Commission as having high commercial value. (Currently, Europe imports over 95% of its magnesium from China.) The remaining calcium-rich solution could be used as a de-icing liquid. The nanofiltration permeate is concentrated in a hybrid reverse osmosis-electrodialysis system, which produces demineralized water of quality close to distilled water, highly saline concentrate, and the diluate, an essential commodity that can be used at the site. The highly saline concentrate could then be sold directly or used as a source for salt crystallization.

The pilot plant operating in the "Bolesław Śmiały" coal mine tests the nanofiltration-reverse osmosis-electrodialysis part of the proposed technology.

General scheme of the proposed technology



The ZERO BRINE project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 730390.

Key results and conclusions

The pilot plant aimed at testing the proposed technology has been constructed in the "Bolesław S´miały" coal mine in Łaziska Górne, Poland. The pilot plant consists of pretreatment system, ultrafiltration, decarbonization, two-pass nanofiltration, reverse osmosis and electrodialysis, and is capable of treating 400 L/h of coal mine wastewater. The desalination experiments have been run in the pilot plant since July 2019 and the initial results are promising. Though some modifications were required to the pretreatment and decarbonization unit, it was confirmed that nanofiltration can split the coal mine wastewater into sodium-chloride rich stream suitable for further concentration and the magnesium-rich stream suitable for magnesium hydroxide recovery. The projected energy consumption in the production of concentrated brine is equal to 12 kWh/m3 of brine treated at 82.8% salt recovery (vs. ca. 70% in existing technology); however, these results are only preliminary and still need to be confirmed and the process needs further optimization.

The ZERO BRINE plant is capable of treating
400 L/hr
of coal mine wastewater

Energy consumption of
12 kWh/m^3
of brine treated

82.8%
salt recovery from treated brine

The ZERO BRINE project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 730390.

ZERO BRINE

INSTALACJA PILOTOWA ZERO BRINE

KWK BOLESŁAW ŚMIAŁY W ŁAZISKACH GÓRNYCH, WOJ. ŚLĄSKIE, POLSKA

Wprowadzenie

Zasolone wody odpadowe są problemem wielu gałęzi przemysłu. Wydobycie węgla jest szczególnie dotknięte tym problemem: co roku do polskich rzek trafia 4 mln ton chlorku sodu pochodzącego głównie z kopalń. Wpływa to negatywnie na środowisko oraz na zyski kopalń ze względu na opłaty środowiskowe. ZERO BRINE zmienia ten problem w źródło przychodu poprzez odzysk cennych dla innych gałęzi przemysłu surowców, takich jak woda demineralizowana, sól oraz inne minerały. Instalacja pilotowa jest nadzorowana przez Politechnikę Śląską w Gliwicach (PŚ).

Kopalnie węgla kamiennego są ważną częścią gospodarki europejskiej. Węgiel jest wydobywany w 11 krajach UE, stanowiąc ważną część surowców energetycznych prawie połowy krajów członkowskich Unii. Dodatkowo, węgiel koksujący został wpisany przez Komisję Europejską na listę 27 surowców strategicznych. Węgiel koksujący ma duże znaczenie ze względu na jego użycie w przemyśle metalurgicznych. Dlatego też wydobycie węgla pozostanie istotną częścią gospodarki w przyszłości.

Górnictwo węgla kamiennego jest szczególnie dotknięte problemem zasolonych wód odpadowych. Co roku do polskich rzek zrzucanych jest w wodach kopalnianych około 4 mln ton soli. Wisła i Odra są szczególnie narażone na działanie przemysłu wydobywczego. Od lat Wisła jest nadmiernie zasolona, a 94% chlorków obecnych w wodzie pochodzi z górnictwa. Wisła zawiera około 55% wszystkich zasobów wody pitnej kraju, a wody jej dorzecza pokrywają około 60% całkowitego zapotrzebowania na wodę w Polsce. Zwiększanie się zasolenia Wisły powoduje wymierne straty dla przemysłu, rolnictwa i transportu, sięgające 100-250 mln USD rocznie.

Jednych z możliwych rozwiązań jest użycie wód kopalnianych jako źródła surowców, zmieniając w ten sposób problem w źródło dochodu. W Polsce istnieje jedna przemysłowa instalacja odsalania w Czerwionce-Leszczynach, będące własnością PGWiR, która produkuje około 70 000 t soli rocznie z wód kopalnianych. Instalacja przemysłowa pracuje na wodach z czynnej kopalni „Budryk" oraz nieczynnej kopalni „Dębieńsko". W procesie nie stosuje się oczyszczania chemicznego. Wody miernie zasolone z kopalni „Budryk" poddawane są zatężaniu metodą odwróconej osmozy (RO), a następnie mieszane z bardziej zasolonymi wodami. Otrzymane solanki są zatężane metodą wyparną (VC) i poddane krystalizacji. Niestety stosowana technologia wykazuje wysokie zużycie energii, a także niski uzysk soli, ograniczony obecnością zanieczyszczeń takich jak wapń czy magnez, które nie są usuwane z solanek przed krystalizacją. Istniejąca technologia nie umożliwia również odzysku cennych surowców, takich jak wodorotlenek magnezu.

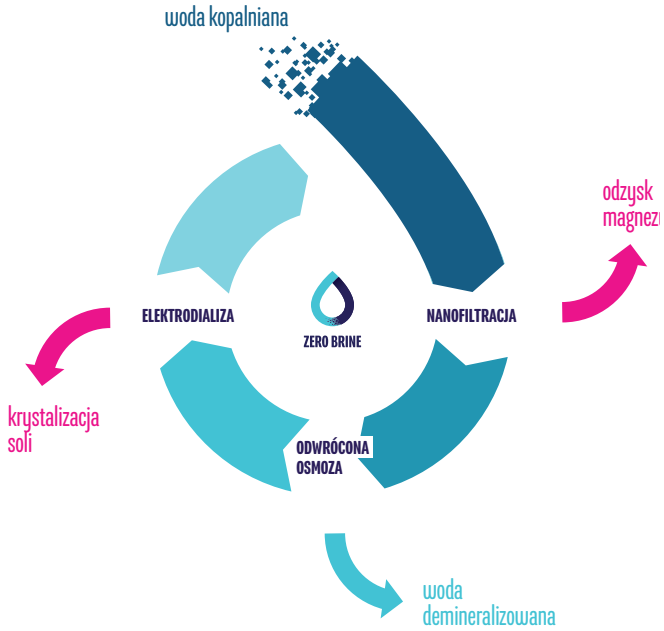
Zmniejszenie zużycia energii o **50%**

Lepsza wydajność w porównaniu z istniejącymi technologiami

Odzysk cennych surowców takich jak sól i wodorotlenek magnezu

Wpływ

Celem projektu ZERO BRINE jest przedstawienie technologii rozwiązującej problem wód zasolonych z wydobycia węgla kamiennego. Technologia ZERO BRINE powinna zmniejszyć zużycie energii w produkcji stężonej solanki o 50% (cel: 22 kWh/m3 solanki) w porównaniu do istniejącej obecnie instalacji w Czerwionce-Leszczynach. Technologia ta pozwoli również na odzysk surowców: soli lub nasyconej solanki, które znajdują szerokie zastosowanie w przemyśle chemicznym, a także wodorotlenku magnezu, który jest cennym surowcem dla przemysłu materiałów ogniotrwałych. Zespół ZERO BRINE już potwierdził zainteresowanie firm z branży materiałów ogniotrwałych nowymi źródłami wodorotlenku magnezu o wysokiej czystości. Co więcej, proponowana technologia może znaleźć zastosowanie w innych gałęziach przemysłu wytwarzających zasolone wody odpadowe.



Komercyjne korzyści

Problem zasolonych wód odpadowych nie dotyczy wyłącznie jednej kopalni lub jednej firmy – jest to problem systemowy, który od lat dotyczy całej branży. Obecnie w Polsce działa 18 kopalni węgla kamiennego, posiadanych przez firmy takie jak Jastrzębska Spółka Węglowa (4 kopalnie), Polska Grupa Górnicza (8 kopalń), Tauron Wydobycie (3 kopalnie), Przedsiębiorstwo Górnicze Silesia (1 kopalnia), Węglokoks (1 kopalnia), Lubelski Węgiel Bogdanka S.A. (1 kopalnia). Wszystkie wymienione firmy mogą być zainteresowane zmianą problemu ekologicznego w potencjalne źródło przychodu.

Istotną korzyścią jest produkcja soli. W Polsce produkuje się średnio 4,3 mln t soli rocznie, z czego około dwie trzecie wytwarzane jest z solanek. 63% produkowanych w Polsce solanek używanych jest w produkcji sody w dwóch fabrykach firmy Soda Polska Ciech. Około 21% solanek używana jest do produkcji soli, a 16% w przemyśle chloro-alkalicznym (Anwil Nitrogen Plant, PCC Rokita, Organika-Zachem).

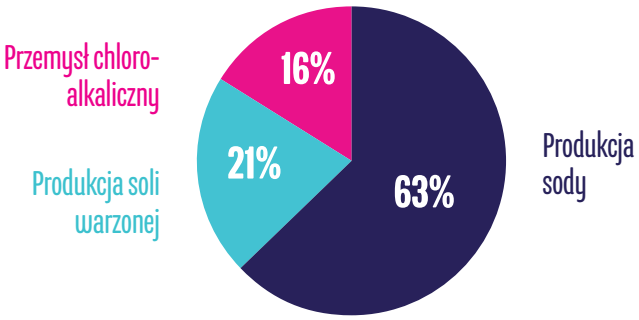
Wodorotlenek magnezu jest cennym surowcem w branży materiałów ogniotrwałych. W 2006 roku produkcja materiałów ogniotrwałych w Polsce wyniosła 300 000 t, z czego 28% stanowiły materiały nieformowane. Głównymi producentami w Polsce są ZM Ropczyce S.A., PMO Komex (część Alcerol-Mittal), PCO Żarów S.A., Vesuvius Skawina.

Komercyjne korzyści z projektu ZERO BRINE nie są ograniczone do Polski. Ponieważ zasolone wody kopalniane mają podobny skład do wody morskiej, technologia ZERO BRINE może być również stosowana w odsalaniu – branży, której rosnące znaczenie związane jest z ograniczonymi zasobami wody.

Zmiana odpadu w potencjalne źródło przychodu dla kopalń węgla

Produkcja soli **4,3 mln** t rocznie

Użycie solanek:



Wodorotlenek magnezu może być użyty do produkcji **300 000 t** materiałów ogniotrwałych rocznie

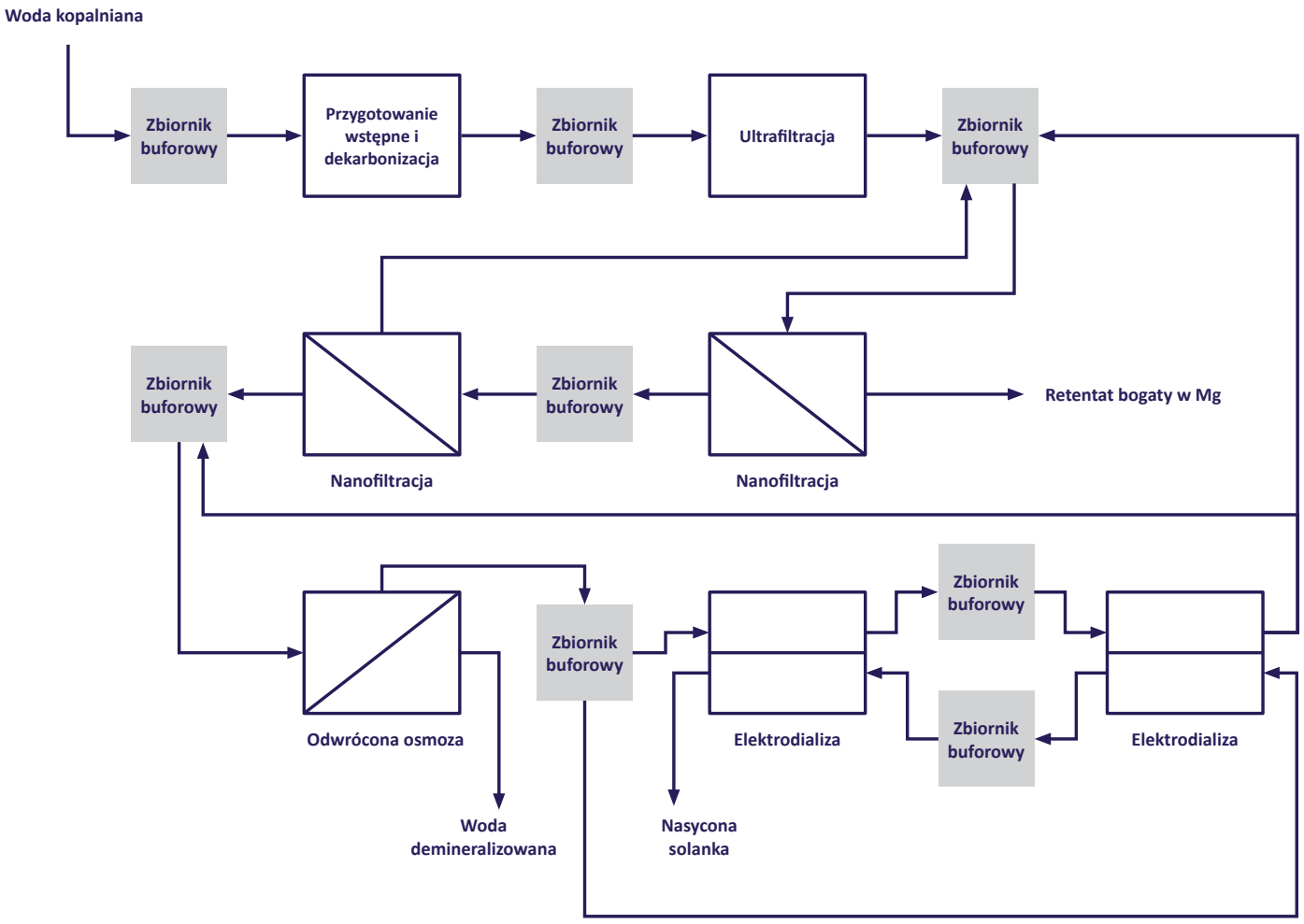
The ZERO BRINE project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 730390.

Technologia

Nadawa – woda kopalniana – jest poddawana wstępnemu oczyszczaniu, ultrafiltracji i dekarbonizacji, następnie jest kierowana do dwuprzejściowej nanofiltracji. Nanofiltracja jest techniką membranową, która umożliwia rozdział jonów jednowartościowych – chlorku, sodu – od wieluwartościowych – wapnia, magnezu, siarczanu. Nanofiltracja rozdziela strumień wody kopalnianej na dwa strumienie: bogaty w chlorek sodu permeat oraz bogaty w wapń i magnez retentat. Retentat może być zastosowany do odzysku wodorotlenku magnezu, cennego materiału, który został oficjalnie uznany za surowiec o wysokiej wartości przez Komisję Europejską (obecnie UE zaspokaja 95% zapotrzebowania na magnez poprzez import z Chin). Roztwór pozostały po wytrącaniu wodorotlenku magnezu, bogaty w chlorek wapnia, może być stosowany do zapobieganiu obladzania dróg. Permeat z nanofiltracji jest kierowany do hydrybowego systemu odwrócona osmoza-elektrodializa, który produkuje wodę demineralizowaną o jakości zbliżonej do wody destylowanej oraz nasyconą solankę. Solanka może być sprzedawana lub zasilać krystalizację soli.

Instalacja pilotowa na „Bolesławie Śmiałym" testuje część proponowanej technologii: nanofiltrację, odwróconą osmozę i elektrodializę.

Ogólny schemat proponowanej technologii



The ZERO BRINE project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 730390.

Główne wyniki i wnioski

Instalacja pilotowa mająca na celu przetestowanie proponowanej technologii została skonstruowana w kopalni „Bolesław Śmiały" w Łaziskach Górnych. Instalacja pilotowa składa się z przygotowania wstępnego, ultrafiltracji, dekarbonizacji, dwuprzejściowej nanofiltracji, odwróconej osmozy i elektrodializy, umożliwiając oczyszczanie 400 L/h wody kopalnianej. Testy odsalania są prowadzone od lipca 2019, wstępne wyniki są obiecujące. Mimo, że przygotowanie wstępne oraz dekarbonizacja wymagały modyfikacji, udało się potwierdzić możliwość zastosowania nanofiltracji do rozdziału wody kopalnianej na bogaty w sól permeat oraz bogaty w magnez retentat. Zużycie energii w produkcji solanki szacowane jest na 12 kWh/m3 przy uzysku soli 82.8% (obecnie stosowana technologia wykazuje uzysk ok. 70%) – są to jednak wstępne wyniki i wymagają dalszej weryfikacji eksperymentalnej i optymalizacji.

Instalacja pilotowa ZERO BRINE może oczyszczać
400 L/h
wody kopalnianej

Zużycie energii
12 kWh/m3
oczyszczanej wody

82,8%
uzysku soli

The ZERO BRINE project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 730390.

ZERO BRINE

ZERO BRINE PILOT DEMONSTRATION

INDUSTRIAS QUIMICAS DEL EBRO (IQE) IN ZARAGOZA, SPAIN

1. Industry context

Synthetic amorphous silica are used in a wide range of industrial applications. Due to their physico-chemical properties, they are used in synthetic resins, plastics, rubbers, cosmetics, nutritional products and drugs, for example, as fillers or anti-caking agents. Synthetic amorphous silica are produced either by a wet process – precipitation of a water glass solution with acids (precipitated silicas, silica gels, silicates) – or by high temperature hydrolysis of chlorosilanes (pyrogenic silicas).

In the production of silica by a wet process, high amounts of water (≈40m^3 per each tonne of silica) are consumed, as well as sulfuric acid (H_2SO_4) and sand. As a result, around 35m^3 of wastewater containing a high concentration (20 g/L) of sodium sulphate (Na_2SO_4) are produced. This wastewater is normally discharged to natural water sources such as rivers and seawater after passing through wastewater treatment plants.

It is estimated that 620,000 tonnes of precipitated silica is produced per year in the EU and 21,700,000 m^3 of wastewater is discharged.

Industrias Quimicas del Ebro (IQE) is seeking novel methods to recover resources (water and sodium sulphate) and minimize the wastewater generated, while reducing the cost of water supply and wastewater treatment. Even so, as it is stated in the BREF for the inorganic chemical industry sector, the concentration of sodium sulphate in wastewaters from the production of precipitated silica is too low for its recovery to be economically viable through available methods (spray drying, precipitation of gypsum or membrane dialysis, etc.).

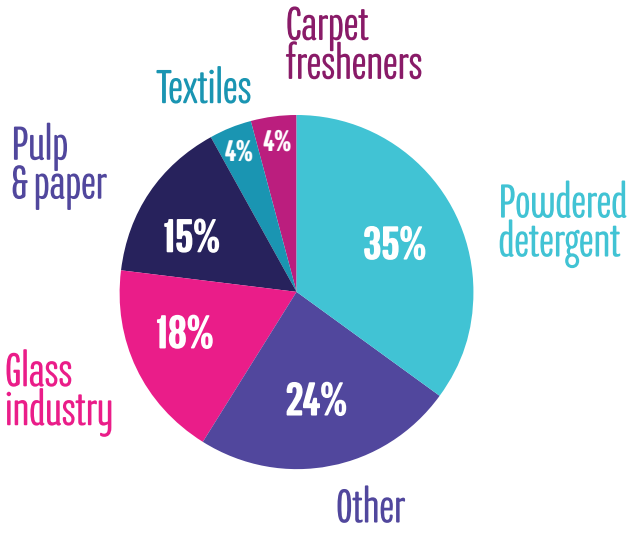
2. Impact of the ZERO BRINE technology

ZERO BRINE aims at providing a technological solution for the saline wastewater problem for the silica industry. The technology applied in the ZERO BRINE project would enable IQE to recover up to 80% of wastewater generated, producing water suitable for its reuse in the same company, thus reducing freshwater consumption. In addition, the technology allows the recovery of raw materials: sodium sulphate, which is a valuable product for various industrial sectors, like the powered detergent or the glass industry.

3. Business opportunities

The ZERO BRINE solution can be applied not only to the silica industry, but also to other industries which generate saline discharges containing high concentrations of sodium sulphate. This is the case for the pulp and paper industry, where sodium sulphate is one of the main reagents and also by-products of the pulping processes, especially the kraft process.

Na_2SO_4 – Uses & Market Shares



Price: €90/tonne

The ZERO BRINE project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 730390.

An important business opportunity is the production of sodium sulphate that is a valued product for various industrial sectors, like the powdered detergent or the glass industry.Business opportunities of ZERO BRINE are not limited to saline wastewater containing sodium sulphate. The technology developed and tested in ZERO BRINE can also be applied to recover valuable inorganic compounds other than sodium sulphate. The potential users are all industries with a high concentration of inorganic compounds in their effluents that could be recovered instead of discharged into the environment, such as desalination plants, salt mining, and chemical industries.

4. Technology + proposed scheme

The ZERO BRINE process is based on: a) a first membrane-based process using tailor-made membranes produced by regenerating end-of-life reverse osmosis (RO) elements from desalination plants otherwise destined for a landfill; b) treatment of the concentrate stream produced in the first stage by crystallization to achieve Zero Liquid Discharge. In order to avoid scaling problems during treatment with membranes, a pre-treatment to remove aluminium and iron is applied.

Regenerated membranes are able to achieve a suitable quality of water, equivalent to the current quality in the industry that could also be reused in the production process. In addition, a high saline concentrate is obtained to be treated by crystallization, either Eutectic Freeze Crystallization (EFC) or Evaporation. The concentration of wastewater using membranes reduces the energy consumption of the crystallization stage.

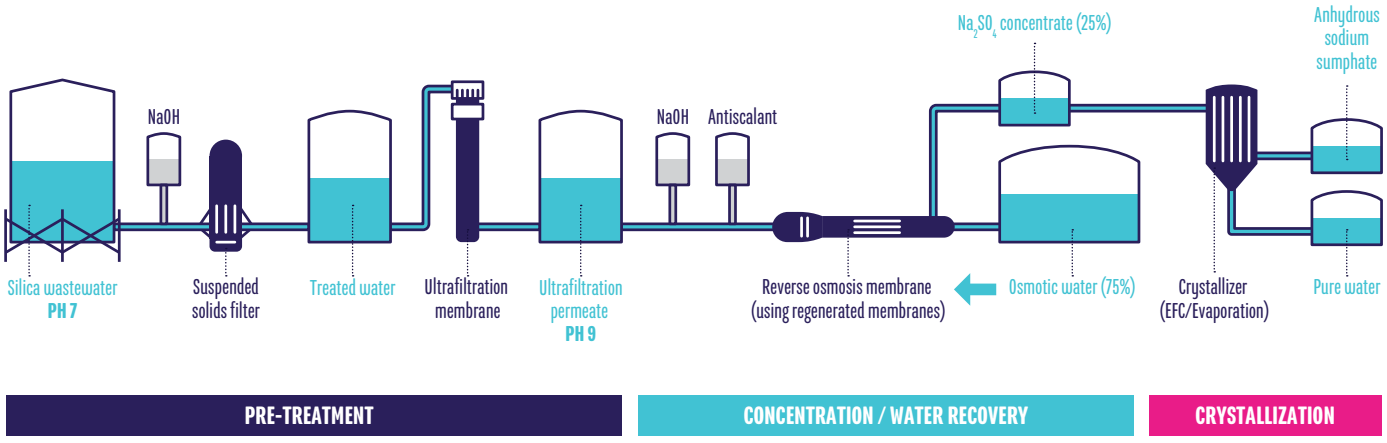
The ZERO BRINE process has been demonstrated at IQE at pilot plant scale.

5. Key results and conclusions

The technology applied in the ZERO BRINE project would enable IQE to recover 20,000 tonnes per year of sodium sulfate and 80% of the wastewater generated (1,000,000 m^3 per year).

The concentration of saline wastewater using regenerated membranes before the crystallization process allows the reduction of treatment costs up to 70% when compared with the direct evaporation of wastewater.

The preliminary business plan elaborated for the development of the ZERO BRINE proposal foresees savings in the cost of water supply and wastewater treatment of around €460,000 per year and turnover of €1,800,000 per year from the sodium sulphate recovered.



The ZERO BRINE project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 730390.

ZERO BRINE

ZERO BRINE PILOT DEMONSTRATION
ZORLU TEXTILE FACTORY IN LÜLEBURGAZ, TURKEY

1. Context

The management of industrial wastewater to comply with Zero Liquid Discharge (ZLD) has been receiving significant attention. The textile industry is one of the largest sectors in Turkey and makes up 10% of the country's GDP and employs around 750,000 people. However, the industry is also responsible for numerous environmental effects due to untreated wastewater discharges which contain various chemicals from unit processes. The industry covers 1-3% GNP of the countries worldwide. Turkey ranks 5th and 6th in production of woolen and cotton products worldwide which makes up close to 40% of total export income and 10% of the industrial work force. Therefore, the implementation of a well-designed solution to prevent pollution along with the ZLD concept is highly favorable for both environmental concerns and economically.

The textile industry is a highly water intensive sector. Water consumption ranges between 60 to 120 L/kg for cotton products and 110-650 L/kg for wool. Water is utilized at various steps of the unit processes such as pre-treatment, dyeing or finishing. Processes require extensive water use for dyeing, rinsing, conditioning and finishing operations. The crucial parameters of discharges from textile enterprises include mainly organic constituents, dissolved solids, inorganic salts, color, sulfate and pH.

Salt usage is also significant in the textile industry. Salt is consumed for dyeing cotton or linen fabrics and acts as a raw and auxiliary material.

Physicochemical and biological treatment techniques are widely employed to treat textile industry wastewater to comply with local discharge criteria. Moreover, membrane processes such as Nanofiltration (NF) and Reverse Osmosis (RO) are also utilized following conventional treatment methods as a tertiary treatment step to obtain a reusable stream. Membrane treatment for reuse is a very effective method for removal of ions and other pollutants. Reusable, high quality water is obtained using RO membrane processes.

RO on the other hand, results in the formation of highly polluted concentrate (brine) along with the high-quality, treated water stream. The impurities and pollutants in brine have serious adverse impacts on the environment. Principally, the brine discharges may cause environmental and ecological impacts on especially inland receiving water bodies such as lakes and rivers and may cause salinization of the soil which is one of the most severe environmental problems in agriculture.

The concept of circular economy and ZLD options are investigated for Zorlu Textile's integrated polyester yarn and cotton home textile manufacturing industry within the context of ZERO BRINE project. In this manner, treatment and recovery of the concentrated salt solution (brine) which can be reused in the dyeing baths of the textile plant and/or utilized as feed for salt production is targeted.

The demo project is primarily focused on the management of brine generated from the RO unit and developing an innovative brine treatment and recovery system. Brine from the RO treatment unit presents an important environmental concern due to the high concentration of impurities including various chemicals, salts, colors, hardness, alkalinity and nutrients. The primary difficulty to be overcome by this approach is the separation of hardness and color from brine while concentrating the salt solution which can, in turn, be used in textile dyeing processes. The recovered salt solution should also comply the criteria for textile dyeing process requirements.

Fig. 1 – Expected outcomes

Decrease salt consumption by 40%	**Reduction in water consumption by 15%**
Decrease CO_2 emissions by 20%	**Significant improvement of aquatic environments and protection of soil from salinization.**

The ZERO BRINE project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 730390.

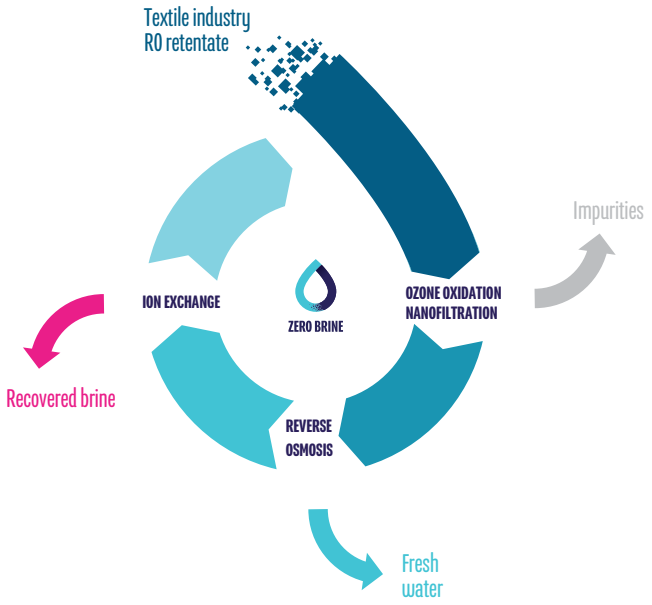
2. Impacts

The ZERO BRINE project intends to reduce saline wastewater streams generated by industry by recovering and reusing minerals, water and metals from wastewater. ZERO BRINE aims at the development of innovative technological solutions of the highly saline wastewater problem for several industrial sectors including the textile sector. In this context, concentrate (brine) recovery of approximately 400 tons/year as NaCl is targeted for Zorlu Textile. Depending on the brine impurity, recovered concentrate is utilized for in-plant processes. The conditions for recovery is appraised, and off-site use may also be made possible. Moreover, production 50 Kt/year high quality water is also among the goals.

The results would have great impacts on the textile industry in achieving resource efficiency and improving sustainability due to the reduced consumption of process inputs, as well as the mitigation of greenhouse gasses accordingly. In this way, it is estimated that the reduction of 200 tons of CO_2 on an annual basis could be achieved.

Moreover, the similar technology and approach can be applied to other sectors of industry which generate saline discharges.

Fig. 2 – Conceptual scheme for textile pilot



3. Business opportunities

Brine is a valuable resource for the recovery of salt and water. In this way, the purpose is to close the loop between the saline wastewater generated by process industries and to contribute the circular economy. The goal is achieved by means of innovative existing and new technologies to recover and reuse high quality end-products. By taking into account the demo system results, other various enterprises actively operating in the textile sectors will likely be encouraged. The solutions developed may sustain;

I. compliance with the relevant regulations likely to be in force in the near future,

II. economic benefits for the enterprise implemented ZLD approach due to the reduction in consumption of salt and water,

III. improvements in visibility of the enterprise due to the increased concerns for environmental issues, and also relevant growth in export potential with good market value,

IV. business opportunities foreseen for the companies involved wastewater treatment and reuse/recovery options,

V. creation of new job alternatives for technical personnel in both textile or other relevant enterprises for various sectors including environmental fields (wastewater treatment and reuse companies).

6. Technology

Zorlu Textile industry wastewater is treated with physicochemical, biological methods and advanced treatment processes (activated carbon adsorption, ultrafiltration and RO) to obtain a reusable stream which is utilized for an energy company's cooling systems located near the Zorlu Textile. RO treatment consequently results in the generation of a highly polluted concentrate retantate (brine).

The proposed configuration of the brine treatment and recovery pilot system was developed based on the comprehensive characterization in bench scale tests, as well as the relevant assessments.

In this perspective, ozone oxidation and (NF) membrane processes are applied as the pre-treatment phase essentially to remove or mitigate impurities such as color, hardness, organic constituents and sulfate. NF provides 50-60% rejection of impurities whilst allowing 10-20% salt passage. Whereas, after NF membrane systems, RO is utilized as the concentration step for the NF permeate stream. At this stage, the concentrate stream of the RO unit is the recovered salt solution while the permeate of the RO unit is the reusable water – close to demineralized water quality – that can be reused for textile processing purposes.

The ion exchange softening process is also applied as the final step to acquire extra hardness removal of the recovered salt solution prior to the dyeing applications. This step would provide additional assurance as hardness is considered to be the critical parameter for textile dyeing processes. An activated carbon adsorption column and an UV oxidation unit are also provided within the pilot system to remove excess ozone remaining in the concentrate stream to provide protection for the membranes.

The ZERO BRINE project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 730390.

Fig. 3 – General outline of the proposed system at Zorlu Textile

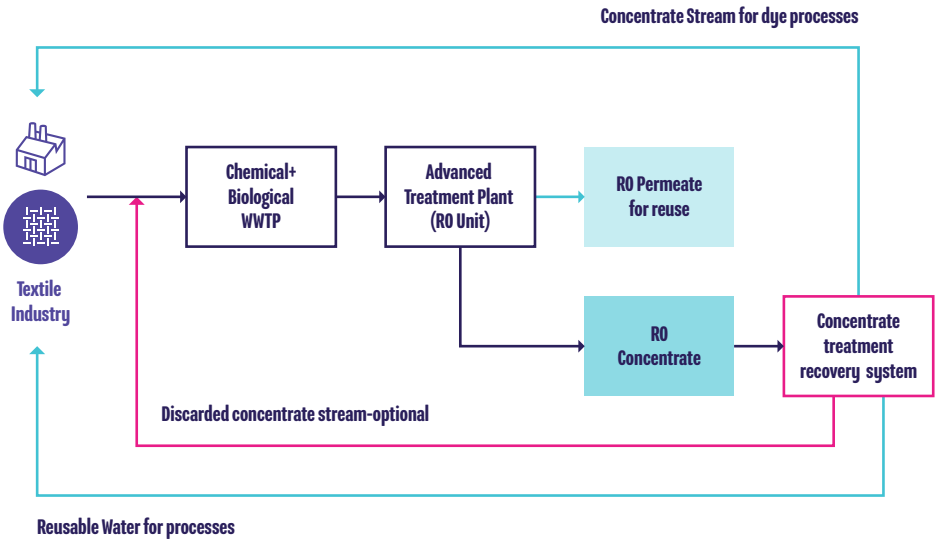
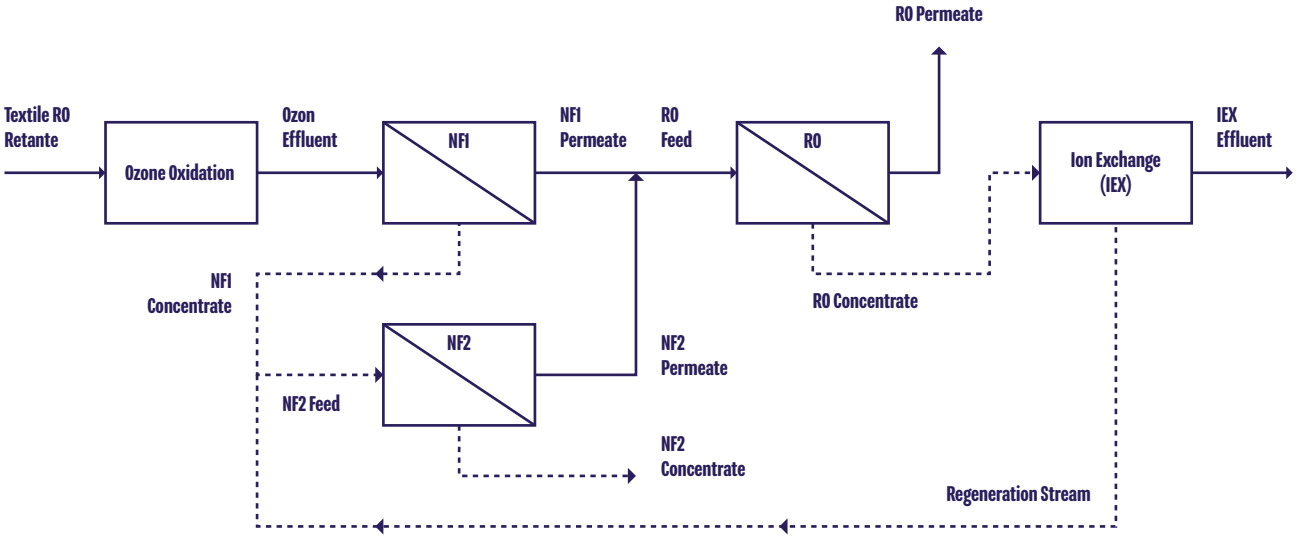


Fig. 4 – Process scheme of the applied technology for the pilot system



7. Key results and conclusions

The textile brine recovery pilot plant is intended for testing and verifying the proposed technology. It has been constructed and is being operated at the Zorlu Textile premises at Lüleburgaz, Kırklareli.

The pilot system involves a pretreatment stage with ozone oxidation, nanofiltration, concentration stage with reverse osmosis and, as a precaution, a softening unit by an ion exchange column. The pilot plant is capable of treating 300 L/hr of RO retentate discharged from advanced wastewater treatment facilities of Zorlu Textile. The developed process scheme results in 70-80% of recovery of NaCl for the dyeing processes. Whereas, the clean water recovery as permeate of the RO treatment unit would be 55-60%. Alternatively, this stream will be reused within the enterprise for various purposes. The process design system allows the flexibility to be operated at relevant variable flow intervals. Moreover, the arrangement of the proposed treatment units and the piping connections could be varied to a certain extent depending on the operational conditions and the requirements throughout the operation period. Hence, by this approach it is anticipated to accomplish efficient recovery of salt solution for dyeing processes.

The ZERO BRINE textile pilot is capable of treating 300 L/hr discharged RO concentrate

70-80% of recovery of NaCl for textile dyeing	**55-60% reusable pure water stream for process**

The ZERO BRINE project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 730390.