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.

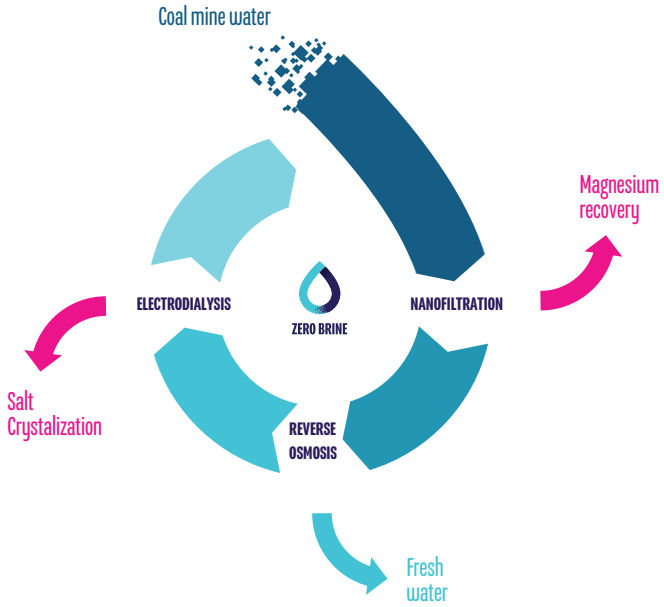
Decrease energy consumption by **50%**

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).

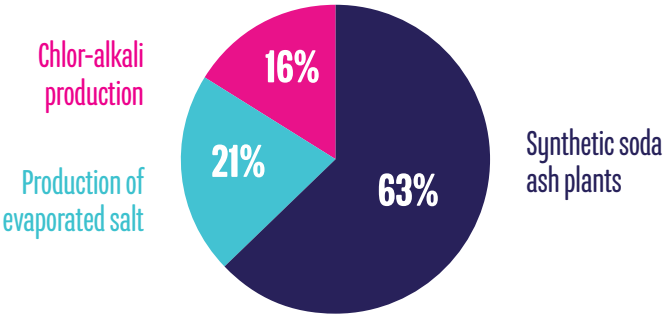
The magnesium hydroxide is of interest for the refractory materials industry. In 2006, the production of refractories in Poland reached nearly 300,000 tonnes, around 28% of which were unshaped materials. The main manufacturers in Poland include ZM Ropczyce S.A., PMO Komex (part of Alcerol-Mittal), PCO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

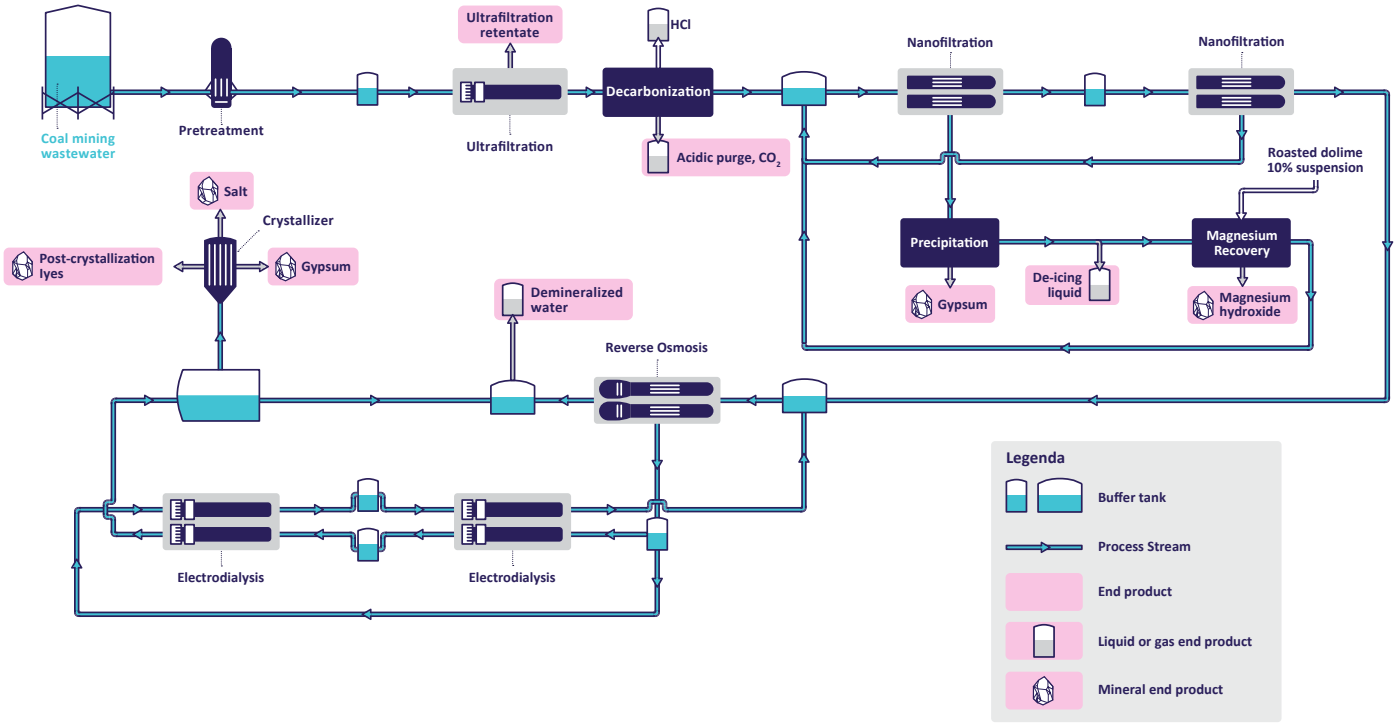
The ZERO BRINE project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 730390.

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



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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

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