

Enablers and barriers identification for the implementation of a wastewater treatment system in the coal mine sector - A multidimensional approach

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Introduction

Significant environmental impacts have been linked to coal mining through the ages [1]. The ongoing extraction and processing of coal result in the generation of substantial quantities of mine wastewater. Statistics indicate that around two tons of mine water are produced for each ton of coal mined [2]. This wastewater discharge has concerning implications for water quality and management in regions with prevalent mining activities. Specifically, the elevated salinity levels in surface waters limit their use for municipal, agricultural, and industrial purposes. Moreover, meeting the environmental objectives mandated by the Water Framework Directive (WFD) becomes unattainable due to the release of saline wastewater containing high concentrations of chlorides and sulfates that leads to the loss of significant and valuable water resources.

In the face of increasing drought challenges throughout Europe, utilizing wastewater presents a viable option for an alternative water supply, as repurposing water derived from industrial wastewater treatment facilities can effectively mitigate water scarcity [3]. The Brine Mining Project aims to enable the coal mining industry to improve its wastewater management performance in a way that yields cost-effective, resource-efficient, and legally compliant results and simultaneously facilitates the implementation of the Water Framework Directive and the Circular Economy package. This has been achieved with an economically viable, innovative system that can treat coal mine wastewater (brine) and recover water and minerals such as NaCl, Mg (OH)₂, CaSO₄, and CaCO₃. The effective implementation of wastewater treatment systems including coal mine wastewater has been supported by various EU initiatives and Legislations like the UN Sustainable Development Goals, the Water Framework Directive, and the Industrial Emissions Directive that have played a crucial role in promoting wastewater treatment and water reuse. On the other hand, there are several factors constraining the effective utilization of mine wastewater and the deployment of a coal mine wastewater treatment system. For instance, public perception has a pivotal role, as public concerns often center around potential health risks, environmental degradation, and the long-term sustainability of such projects. Significant economic barriers can also impede its implementation, as the initial capital investment required for advanced treatment technologies is substantial, often posing a financial burden for mining companies, especially smaller operators with limited budgets.

Methodology

An extended review of the current implemented legislation framework and EU Directives and Initiatives was conducted. The first part of the review focused on wastewater treatment and water reuse, while the second part centered on secondary products/minerals recovery processes and standards. Particular significance was given to the Water Framework Directive (2000/60/EC), the primary legislation for water protection in Europe since 2000, and the various Directives derived from it, such as the Environmental Quality Standards (Directive 2008/105/EC), Directive 2006/118/EC on the protection of groundwater against pollution and deterioration, Regulation (EU) 2020/741 on minimum requirements for water quality, monitoring, and risk management, Directive of 21 May 1991 concerning urban wastewater treatment that refers to the treatment and release of wastewater from specific industrial sectors, Directive 2010/75/EU for prevention and control of pollution arising from industrial activities and the Guidelines on Integrating Water Reuse into Water Planning and Management in the Context of the WFD. Regarding the secondary products recovery, the review started with the assessment of the Waste Framework

Directive on effective resource management, focusing on waste prevention, reuse, recycling and recovery. The End of waste Criteria among the REACH regulation were also reviewed. Lastly, the Industrial Emissions Directive and the BATS and BREFS on extractive waste were also carefully studied. Besides the above, through various stakeholders events, relevant to wastewater treatment and the coal mining industry, participants identified the significance of barriers and especially financial, such as the CAPEX and OPEX when implementing such systems. In the context of monitoring the socio-economic impact of the project, the site-specific analysis on the Ziemowit coal mine, indicated concerns from the public perception regarding the deployment of systems of that range. Supplementary, a bibliography review for potential barriers that could disable the successful implementation and deployment of a coal mine wastewater treatment system was executed.

Results and discussion

The extensive review of the EU Initiatives, legislations, and Directives on Water management and secondary products recovery indicated an enabling environment for the deployment of wastewater treatment systems. Many of the Goals of sustainable development of the UN promote the increase of water-use efficiency across all sectors, the implementation of integrated water resource management at all levels (6th Goal), environmentally sound management of chemicals and all wastes throughout their life cycle (12th Goal) and the prevention and significant reduction of marine pollution of all kinds (14th Goal). The WFD and all the derived directives and regulations on water protection (Table 1) aim to reduce pollution, maintain sufficient water for human and wildlife needs, and mandate the adoption of an integrated approach to water management. The Waste Framework Directive along with the End of Waste Criteria promotes the effective resource management, with a primary focus on waste prevention, followed by an emphasis on reuse, and ultimately, recycling and recovery of secondary materials. The REACH regulation encompasses all chemical substances that need to be registered in the ECHA platform before introducing its product in the market. Salts such as NaCl, Mg (OH)₂, CaSO₄, and CaCO₃ that can be recovered from coal mine wastewater, have been registered on the ECHA platform and are already widely commercialized. The system's processes are also supported/included by the BATs and BREFs on the extractive waste that include techniques to reduce the environmental footprint of the extractive industry and for the removal of specific emissions to water. Although the implementation of such systems is enabled by various legislations, specific Barriers hinder the deployment of the system. The initial investment of such systems combined with the operational and maintenance costs and the low price of the recovered products often discourage companies. Moreover, such an investment is combined by extra financial burden for the transportation and storage of the large, recovered quantities. Lastly, the public perception centered around potential health risks, environmental degradation, and long-term sustainability plays a significant role.

Table 1: Enablers and barriers identification for the implementation of the Brine Mining System.

Enablers	Barriers
Goals of Sustainable Development by the United Nations on water reuse and wastewater treatment	CAPEX and OPEX for the implementation of a coal mine wastewater treatment system from mining companies
Water and Wastewater related legislation framework	Large quantities of recovered products - need for new market
Waste Framework Directive	The low price of recovered water and salts compared to the high CAPEX and OPEX of the wastewater treatment system
End of Waste Criteria	Time is needed to have several systems in the market to increase acceptance of the new process train
REACH Regulation	Origin of recovered salts - Social and market acceptance within the value chain
Industrial Emissions Directive	Lack of a strict national legislation framework regarding (coal mine) wastewater discharge
BATS and BREF on extractive industry	Lack of financing programs/initiatives for innovative coal mine wastewater (brine) management technologies discourages their adoption in the industry
High technology readiness level	
One of the recovered materials is salt of Mg which is one of the critical raw materials	
Creation of new green jobs	

References

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