Unveiling the Social Impact of an Innovative System for coal mine wastewater management – Site-specific analysis of Ziemowit Mine in Poland

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Introduction

Coal's significance as a conventional energy source throughout the years can be attributed to its abundance and relatively easy access. In contrast with the high cost of developing alternative energy sources, it solidified its position as the preferred choice for many nations, particularly in regions with limited access to alternative energy sources. However, the continued reliance on coal has resulted in detrimental environmental and social consequences. The combustion of coal itself produces a variety of pollutants dependent on the coal's composition and emission control measures. These pollutants encompass heavy metals, and potential carcinogens like polycyclic aromatic hydrocarbons, sulfur dioxide, and nitrous oxides, all of which result in poor air quality [1]. Other significant environmental impacts include land and soil degradation and water and noise pollution.

Poland's economy has been inextricably linked with its coal mining sector, which has played a critical role in establishing its economy. The total reserves of this raw material amount to approximately 34.5 billion Mt [2]. Mine waters from these mines are indirectly discharged into tributaries of the upper Vistula and upper Oder rivers [3]. These mine waters are generally alkaline and have elevated concentrations of sodium ions, chloride ions, and sulfate contributing to the degradation of the environment. Moreover, Poland has been and is facing social problems including uncertainty surrounding the future of coal mining jobs.

The Brine Mining Project was started in the Upper Silesian Region of Poland opening the perspective for the coal mining industry to demonstrate the possibility of optimizing wastewater management performance and minimizing the social impacts of the coal mining activities in a way that yields cost-effective, resource-efficient, and legally compliant results. The project proposed and tested an innovative system that combines various units such as Ultrafiltration, Precipitation, Nanofiltration, Electrodialysis, Reverse Osmosis, Evaporator, and Crystallizer. To assess the social impact of the project's actions, a site-specific analysis was conducted in the Ziemowit Coal Mine where the demonstration system was installed and operated. Furthermore, a Social Life Cycle Analysis (S-LCA) was conducted to explore the social hotspots throughout the life cycle of the system.

Methodology

For the site-specific analysis of the Ziemowit coal mine, a social data questionnaire was developed based on the methodological sheets of UNEP/SETAC 2020 [4] and was distributed to the coal mine representatives. The Methodological Sheets of UNEP and SETAC (2020) are grouped according to 6 stakeholders: Workers, Local communities, Value chain actors (e.g., suppliers), Consumers, Society, and Children. Each stakeholder group includes several assessment subcategories (e.g., Freedom of Association is a subcategory of the Worker stakeholder category). The Subcategory Assessment Method (SAM) was chosen to analyze the data inputs. SAM enables the shift from qualitative to quantitative data using a scoring system with four levels, ranging from A to D. D indicates the lowest score and A the highest [5]. Those scores can also be translated into numbers: A equals 1 point, B: 2 points, C: 3 points, and D: 4 points. Thus, higher scores result in worse overall impacts. A total performance score can be summed and results from various organizations can be compared [6].

For the social hotspot analysis of the system, Social Life Cycle Analysis (S-LCA) was chosen. S-LCA is a methodology created to evaluate the sustainability of organizations, products, and services, with a specific focus on the Human Factor. It employs a combination of quantitative and qualitative data to assess the potential positive or negative social impacts of a product throughout its entire life cycle, including activities such as raw material extraction, production, distribution, application, reuse, maintenance, recycling, and final disposal [7]. The analysis was conducted using the SHDB which is compatible with the SimaPro software.

Results and discussion

The analysis of the Brine Mining System's social footprint using the SHDB and the site-specific analysis with SAM revealed several positive and negative impacts.

Regarding the site-specific assessment of the Ziemowit coal mine, various stakeholder groups and indicators were selected in order to evaluate its social impact. Overall, the coal mine presented a strong commitment to social responsibility across various stakeholder groups and did particularly well in areas related to worker welfare and safety. Additionally, it showed dedication to promoting social responsibility within the value chain and engaging with local communities through initiatives supporting local employment and suppliers. Furthermore, as for the local community stakeholder group, the highest score was achieved in the "Local Employment" category, particularly in indicators related to local hiring and spending on local suppliers. On the contrary, for the society stakeholder group, the lowest performance was in the "Public commitment to sustainability issues" category, due to the absence of a legal obligation to produce sustainability reports. While the coal mine has shown strengths in several areas, there is room for enhancement, particularly in terms of formalizing sustainability reporting practices and expanding social responsibility audits within its supply chain.

The Hotspot analysis of the Brine Mining System revealed a distinct pattern in commodity sourcing and its social implications. Predominantly, European countries serve as the primary sources of commodities, while metals and ferrous metals are also imported from China. Stakeholder impact assessments indicate that ferrous metals from Greece and China exert the highest influence across various categories, with notable effects on governance, human rights, health and safety, and community welfare. Further examination of social indicators highlights significant negative impacts associated with ferrous metals from both countries, particularly in indicators such as poverty, child labor, labor laws, and unemployment. These disparities between commodities from China and other countries are attributed to a range of factors including differing labor standards, regulatory environments, and production practices. Ferrous Metals and metal products from Cyprus and chemical, rubber, and plastic products from Germany and Greece follow with moderate impact on all the impact subcategories.

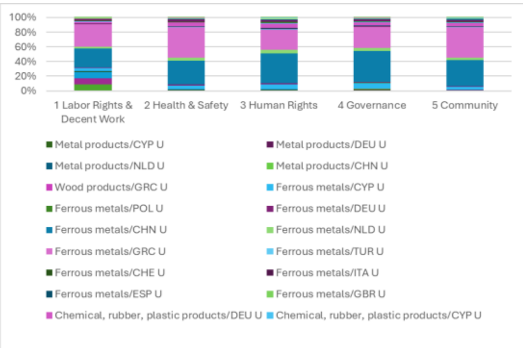

Figure 1: Analyzing 1 Brine Mining System with Social Hotspot 2019 Subcat & Cat Method w Damages/Equalsubcatweights / Normalization.

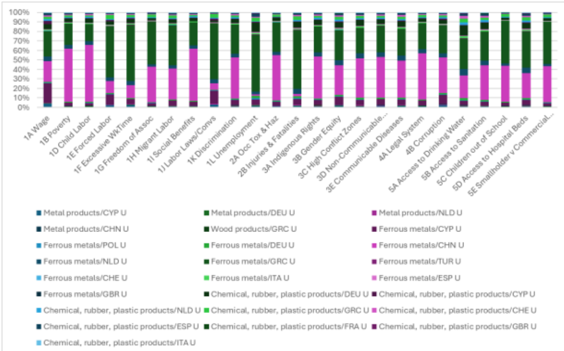

Figure 2: Analyzing 1 Brine Mining System with Social Hotspot 2019 Subcat & Cat Method w Damages/Equalsubcatweights / Characterization.

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