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GEOTECHNOLOGICAL APPROACHES TO THE DEVELOPMENT AND PROCESSING OF POTASH DEPOSITS

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Abstract. Potash fertilizer production plays a significant role in modern economic systems; however, its extraction and processing are often associated with notable environmental challenges. This study analyzes the environmental implications of potash mining, focusing on the impacts related to underground extraction of water-soluble ores. Particular attention is given to issues such as groundwater infiltration into mine workings, land subsidence, and the accumulation and disposal of solid and liquid wastes. The research highlights that mining activities influence multiple environmental components, including air quality, surface and groundwater systems, soil conditions, and vegetation cover. Among various mitigation strategies, hydraulic backfilling of underground voids is identified as one of the most effective methods, as it reduces the risk of flooding, limits subsidence processes, and minimizes the spatial extent of waste disposal. The findings emphasize the necessity of integrated environmental management approaches to ensure sustainable development of potash resources.

Keywords: potash industry, environmental impact, underground mining, potash waste, groundwater infiltration, hydraulic backfilling, waste management

Introduction

Potash minerals occupy an important place among strategically significant mineral resources due to their wide application in agriculture and industry. These minerals, mainly represented by chlorides and sulfates of potassium, are formed within sedimentary rock environments and are characterized by relatively high solubility and chemical activity. Their unique physicochemical properties determine both the complexity of extraction processes and the efficiency of their industrial utilization.

The growing demand for potassium compounds is primarily associated with their essential role in ensuring soil fertility and increasing agricultural productivity. Potassium is one of the key macronutrients required for plant growth, influencing metabolic processes, resistance to environmental stress, and overall crop quality. As a result, potash fertilizers have become a critical component in modern agricultural systems, contributing to food security and sustainable development.

At the same time, the extraction and processing of potash ores present a number of technological and environmental challenges. These challenges are linked to the geological structure of deposits, the variability of mineral composition, and the high solubility of potassium-bearing minerals, which complicates traditional mining methods. In this context, the application of geotechnological approaches offers promising solutions by enabling more efficient, environmentally safe, and economically viable exploitation of potash resources.

Materials and Methods

This study is based on a comprehensive analysis of scientific literature, experimental data, and industrial practices related to potash mining and processing. A wide range of sources in the fields of mining engineering, mineral processing, environmental science, and waste management were reviewed to identify the key technological and environmental aspects of potash production.

The research methodology includes a comparative analysis of existing mining and beneficiation technologies, with a focus on underground extraction of water-soluble ores and subsequent processing methods such as flotation and halurgical treatment. Special attention is given to the physicochemical characteristics of potash ores, including their mineral composition, solubility, and behavior under different geological and hydrogeological conditions.

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A systems-based approach was applied to assess the environmental impact of potash mining. This includes the evaluation of solid and liquid waste generation, their composition, and disposal techniques such as tailings storage, brine accumulation, and subsurface injection. Both natural and anthropogenic factors affecting environmental safety were considered, including groundwater contamination, surface water salinization, and land subsidence.

Geomechanical and hydrogeological analyses were used to assess the stability of rock masses and the risks associated with water inflow into mine workings. Particular emphasis was placed on the processes of fluid migration through fractured and porous media, which are critical for understanding flooding mechanisms and the integrity of protective geological layers.

In addition, monitoring-based methods were considered, including the analysis of environmental indicators and operational parameters. These approaches allow for evaluating the effectiveness of mitigation measures such as hydraulic backfilling, improved waste management systems, and environmentally sustainable mining technologies.

Results and Discussion

Potash ores extracted from subsurface deposits are not suitable for direct application and therefore require beneficiation to obtain marketable products. The enrichment of potassium-bearing ores is primarily aimed at separating valuable components, mainly potassium chloride, from associated minerals such as halite and other impurities. Historically, methods of thermal leaching and crystallization were applied; however, at present, flotation and galurgical techniques dominate industrial practice.

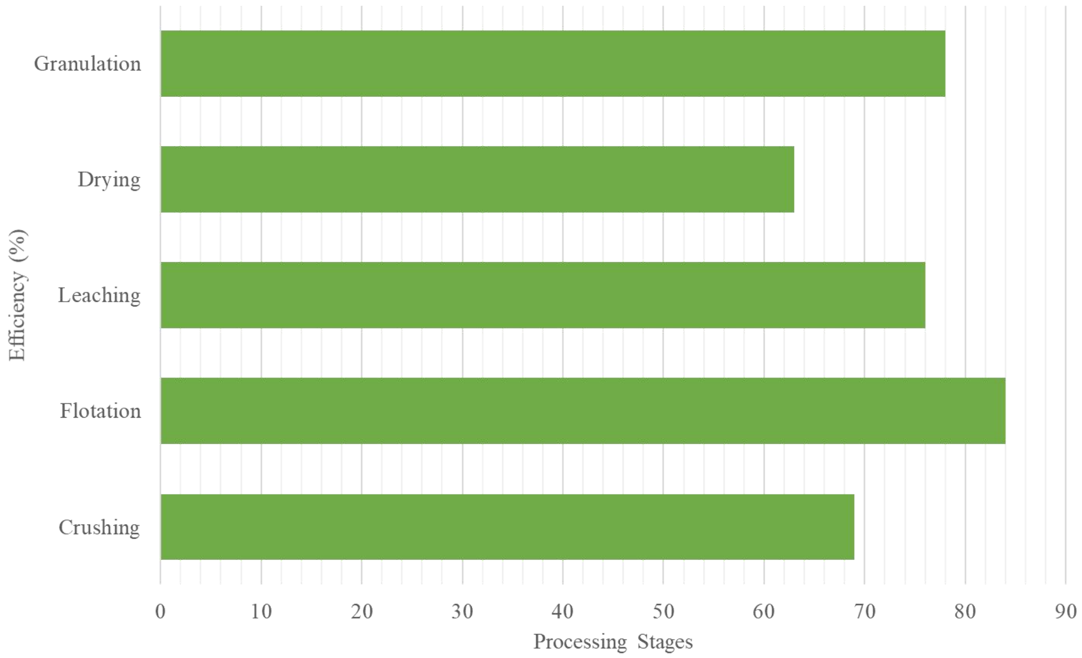

Fig. 1. Efficiency of technological stages in potash ore processing

The flotation method is based on the difference in surface wettability between sylvite and halite. By applying flotation reagents, sylvite particles become hydrophobic and are selectively transferred into the foam phase, enabling their separation from halite. This method produces fine-grained potassium chloride with a high KCl content, typically ranging from 95 to 96%, and ensures a recovery rate of approximately 85–87%. The technological scheme includes crushing, classification, removal of fines, flotation separation, dewatering, drying, and granulation of the concentrate, followed by product finishing and storage.

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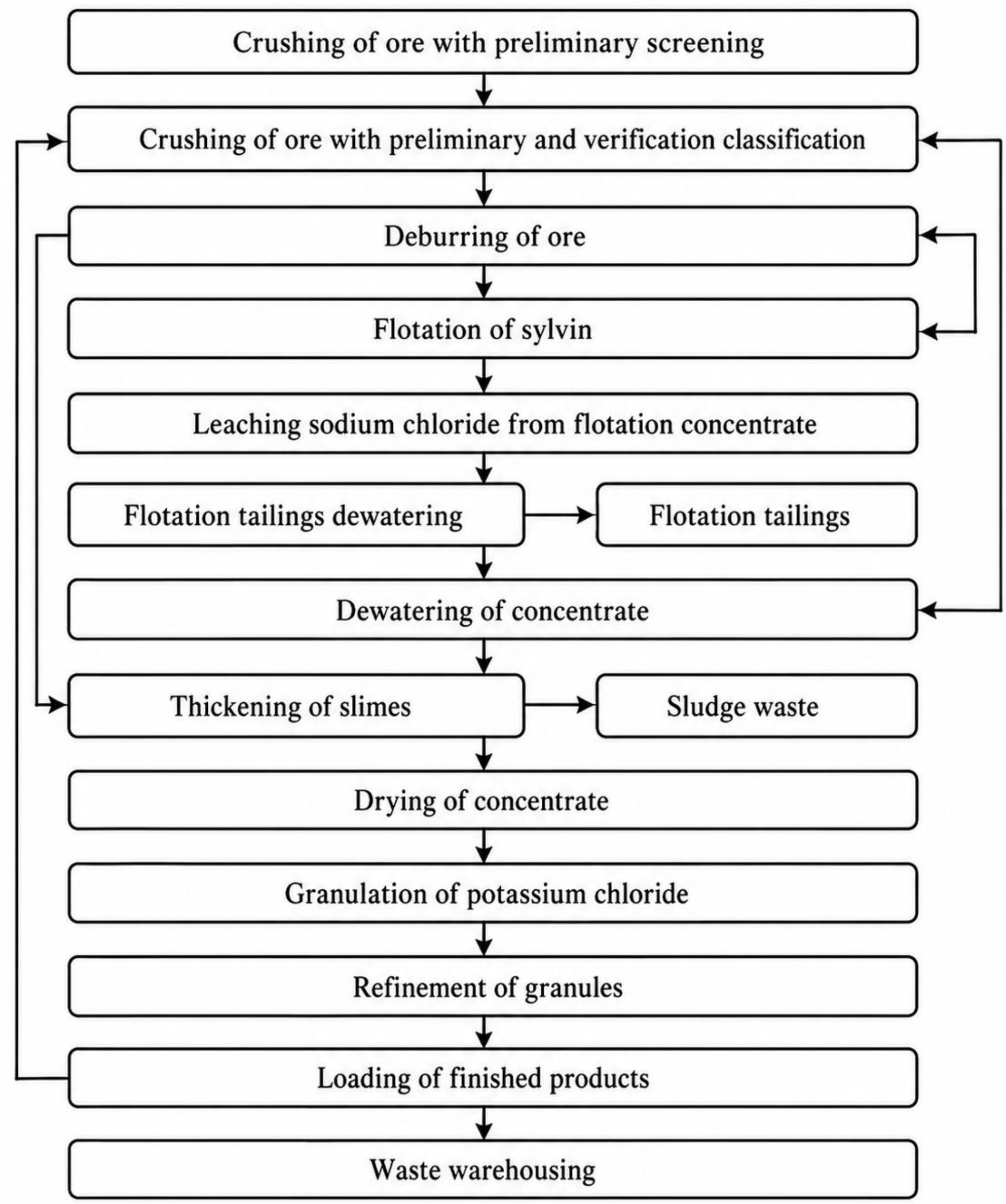

Fig. 2. Main technological stages of potassium chloride (KCl) production by flotation method

The galurgical method relies on the temperature-dependent solubility of potassium chloride in aqueous solutions. In this process, ore is subjected to dissolution, followed by purification of the solution and crystallization of potassium chloride during controlled cooling. The resulting product is characterized by high purity and stable granulometric composition. This method is particularly effective for ores where halite predominates and allows achieving recovery rates comparable to flotation.

In addition to these conventional approaches, alternative methods such as electrical separation have been considered. Although less widely implemented, such methods offer advantages in terms of reduced water consumption and environmental impact. However, due to the dry nature of the process, additional stages of drying and energy consumption may be required.

Efficient processing of potash ores requires minimizing losses of valuable components at all stages of beneficiation. This involves optimization of crushing, classification, and separation processes, as well as careful control of particle size distribution and moisture content.

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Granulation plays a key role in producing a final product suitable for transportation and agricultural application, ensuring mechanical strength and uniformity of fertilizer particles.

Conclusion

The study demonstrates that the efficient development and processing of potash deposits require an integrated approach that combines geological assessment, geotechnological methods, and optimized beneficiation processes. The analysis of flotation and galurgical techniques shows that both methods ensure high recovery and product quality when adapted to the mineralogical composition of the ore. Particular importance is given to controlling hydrogeological and geomechanical conditions, as they directly affect mining safety and the stability of the water-protective layer. The results confirm that the application of advanced processing technologies, along with proper process optimization and monitoring, significantly improves resource utilization, reduces losses, and enhances the overall efficiency and sustainability of potash production.

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