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Industrial Waste As a Secondary Source of Rare Earth Elements for Nuclear Fuel Applications

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The rising global demand for rare earth elements (REEs), especially in advanced nuclear energy systems, has increased interest in alternative and sustainable sources. Phosphogypsum (PG), a byproduct of phosphate fertilizer production, contains notable amounts of REEs such as lanthanum, uranium, thorium, cerium, neodymium, samarium, and dysprosium—elements critical to nuclear fuel applications. This study evaluates PG as a secondary source of these materials by focusing on its radiochemical and elemental composition. Samples from three PG sources, Wizów, Police, and Wiślinka (Poland), were analyzed to assess variations in radionuclide content and REE concentrations. High-purity germanium (HPGe) gamma and alpha-particle spectrometry were employed to quantify radionuclides from the 238U and 232Th decay series and 40K based on IAEA methodologies. Results revealed significant differences in activity levels between samples. The chemical composition was determined by ICP-MS and XRF, detecting REEs in all samples, with Police PG showing notably higher concentration. This research demonstrates the viability of PG as a REE-bearing material and potential input for nuclear-related applications by determining the precipitating methods of REEs. The study's primary objective is to assess PG as a dual-purpose material, addressing environmental waste management and the sustainable supply of critical resources for the nuclear fuel cycle. The work reduces REE extraction's environmental impact and carbon footprint by identifying PG as an alternative to traditional mining. This approach aligns with circular economy principles in the nuclear sector and advances long-term sustainability goals, including CO_2 emission reduction.

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