Contribution ID: **25428** Type: **Student Competition**

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

Monday, 3 November 2025 15:19 (7 minutes)

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 spectrometry was employed to quantify radionuclides from the 238U and 232Th decay series and 40K. The methodology followed IAEA protocols to ensure accuracy, including equilibrium sealing and extended counting durations. Results revealed significant differences in activity levels between samples: Ra-226 activity ranged from 279.01 $Bq\,kg^{-1}$ (Wizów) to 408.46 $Bq\,kg^{-1}$ (Wiślinka), while Th-232 was highest in Wizów (45.36 $Bq\,kg^{-1}$), suggesting variable radiological behavior. ICP-MS and XRF determined elemental composition, detecting REEs in all samples, with Police PG showing notably higher radioactivity, and Wizów PG containing approximately 0.09 wt% total REEs. This research demonstrates the viability of PG as a REE-bearing material and potential input for nuclear-related applications. 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 the environmental impact and carbon footprint of REE extraction 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 reducing CO_2 emissions.

Technical Track

Student Competition

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Session Classification: Student Competition