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Development of novel porous geopolymer monoliths based on Moroccan oil shale for effective removal of heavy metals (Zn (II), Cu (II), Pb (II)) from wastewater.

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This study presents the synthesis of Porous Geopolymer Monoliths (PGMs) through the utilization of metakaolin (MK) and oil shale (OS) as raw materials. MK contributed aluminosilicates, while OS played a multifaceted role, acting as a pore-forming agent upon mixing with phosphoric acid, enhancing the selectivity of geopolymers towards organic pollutants and heavy metals, and aiding in the sustainable utilization of local natural resources. Employing experimental design methodology, we systematically optimized the synthesis conditions of these geopolymer monoliths, systematically investigating the influence of critical factors, including the solid-to-liquid ratio (L/S), oil shale mass percentage, and phosphoric acid molar concentration. The resulting adsorbents underwent rigorous evaluation, encompassing apparent porosity measurements and assessments of their methylene blue adsorption capacity. Additionally, we assessed the optimal material's performance in the removal of heavy metals from wastewater. An extensive array of characterization methodologies, such as scanning electron microscopy (SEM), Brunauer–Emmett–Teller (BET) surface area analysis, optical microscopy, X-ray fluorescence (XRF), X-ray diffraction (XRD), Fourier-transform infrared spectroscopy (FTIR), and UV-visible spectroscopy, was employed to comprehensively analyze the produced geopolymers. Our research findings unveiled that the highest heavy metal adsorption was achieved with monolithic geopolymers prepared under specific conditions, characterized by L/S=1.08, OS=7.5%, and [H3PO4]=9.76M. These conditions demonstrated remarkable adsorption metrics, with rates of 12.5 mg/g for Cu(II), 33.3 mg/g for Pb(II), and 30.30 mg/g for Zn(II), all aligning with the expectations set by the Langmuir model.

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