Metakaolin/red mud-derived geopolymer monoliths: Novel bulk-type sorbents for lead removal from wastewaters

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In recent years, the exploration of the use of metakaolin and red mud in developing alkali-bulk-type activated materials (AAMs) as adsorbents for heavy metal removal from wastewaters has been gaining attention. The capacity to produce highly porous samples showing suitable compressive strength to assure integrity upon use in the wastewater treatment is crucial. Moreover, porous AAMs represent a cost-effective and sustainable option, as they can be produced at near-room temperature while using industrial waste as solid precursors, aligned with the principles of the circular economy, and offering a pragmatic approach to material recycling.

The current research showcases the viability and effectiveness of this approach, presenting an innovative method for tackling heavy metal removal from industrial effluents. By recycling hazardous industrial waste such as red mud, the research demonstrates the potential to transform it into valuable sorbents for environmental remediation applications.

Figure 1 shows the samples shape and their typical porous microstructure.

This innovative approach has yielded promising outcomes, with the monoliths demonstrating a maximum lead removal capacity of 30.7 mg/g (at pH 5, C_0 = 600 ppm, 6 h), which, to date, stands among the highest values reported for bulk-type AAMs. Figure 2 illustrates some results.

Furthermore, desorption tests performed to evaluate the feasibility of regeneration and reuse the sorbents multiple times have proven very promising indications. Indeed, the present study shows that the sorbents can be successfully regenerated and reused without a significant decrease in performance if a suitable regeneration agent is employed. Specifically, the results indicate that the usage of EDTA-2Na as a desorption agent, rather than a nitric acid solution, is preferred as it preserves the sorbents' performance after regeneration: the cumulative uptake after five sorption cycles with the EDTA-2Na treated samples reaches 61.8 mg/g, compared to 27.8 mg/g for the samples treated with nitric acid. This can also be observed on figure 2.

The study highlights the potential of employing AAMs in wastewater treatment systems while encouraging a sustainable approach from multiple perspectives: recycling hazardous waste while creating a new material that can be regenerated and reused numerous times for wastewater treatment.

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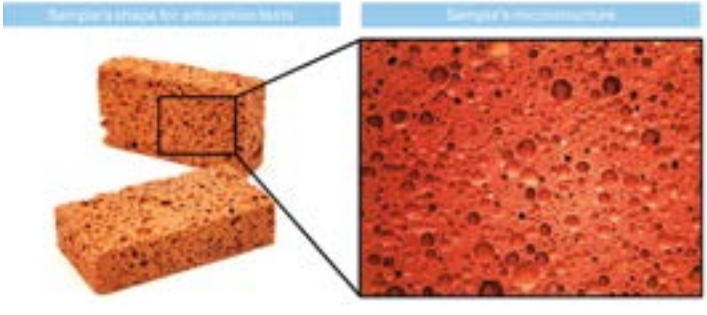

FIGURE 1
Samples shape and microstructure.

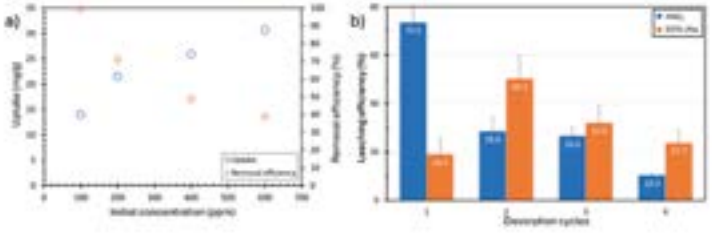

FIGURE 2
Results of adsorption a) uptake and efficiency for different lead concentrations; and b) efficiency after various desorption cycles using HNO_3 or EDTA-2Na.