Competitive Adsorption of Toxic Metals Using Activated Carbon Derived from Sargassum for Polymetallic Acid Mine Drainage Treatment

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Abstract

Acid mine drainage (AMD) represents a significant environmental threat due to high concentrations of potentially toxic elements. Adsorption with activated carbons is one of the processes used to treat these waters. In scientific literature, activated carbons are widely recognized as effective materials for the adsorption of contaminants, but activation methods and the choice of base material affect their performance. This work uses sargassum, an algae that has proliferated excessively in areas of the Caribbean, as an alternative and economic resource for producing activated carbon, thus contributing to managing this environmental waste.

This study investigated the competitive adsorption efficiency of three metals (Mn, Al, and Zn) in acid mine waters using activated carbon derived from sargassum. The relevance of this study lies in its innovative and sustainable approach to reduce metallic concentrations in AMD. The adsorption kinetics of the three study metals in an aqueous solution on activated carbon from sargassum were established. Activated carbon from sargassum was obtained by acid activation, achieving the prevalence of acid groups on its surface. The simple and competitive adsorption isotherms were determined for the three metals at different pH to evaluate this factor's influence on adsorption at room temperature.

The concentration of metals is higher in acidic water at pH 3 when compared to the model solution at pH 7. The isotherm models that best described the adsorption were the Langmuir and Jovanovic models, with a random distribution of settling times for the cases of simple and competitive adsorption. The breakthrough curves for simple and competitive adsorption on activated carbon for the three metals were determined experimentally. The results were validated in a real acidic water matrix from Barrick Gold's gold mine, demonstrating the effectiveness of acid-surfaced sargassum activated carbon under real-world conditions.

The next step will be to design a pilot adsorption column to evaluate the efficiency of the process under real-world working conditions at the mine. Using sargassum as a base material, the study offers a solution to metal contamination in AMD and takes advantage of a low-cost and abundant biomass. This presents an economically viable and sustainable alternative to conventional methods of remediating acidic mine water, which are often expensive and generate secondary by-products.

Keywords: Sargassum, gold mine, sustainable treatment, Dominican Republic