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Adsorption Studies in a Packed Bed Column for the Removal of Ca^{2+} and Mg^{2+} Ions from Water Using a Novel Polyacrylamide-*Strychnos potatorum* Seed-Derived Activated Carbon Composite (Pa-Acsp)

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Abstract

Calcium (Ca^{2+}) and magnesium (Mg^{2+}) ions contribute significantly to water hardness, which poses challenges in both residential and industrial settings. In Sri Lanka, especially in the Anuradhapura District, elevated hardness levels in drinking water are also hypothesized to be a factor in the incidence of chronic kidney disease of unknown etiology (CKDu). Drinking water in this region typically has Ca^{2+} concentrations averaging 212 ppm (ranging from 5–429 ppm) and Mg^{2+} concentrations averaging 78 ppm (ranging from 2–160 ppm). WHO recommended values for maximum Ca^{2+} and Mg^{2+} ion concentrations in drinking water are 100 ppm and 30 ppm, respectively. Adsorption is a widely recognized method for the effective removal of Ca^{2+} and Mg^{2+} ions from water. This study investigates the adsorption efficiency of a packed bed column filled with a polyacrylamide-*Strychnos potatorum*-derived activated carbon composite (PA-ACSP) for reducing water hardness.The primary goal of this research is to develop a user-friendly, economical and efficient water filtration method to mitigate water hardness, particularly in CKDu-endemic areas. The PA-ACSP composite adsorbent was synthesized by combining activated carbon derived from *Strychnos potatorum* seeds (ACSP) with acrylamide. The composite was characterized using Fourier-transform infrared-attenuated total reflection (FTIR-ATR) spectroscopy. To evaluate the adsorption performance, experiments were conducted to assess the impact of variables such as flow rate, bed height, and inlet ion concentrations on the removal efficiencies of Ca^{2+} and Mg^{2+}. Experiments were conducted at a constant temperature with fixed column dimensions. Results indicated that increased bed height enhanced removal efficiency for both ions, while higher inlet concentrations and flow rates resulted in decreased efficiency. Preliminary optimization of column parameters 6 cm in diameter, 10 cm bed height, with a 200 ppm Ca^{2+} solution and a 75 ppm Mg^{2+} solution revealed that approximately 4.5 L of water could be treated, achieving around 67.02% (±0.4) Ca^{2+} removal efficiency and 73.31% (±0.86) Mg^{2+} removal efficiency. These findings suggest that with further refinement, the packed bed column design could be adapted into an effective water filtration solution for reducing water hardness, particularly in areas affected by CKDu in Sri Lanka.

Keywords: *Ca(II), Mg(II), Strychnos potatorum, Polyacrylamide, Composite*