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Tea waste derived activated carbon – polyacrylamide composites as a potential agent for the removal of Calcium and Magnesium based water hardness

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Water hardness is caused by dissolved minerals, mostly by Calcium and Magnesium. Hardness in natural water can interfere with day-to-day household activities like laundry, washing, bathing, and personal beauty services. Clothes washed in hard water may look dull and rough. Long-term consumption of hard water can cause kidney dysfunction, which may lead to other diseases such as cerebrovascular disease, diabetes, and others. In this study, Polyacrylamide (PAM) and activated carbon derived from tea waste have been used to prepare a novel adsorbent material at temperature 55 °C, where the prepared polyacrylamide-activated carbon (PAC) composite was used as an alternative and low-cost adsorbent for reduction of Calcium and Magnesium from hard water. Batch experiments were done for both Calcium and Magnesium solutions to find out the influences of different conditions such as adsorbent dosage, initial pH of the solution, temperature, initial concentration, and contact time on the adsorption of each metal. The residual concentrations of Calcium and Magnesium were determined by Atomic Absorption Spectroscopy (AAS). A maximum reduction percentage of 98% was obtained for both Calcium and Magnesium at optimized conditions namely, adsorbent dosage 0.5 g, initial pH 7, temperature 25 °C, initial concentrations of Calcium 71 mg/L, and Magnesium 51 mg/L and contact time 120 minutes. Adsorption processes were analyzed using Langmuir and Freundlich isotherm models, and it has been shown that the adsorption of Calcium was best fitted to the Langmuir model where the adsorbate molecules have equal adsorption energies on the surface. The adsorption of Magnesium was best fitted to the Freundlich model which describes different adsorption energies. The adsorption kinetic studies revealed that the adsorption of Calcium and Magnesium onto the prepared PAC composite is best fitted to the pseudo-first-order kinetic model which assumes the rate of change of solute uptake is proportional to the difference in saturation concentration. Thermodynamic results showed that both adsorption processes were feasible and spontaneous under adsorption conditions. Further, the prepared PAC composite had a greater reduction percentage for Calcium and Magnesium than pure polyacrylamide gel or activated carbon. For both metals, the PAC composite showed a 98% reduction percentage while pure polyacrylamide gel and activated carbon showed only 16% and 75% reduction percentages, respectively. Therefore, prepared PAC composite can be used as a potential adsorbent in removing Calcium and Magnesium from aqueous media.

Keywords: Activated Carbon, Adsorption, Hardness removal, Polyacrylamide, Tea waste.