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DEVELOPMENT OF AN ECO-FRIENDLY LANTANA-BASED BIOADSORBENT FOR EFFECTIVE ALUMINIUM REMOVAL FROM INDUSTRIAL WASTEWATER

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Aluminium (Al) contamination in industrial wastewater, especially under acidic conditions, poses environmental and health risks. Conventional treatments such as chemical precipitation produce hazardous sludge. This study explores the use of invasive plant *Lantana camara* as a low-cost biosorbent for Al removal. Three approaches were applied to leaves and stems of *L. camara* as raw material, chemical surface modification, and thermal conversion to biochar. In a typical experiment, adsorbent (1.00 g) was added to 50.0 mL of 100 mg L^{-1} Al solution, shaken for 1.0 h at 150 rpm at room temperature, and analysed through atomic absorption spectroscopy. As the raw biosorbent exhibits insignificant Al removal, it is necessary to modify it for efficiency improvement. Alkaline treatment of raw biosorbent with 0.1 mol L^{-1} NaOH achieves a removal efficiency of 71.2% for leaves, and 36.0% for stems, while acidic treatment with 0.5 mol L^{-1} HNO_3 results in 61.2% and 23.6% removal for leaves and stems, respectively. Sequential acid–base treatment (0.2 mol L^{-1} NaOH followed by 0.5 mol L^{-1} HNO_3) shows maximum efficiencies of 90.4% and 93.1% for leaves and stems, respectively. Furthermore, thermal conversion of leaves into biochar showed Al removal efficiencies of 90.5%, 90.7%, 91.4%, and 92.0% at pyrolysis temperatures of 250 °C, 300 °C, 350 °C and 600 °C, respectively. Dosage optimisation reveals that even 0.10 g of leaf biochar achieves 80.6% Al removal, increasing progressively to 87.1%, 95.6%, 96.6%, 97.3%, and 99.1% at dosages of 0.25, 0.50, 0.75,1.00, and 2.00 g, respectively. Al removal increases from 73.0% at 3 min to 81.1% at 50 min with only slight improvements at 60 (83.8%) and 90 min (86.0%), making 50 min the optimal shaking time. Thermal treatment outperforms chemical modification in adsorption, structure, and sustainability. X-ray fluorescence spectroscopy shows high native Ca and K, enabling effective ion exchange. Utilising *L. camara* provides a sustainable solution for Al removal while aiding in invasive species control, ecological balance, and resource recovery.

Keywords: Aluminium removal, Biochar, Chemical modification, Invasive plant, *Lantana camara*