Evaluation of heavy metal removal potential of *Terminalia catappa* leaves using biosorption

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The contamination of aquatic systems with toxic heavy metals is a significant environmental and health concern. This study assessed the biosorption potential of *Terminalia catappa* leaves for Pb^{2+}, Cd^{2+}, Hg^{2+}, As^{3+}, and Cr^{3+} ions. Batch experiments were conducted at pH ~6, 30 °C, and contact times of 10–70 min. Initial metal concentrations were adjusted to 3–15 µg/L for Pb, Cd, and Cr; 0.3–1.5 µg/L for As; and 0.06–0.5 µg/L for Hg, in order to evaluate adsorption behavior using the Langmuir and Freundlich isotherm models. Metal quantification was performed using ICP–MS. Adsorption data showed strong agreement with the Langmuir model (R^2 = 0.98–0.99), confirming monolayer adsorption. Maximum adsorption capacities (Q_{max}) were 14.2 µg/g for Cd^{2+}, 4.8 µg/g for Cr^{3+}, 3.2 µg/g for Pb^{2+}, 0.2 µg/g for As^{3+}, and 0.1 µg/g for Hg^{2+}. Arsenic displayed the highest removal efficiency (~95%) at trace levels, while cadmium exhibited the greatest adsorption capacity overall. Lead showed moderate uptake (~75%). Freundlich modeling indicated favorable adsorption only for Cd^{2+} (K = 1.05, R^2 = 0.9999), with K representing adsorption capacity. Other metals showed weaker fits (R^2 < 0.85), further supporting Langmuir as the better model. Fourier transform infrared (FTIR) analysis revealed shifts in –OH stretching (3293 → 3296 cm^{-1}, broad peak), C=O stretching (1730 → 1736 cm^{-1}), and amide I (1607 → 1630 cm^{-1}), suggesting the participation of hydroxyl, carboxyl, carbonyl, and amide groups in binding. Though some shifts were small (>5 cm^{-1}), their consistency indicated meaningful structural changes due to metal chelation. Overall, *T. catappa* leaves demonstrate potential as a sustainable biosorbent, with particular effectiveness towards Cd^{2+} and As^{3+} removal. Further investigation into regeneration and real wastewater performance is recommended for assessing field-scale applicability.

Keywords: *Terminalia catappa, Biosorption, Heavy metals, FTIR, Langmuir isotherm*