INDIAN INSTITUTE OF TECHNOLOGY GUWAHATI
SHORT ABSTRACT OF THESIS

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Thesis Title: **Remediation of Lead-acid Battery Wastewater and Sludge: Synthesis of Functionalized Sorbents and Manufacturing of Fired Clay Bricks**

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SHORT ABSTRACT

The lead acid battery (LAB) industry is one of the most polluting industries that generate highly contaminated heavy metal laden wastewater (LABW) as well as sludge (LABS). Two functionalized sorbents viz. functionalized fibrous adsorbent (FFA) and functionalized mercerized husk (FMH, a bio-resin) were synthesized using a locally abundant waste biomass, arecanut husk, for the decontamination of LABW. Both FFA and FMH achieved 99% removal efficiency of Pb(II) from an initial concentration of 32 mg/L at pH 5 with a dose of 1 and 5 g/L, respectively. A simple proton adsorption model (PAM) was developed, and the pK_a values were estimated to be 3.21 (carboxylic site) and 1.62 (sulfonic site) for FFA, and 3.29 (carboxylic site) for FMH, respectively. The Pb(II) binding constant to carboxylic and sulfonic groups of FFA were found to be 5.2×10^6 and 28.11 L/mol, respectively, whereas it was 1.73×10^3 L/mol for FMH as estimated from the modified PAM. FFA showed the exhaustion capacity of 194.94 mg/g, which was about 3.4 times higher than the commercial activated carbon. FFA exhibited complete removal of Pb from LABW, and the removal efficiencies were 85, 84, and 56% for Fe, Cd, and Mg, respectively, with 5 g/L of FFA at pH 5 complying the discharge standards adopted in India.

The second part of the doctoral work explored valorization potential of LABS through heavy metal recovery and production of fired clay bricks. The abundance of Pb, Fe, Zn, Cu, and Cd in LABS determined to be 8322±11, 15721±21, 310±2, 175±4, and 1215±7 mg/kg, respectively. The metals were mostly concentrated in the finer fractions and only 5% metals were present in the coarser fraction (>75 µm). LABS was found to be highly hazardous in nature based on the toxicity characteristic leaching procedure (TCLP) and potential environmental risk (PER) analyses. Valorization through acidification showed citric acid to be best eluting agent with leaching efficiencies of 47, 77, 60, 19, 58, 59, 67, 41, and 51 for Pb, Fe, Cu, Cd, Ni, Mn, Al, Co, and Zn, respectively. The bricks produced with 5% LABS showed the highest compressive strength of 74 N/mm^2 against the water absorption of 2.1% at a firing temperature of 1050°C. The addition of LABS with virgin clay improved the ductile behavior of bricks avoiding catastrophic failure and imparted yellow coloration due to high CaO content. Furthermore, the TCLP test confirmed effective fixation of Pb, Cd Ni, and Zn, and the bricks (B20) with 20% LABS complied IS:1077:1992 class 12.5 and ASTM International.