



INDIAN INSTITUTE OF TECHNOLOGY GUWAHATI  
SHORT ABSTRACT OF THESIS

Name of the Student : PARTHA PROTIM BAKAL  
Roll Number : 156152010  
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Name of Thesis Supervisor(s) : Prof. Gopal Das and Prof. Aiyagari Ramesh  
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Generally, biosorbents can be derived from animals, plants, and microbial wastes. The animal sources are fishery and animal husbandry, while plant-based biomass is forestry and agriculture. Herein, our focus is on the plant-based biosorbent for synthesizing activated biochar and hydrochar for the removal of dyes and heavy metals and the synthesis of carbon dots for metal sensing applications. *Ricinus communis* stem (RCS) was chemically activated with potassium carbonate ( $K_2CO_3$ ) and heated at  $300^\circ C$  to produce low-temperature *Ricinus communis* stem-activated biochar (RCSB). Initially, adsorption experiments were carried out with nine cationic and anionic dyes. Among these dyes, two cationic dye, malachite Green (MG) and methylene Blue (MB), shows more than 90% dye removal using RCS (92%) and RCSB (99%). The kinetics and equilibrium data were best fitted with the intra-particle diffusion kinetics model ( $R^2=1$ ) and the Langmuir isotherm model. Adsorption experiments were performed to evaluate the effect of pH, adsorbent dosage, contact time, initial dye concentration, stirring speed, particle size, and temperature. The thermodynamic parameters support the feasible, spontaneous, and exothermic adsorption in the temperature range of 293-323K. Desorption experiments were carried out at pH 2 with an efficiency of ~97 %. Regeneration study indicates biosorbents can be recycled in up to five cycles. The present studies suggest using RCS and RCSB has potential application as eco-friendly biosorbents for efficient removal of MG and MB dyes up to 99%.

Similarly, potassium carbonate-activated biochar derived from the stems of *Ricinus communis* (RCSB) and *Colocasia esculanta* (CESB) were used for the efficient removal of  $Cd^{2+}$  and  $Pb^{2+}$  ( $50\text{ mg L}^{-1}$  each) from synthetic water. These two ions adsorption is higher than other tested heavy metal ions (*viz.*  $Ni^{2+}$ ,  $Zn^{2+}$ ,  $Cu^{2+}$ ,  $Hg^{2+}$ ,  $As^{5+}$ , and  $Cr^{6+}$  ions). Different adsorption

parameters (pH, metal concentration, time, dosage, and temperature) were studied for the optimized result. The adsorption isotherm, kinetics, thermodynamics, and mechanism were studied. The adsorption isotherm studies indicate that heavy metal ion biosorption follows the Freundlich isotherm. The adsorption kinetic model can be best described as pseudo-second-order, and the adsorption mechanism is physical adsorption. The optimum conditions for the adsorption of  $\text{Cd}^{2+}$  and  $\text{Pb}^{2+}$  by activated biochars were: adsorption time 120 minutes, temperature 20-25°C, and pH between 6.8 and 7.2. The adsorption capacity of Cd-RCSB, Cd-CESB was  $\sim 204 \text{ mg. g}^{-1}$ , and Pb-RCSB, Pb-CESB was found to be  $\sim 200 \text{ mg. g}^{-1}$  and  $\sim 208 \text{ mg. g}^{-1}$ . The adsorption thermodynamics showed that the adsorption was a spontaneous and endothermic process. Desorption studies show that biochar can be recycled for up to 5 cycles. All these results can be summed up that RCSB & CESB have good potential for removal of heavy metal ions (particularly  $\text{Cd}^{2+}$  &  $\text{Pb}^{2+}$ ) from an aqueous environment up to 99%.

In another study *Colocasia esculanta* stems (CES) have been chosen for simultaneous removal and sensing applications of heavy metals. Hydrochar generated in the hydrothermal treatment process is used for the adsorption of  $\text{Pb}^{2+}$  and  $\text{Cd}^{2+}$  ions. Various experimental parameters (pH, metal concentration, time, dosage, and temperature) were studied for the optimized result. The adsorption isotherm studies indicate that heavy metal ion biosorption follows the Freundlich isotherm. The adsorption kinetic model can be best described as pseudo-second-order, and the adsorption mechanism is physical adsorption. The optimum conditions for  $\text{Cd}^{2+}$  and lead  $\text{Pb}^{2+}$  by activated hydrochar were: adsorption time 120 minutes, temperature 20-25°C, and pH between 6.8 and 7.2. The filtrate is taken for preparing carbon dots and heavy metal sensing applications. The synthesized carbon dots were characterized by UV, transmission electron microscopy, atomic force microscope, Raman, FTIR, UV-Vis, and fluorescence spectroscopy. The resulting carbon dots exhibit stable fluorescence with a quantum yield of 15.5%. The carbon dots emitted the fluorescence emission in 445nm wavelength and were used to detect  $\text{Hg}^{2+}$  and  $\text{Fe}^{3+}$  ions at the excitation of 370 nm. It has been found that  $\text{Hg}^{2+}$  and  $\text{Fe}^{3+}$  ions influence the fluorescence intensity quenching of carbon dots stronger than other heavy metals, and detection can be achieved within 2 minutes. Hence, *Colocasia esculanta* stem Simultaneous removal and sensing of heavy metal ions using plant-derived biosorbent.