INDIAN INSTITUTE OF TECHNOLOGY GUWAHATI
SHORT ABSTRACT OF THESIS

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Thesis Title: **Vegetal Route for the Synthesis of Iron Oxide and its Composite Nanostructures for Cr(VI) Decontamination**

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Thesis Submitted to the Department/ Center	:	**Centre for the Environment**
Date of completion of Thesis Viva-Voce Exam	:	**12-06-2024**
Key words for description of Thesis Work	:	**Nature-inspired process; Plant-based polyphenols; Iron oxide nanoparticles; Central composite design; Green synthesis process; Cr(VI) adsorption; Bi-functional composite adsorbent; Cr(III) co-precipitation; Hydrogel beads; Antibacterial functionality; Fixed-bed column; Breakthrough curve; Adsorbent regeneration and reuse**

SHORT ABSTRACT

Access to drinkable water is fundamental for all life forms, including the human species. Water is necessary for various purposes beyond consumption, including home, industrial, and agricultural uses. Large quantities of hazardous chemicals, metals, dyes, and similar substances were discharged into water bodies like rivers. This causes water pollution by releasing harmful environmental substances such as heavy metals, pigments, and chemicals. Hexavalent chromium is a prime example of this type of pollutant. Many diseases, including cancer, have been linked to exposure to hexavalent chromium. The World Health Organization and the Indian Standard (IS:10500) have established a permissible limit for hexavalent chromium in drinking water at 0.05 mg/L. The removal of Cr(VI) through its adsorption, specifically using nanoparticles synthesized from green sources (plant part extract), is an environmentally benign technology that does not require harmful chemicals. This doctoral study utilizes phytochemicals from matured Tea (*Camellia sinensis var. Assamica*) leaves extract and polyphenols (tannic acid) to synthesize engineered Iron oxide nanoparticles (IONPs) for the adsorption of hexavalent chromium from aqueous solution.

The IONPs were synthesized using tea leaves extract of *Camellia sinensis var. assamica* for Cr(VI) removal from an aqueous solution. The various removal conditions (pH, temperature, contact time, doses, and initial Cr(VI) concentration) of Cr(VI) through synthesized IONPs were also optimized. The adsorption process followed a pseudo-second-order kinetic and Langmuir isotherm, with a remarkably higher maximum adsorption capacity of 1272 mg g^{-1} of IONPs. Furthermore, reusable and bi-functional composite chitosan (CS) beads (CS/IONPs) were developed by infusing IONPs in the CS matrix and applied for Cr(VI) adsorption and detoxification from synthetic wastewater. At the optimized conditions (pH 3, 25°C, 480 min, 2.5 g/L of CS/IONPs beads, and 150 mg/L of Cr(VI)), 98.71% removal of Cr(VI) was observed. The synthesized adsorbent (CS/IONPs) was tested for reusability, and a gradual decay was perceived in Cr(VI) removal within 5th cycles of adsorption. Moreover, the investigation further focuses on synthesizing

multifunctional beads utilizing sodium alginate (Alg) and tannic acid (TA). These formed Alg-TA beads possess distinctive properties, including metal(s) ion adsorption, antimicrobial effects, and metal particle generation. Thus, formed Alg-TA75-Fe beads facilitate the removal of 95% Cr(VI) from 20 mg/L aqueous solution at pH-4 and a dosage of 2 g/L, respectively. Also, Alg-TA75-Fe beads improved antibacterial performance by 3.89 and 1.37 times for *E.coli* and *E.hirea*, respectively, compared to Alg-TA75 beads.

The synthesized CS/IONPs and Alg-TA55-Fe adsorbent beads for removing Cr(VI) from an aqueous solution in a fixed-bed column was also demonstrated. The duration of the breakthrough time (t_b) was increased from 5 to 22 h and 0.75 to 4.5 h with an increase in bed height from 5 to 15 cm at a flow rate of 1 mL/min for CS/IONPs and Alg-TA55-Fe beads, respectively. On the other hand, when the flow rate increased from 1 to 3 mL/min, the tb values for CS/IONPs and Alg- TA55-Fe beads dropped from 5 to 1.5 h and 0.75 to 0.37 h, respectively. A maximum bed capacity of 391.9 and 60 mg g^{-1} was achieved with a 5 cm bed height and 1 mL/min flow rate at a fixed 20 mg/L Cr(VI) influent concentration for CS/IONPs and Alg-TA55-Fe beads, respectively. The reusability studies revealed that CS/IONPs beads outperformed Alg-TA55-Fe beads, exhibiting a longer breakthrough time and high adsorption capacity.