



INDIAN INSTITUTE OF TECHNOLOGY GUWAHATI
SHORT ABSTRACT OF THESIS

Name of the Student : VIBHA SINHA
Roll Number : 11610602
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Name of Thesis Supervisor(s) : Prof. Kannan Pakshirajan
Prof. Rakhi Chaturvedi
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SHORT ABSTRACT

Chromium (Cr) is one of the high priority heavy metal pollutants commonly present in soil, aqueous waste stream and groundwater and, therefore, it can cause serious health hazards. Water pollution by Cr is of considerable concern in many countries, including India as it is widely used in many industries. Hexavalent form of chromium [Cr(VI)] is considered highly hazardous for most organisms due to its potential mutagenic, carcinogenic and teratogenic effects. Therefore, it is essential to treat effluent from Cr utilising industries prior to its discharge into aquatic environment.

In comparison with the physico-chemical and biological processes employed to treat Cr containing wastewater, phytoremediation using indigenous and wild plant species is a more cost-effective, efficient and sustainable alternative. It also requires no special growth conditions particularly for treating large-scale, low-level Cr contamination.

The present thesis aimed to mitigate the environmental pollution due to the discharge of Cr(VI) containing industrial wastewater. The potential application of phytoremediation using indigenous *Tradescantia pallida* plants that can tolerate, absorb and significantly bioaccumulate Cr(VI) in their parts is demonstrated. This plant species could be used in constructed wetlands to enhance the Cr(VI) reduction and retention in the soil, thereby serving as an efficient system to treat Cr contaminated water.

The present research work is focused on studying the mechanism of Cr(VI) tolerance, uptake and transport, localization and storage in *T. pallida*. Kinetics, biochemical and factorial analysis of Cr uptake in a multi-ion system by *T. pallida* were further examined. Continuous studies employing a laboratory

scale constructed wetland were carried out further to study the plants efficiency and its applicability to treat Cr contaminated water. Different indigenous plant species were initially screened for their Cr(VI) tolerance and uptake under batch hydroponic conditions. Among the different plants screened in this study, *T. pallida* was selected based on its significant bio-concentration factor (40.8), translocation factor (0.759) and tolerance index (87%) towards Cr. In order to understand the mechanism of Cr uptake and tolerance by *T. pallida*, analyses of its antioxidant enzyme system and different biochemical parameters were carried out during its growth and in the presence of 5-20 mg/L Cr(VI) concentration in hydroponic environment for up to ca. 90 days. Maximum Cr(VI) bioaccumulation in *T.pallida* roots reached up to 536 µg/g dry weight after 60 days of hydroponic culture. Increased activities of antioxidant enzymes, particularly ascorbate peroxidase (9,823±25 U/mg protein) was found to be highly up-regulated, which showed their important role in overcoming the Cr-induced oxidative stress on the plant.

Many of the tannery and electrochemical industries discharge different types of wastewater into the environment primarily in the form of liquid effluents containing both organic matter and toxic chemicals. Among them, SO_4^{2-} , NO_3^- and PO_4^{3-} ions are commonly present in industrial wastewater along with Cr oxyanions species that can effect each other removal. Thus, interaction effect and simultaneous removal of Cr(VI) in presence of co-ions viz SO_4^{2-} , NO_3^- and PO_4^{3-} were evaluated. Removal of Cr(VI) was found enhanced in the presence SO_4^{2-} ions at a high initial Cr(VI) concentration (20 mg/L). At the optimized conditions of the process parameters, a maximum removal of 84% Cr(VI), 87% SO_4^{2-} , 94% NO_3^- and 100% PO_4^{3-} was achieved with no visible phytotoxicity to *T. pallida*, thereby demonstrating an excellent tolerance of the plant towards Cr even in presence of the co-ions. Cr uptake mechanism and its subcellular distribution within *T. pallida* plant tissue were determined using different techniques, including atomic absorption spectroscopy (AAS), differential centrifugation and energy dispersive X-ray (EDX) analyses. Subcellular fractionation of Cr-containing tissues showed that most of the accumulated Cr was found in the root vacuoles and the plant cell wall. Whereas the EDX spectra showed that the electron dense areas contained high Cr in these cell compartments. All these studies confirmed a very good potential of *T. pallida* plants in Cr(VI) removal from contaminated water.

Continuous Cr(VI) removal from synthetic wastewater by *T. pallida* was evaluated using a laboratory-scale vertical subsurface flow constructed wetland (CW) system. The effect of different parameters (pH, HRT and inlet Cr(VI) concentration) on the continuous Cr(VI) removal was carried out using the constructed wetland system. Best results were achieved for 2 d HRT and for an influent pH of 7 with a maximum Cr(VI) removal efficiency of 97.2-98.3%. This study showed the importance of influent pH which controls the Cr removal mechanism in the CW. At the same pH, a maximum total Cr removal efficiency in the range 86-88.2% was achieved. Distribution of Cr in CW revealed that the soil acts as the main sink for Cr, sequestering up to 40-68.41% of the total Cr supplied to the system. Thus, the present study successfully demonstrated the potential of *T. pallida* plants based vertical subsurface CW as an alternative sustainable remediation method for the removal of Cr(VI) from industrial wastewater.

Biosorption experiments aimed at reusability of the Cr(VI) accumulated *T. pallida* plant biomass were carried out. It serves as a value added step in the process from remediation to biomass disposal. Cr(VI) biosorption studies using plant biomass, showed that Cr(VI) exposed/unexposed *T. pallida* leaf biomass could remove 94% of chromium with a sorption capacity of 64.672 mg/g. Optimum Cr(VI) sorption conditions was achieved at pH 2, contact time (5 h), sorbent dosage (1 g), Cr(VI) initial concentration (100 mg/L) and temperature 50°C. The significant biosorption capability of the Cr accumulated plant biomass revealed a very good potential application as well as safe disposal of generated toxic biomass following phytoremediation, thus reducing their environmental impact.