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EICHHORNIA CRASSIPES: A HYDROPHYTE REMOVES CHROMIUM IN INDUSTRIAL WASTEWATERS. A ECO-FRIENDLY PHYTOREMEDIAL PLANT SOURCES

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ABSTRACT

Chromium is one of the environmental pollutant that is toxic even at low concentration. Industrial waste water discharge is the most important source of chromium in water. Phytoremediation an emerging technology for contaminated soils, ground water and waste water that is low cost and environmental friendly have been employed in this study. Water hyacinth *(Eichhornia crassipes)* has been used to remediate the industrial waste water. In the present study, *Eichhornia crassipes* has been tested for removal of chromium from aqueous chromium solution. Young plants of equal size were cultured in a plastic tub containing a synthetic solution of chromium ($K_2Cr_2O_7$). *Eichhornia crassipes* was cultured in tap water which was supplemented with three different concentrations 10, 25 and 50 mg/L of chromium for 10 and 20 days. The digested samples were analyzed using AAS (Atomic Absorption Spectrophotometer). The plant performed extremely well in removing the chromium at low concentration. Addition of chromium at lower concentration (10mg/L) was found harmless and the absorption of chromium was found to be higher upto 20 days, but at 25 and 50 mg/L of chromium, the plants have shown morphological symptoms of toxicity. The present study conducted in this regard revealed the efficiency of *Eichhornia crassipes* in removing chromium from industrial waste waters.

KEYWORDS: **Phytoremediation, Potassium dichromate, *Eichhornia crassipes*, Atomic Absorption Spectrophotometer (AAS).**

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INTRODUCTION

Water bodies are the main targets for disposing the pollutants directly or indirectly. The main hazardous content of the water pollution are heavy metals. Heavy metals pollution of water is a major environmental problem in the modern world faces. Rapid industrialization and urbanization have resulted in elevated emission of toxic heavy metals entering the biosphere.[1] Activities such as mining and agriculture have polluted extensive areas throughout the world.[2,3] The release of heavy metals in biologically available forms by human activity, may damage or alter both natural and man-made ecosystems.[4] Chromium, a non essential micronutrient, has been reported to be one of the most toxic heavy metal present in waste water. It gets discharged from electroplating, dye and pigment manufacturing, wood preserving and tanning industries. Chromium is mobile and has long resident time in water environment. It causes severe health hazards to living organisms and impairs the development and growth of plants.[5] Heavy metals are reported to be toxic and found associated with the occurance of several health effects. However, at high concentration, Cr (VI) is toxic, mutagenic, carcinogenic and teratogenic. [6] For the treatment of such industrial waste water containing toxic metals, various chemical and engineering method are available, however they are expensive and energy consuming.[7] Treatment systems using plants are low cost and suits to our environment. The uptake of metals by watery hydrophytes may give an indication of the major source of pollutants in the aquatic system. The uptake of pollutants from water using aquatic hydrophytes is one of the pathways aimed at assessing the hazard of chemical contaminants in water. Plants such as *Eichhornia crassipes* can facilitate biodegradation of organic pollutants, it can absorb heavy metals and it is a good accumulator of Cr, Zn, Cu, Pb, Ag, and Cd.[8] Hydrophytes can absorb heavy metals via roots, stems or leaves, and accumulate them in the organs. They can absorb elements selectively. Accumulation and distribution of heavy metals in the plant depend on the plant species, bioavailability, pH, cation exchange capacity, dissolved oxygen, temperature, and secretion of roots. Plants are employed in the decontamination of heavy metals from polluted water and have demonstrated high performance in treating mineral water and industrial effluents.[9] Hydrophytes absorb heavy metals from the water and those rooted ones also from the bed material. Hydrophyte accumulates high amounts of heavy metals. In this way, they reflect the toxicity of the water environment and may serve as a tool for the biomonitoring of contaminated waters.[10-14] For growth and development plants absorb large amounts of elements and only small amounts of toxic elements that could harm them. Removal of toxic heavy metals from industrial wastewater is essential from the standpoint of environmental pollution control.[15] The laboratory studies demonstrated that the potential use of water hyacinth plants in removing metals from polluted water and have shown that metal concentrations of the plant and the water column are correlated. Water hyacinth, *Eichhornia crassipes*, is a floating hydrophyte whose appetite for nutrients and explosive growth rate has been put to use for cleaning up municipal and agriculture waste water.[16] The focus on water hyacinth as a key step in waste water recycling is due to the fact that it forms the central unit of recycling engine driven by photosynthesis and therefore the process is sustainable energy efficient and cost efficient under a wide variety of rural and urban conditions.[17] The aim of the present study was to demonstrate the phytoremediation potential of water hyacinth, *Eichhornia crassipes* for the removal of chromium. The water hyacinth plant is rapidly infesting many aquatic ecosystems in the country. However there are possibilities for using the hyacinth plant in heavy metal removal, considering its reported success in general waste water treatment .[18] Such system could be inexpensive, providing the developing countries with an appropriate technology thus contributing to environmental sustainability.

Water Hyacinth

Water Hyacinth *(E.crassipes.)* is a fast growing perennial aquatic macrophyte and its name *Eichhornia* was derived from well known 19th century Prussian politician J.A.F. *Eichhorn* [19] It is well known for its reproduction potential and the plant can double its population in only twelve days. Water hyacinth is also known for its ability to grow in severe polluted waters. *E.Crassipes* is well studied as an aquatic plant that can improve the effluent quality from oxidation ponds and as a main component of one integrated advanced system for the treatment of municipal, agricultural and industrial waste waters.[20]

MATERIALS AND METHODS

(i) Plant material

Young plants of *Eichhornia crassipes* were obtained from a local unpolluted pond located at Tamilnadu. Aquatic hydrophyte *Eichhornia crassipes* was selected to assess its heavy metal removal capacities for chromium from tannery effluent under laboratory condition. Uniform sized plants approximately 200g weight of *Eichhornia crassipes* with similar shoot area and root length were selected for the present study. They were washed thoroughly under a running tap water propagated hydroponically for twelve days and subjected to heavy metal treatments (PARC/2016/3284).

(ii) Study of growth characteristics

Plants from each treatment were carefully removed and washed thoroughly with distilled water. This plant material was analyzed for their growth characteristics, Fresh weight biomass, Dry weight biomass, Chromium accumulation of the plant and Relative Growth.

(iii) Preparation of chromium solution

The source of chromium used in this study was a solution of potassium dichromate ($K_2Cr_2O_7$) of analar quality. A stock solution of potassium dichromate was prepared by dissolving 2.828 g of potassium dichromate in one litre of distilled water.[21] So as to make a concentration of 1000µg cr/ml. Aliquots of this stock solution were added to the experimental plastic tubs in varying amounts to attain varying concentration (0, 10, 25,50mg/l) of chromium in the four treatments as T1, T2, T3 and control.

(iv) Biological Treatment

An experiment was conducted to investigate the accumulation of chromium by *Eichhornia crassipes.* Synthetic solutions of chromium having various concentrations of 10, 25, & 50 mg/l were prepared and treated to the plants. All the experiments were maintained in triplicate in an outdoor condition (ENVIRONMENTAL TEST HOUSE, Pondicherry). The aquatic plant grown in tap water was taken as control.

(v) Description of the experimental set up in the laboratory

The laboratory experimental set up for chromium removal mechanism consisted of four plastic tubs with water hyacinth as shown in figure 1. The first tub served as control (blank) without $K_2Cr_2O_7$. Second, Third and Fourth tub containing 10, 25and 50 mg/L of $K_2Cr_2O_7$. Whole experiment was run with the above concentration and all the parameters were studied after 10 and 20 days.

(vi) Chromium Accumulation

Chromium metal content in different parts of the plant was analysed. The aquatic plant was harvested after10th and 20th days of chromium exposure. The collected plants were wiped with 0.01 N HCl washed thoroughly with tap water and finally washed with distilled water in order to remove adsorbed ions. The plants divided into root,stem and leaves and oven dried at 150^0 C for one hour. Then the samples were grinded with a pestle mortar and sieved and it was digested with HNO3: HCl in the ratio of 7:5 then it was made upto 100ml using SMF (Standard Measuring Flask) and it was filtered using whatmann No.1 filter paper. At last it was placed in plastic bottles and namedasT1R,T2R,T3R,T1S,T2S,T3S,T1L,T2L,T3LRL respectively and analyzed by AAS(Atomic Absorption spectrophotometer).

(vii) Relative growth (RG)

The relative growth of control and treated plants was calculated using Equation given below to assess the effect of chromium concentration on water hyacinth plant growth.

RG=FFW/IFW

Where RG denotes relative growth of water hyacinth plants during experimental period, dimensionless; FFW denotes final fresh weight in grams of water hyacinth plants taken at the end of each experimental period, and IFW denotes the initial fresh weight in grams of water hyacinth plant taken before starting experiment.

(viii) Statistical analysis

In order to detect quantitative differences in the data, statistical analysis was performed. The data were analyzed through SPSS statistical package for one way ANOVA.

RESULTS

Phytoremediation technique is useful for the cleanup of pollutants. It showed the ability of bioaccumulation and degradation of contaminants with *Eichhornia crassipes.* The plant has been studied and was found to be suitable for reducing the concentration of chromium. The present study focuses on the overall performances of *Eichhornia crassipes* for reducing the chromium concentration and showing its absorbance in the root,stem and leaves.

Figure I
Experimental Set up of Water Hyacinth

Table1
Effect of Potassium dichromate(mg) on fresh weight and dry weight of Eichhornia crassipes

Chromium concentration	Plant weight in grams on 10th day	Plant weight in grams on 20th day	P value
Fresh weight Control	210.65±0.932	220.14±0.765	0.001
10 mg/l	209.95±0.405	205.54±0.955	
25 mg/l	199.77±1.254	189.62±0.521	
50 mg/l	179.54±2.259	160.12±0.161	
Dry weight Control	119.63±1.203	125.26±1.175	0.001
10 mg/l	90.29±0.454	80.80±0.463	
25 mg/l	78.95±0.836	60.49±0.450	
50 mg/l	60.80±1.074	49.88±0.810	

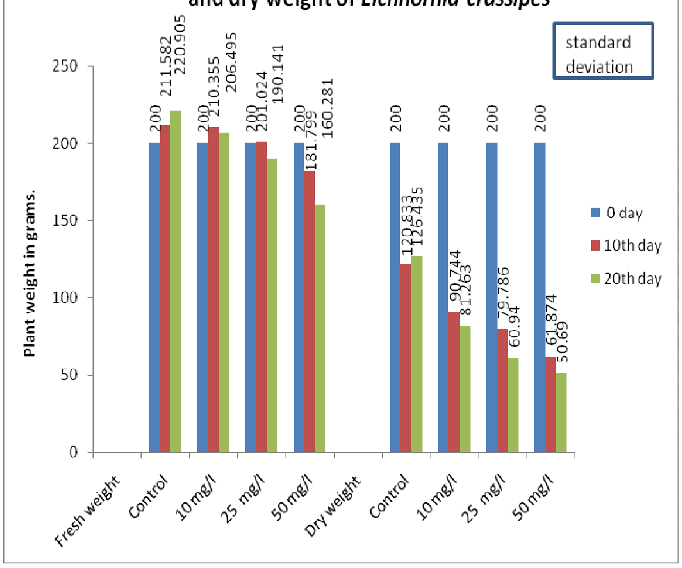


Fig:II Effect of Pottassium dichromate on fresh weight and dry weight of *Eichhornia crassipes*

(i) Biomass

(i)a. Fresh weight

It is evident from the results that fresh weight of *Eichhornia crassipes* at various concentration of $K_2Cr_2O_7$. Fresh weight of *Eichhornia crassipes* was maximum with 220g in control set on the 20th day and the minimum fresh weight was 160g on the 20th day at 50mg/L concentration of $K_2Cr_2O_7$ (Table 1) . On the 20th day the fresh weight was decreased serially with the increase in concentration of chromium. Though the plants showed slight increase in fresh weight on 10th day at 10mg/L concentration. Over the control it was adversely affected at higher dose at the end of the treatment (Table 1). It is well known that aquatic biomass irrespective living or dead, exhibits capacity to remove heavy metals from waste water. The reduction in shot biomass production by the plant may be due to the chlorosis and necrosis of the leaves that reduce the photosynthetically active area.[22] The decrease in fresh weight of leaves of *Eichhornia crassipes* might be due to toxic nature of $K_2Cr_2O_7$ and the suppression of growth under such stress during the early developmental stress.

(i)b.Dry Weight

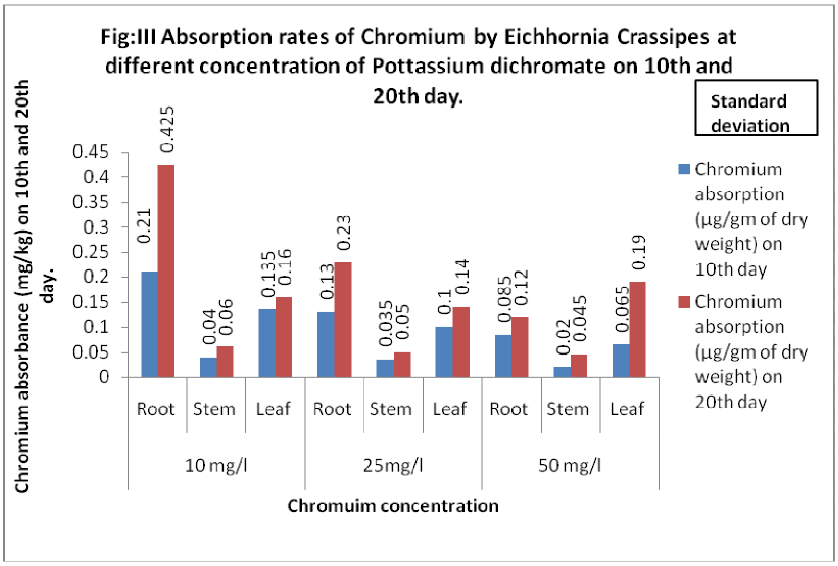
It is evident from the result that the dry weight of the plants is also like the fresh weight. Dry weight of the plant was maximum with 110g on the 20th day in control set and minimum dry weight was 50 g on 20th day at 50mg/l concentration (Table 1). On the 20th day, the dry weight decreased serially with increase in concentration showing a perfect negative correlation. The dry weight decreased with high concentration of $K_2Cr_2O_7$ (Table 1). The reduction might be atributed to the inhibition of hydrolysis of reserved foods and their translocation to the growing shoots.[23] the plant growth was not affected to any great extent but some yellowish and necrotic spots appear on the leaves. The biomass of plant showed some significant ($p \leq 0.005$) reduction in fresh and dry weight after 10 and 20 days exposure with different chromium concentration.

(ii) Chromium Accumulation

The chromium accumulation in the root, stem and leaves of *Eichhornia crassipes* are shown in(Table 2) figure 3.. The chromium accumulation in the root extracts after 10 days were found 0.20, 0.12, and 0.07 at 10, 25 and 50 mg/L respectively. The chromium accumulation in the root extracts after 20 days were found 0.41, 0.22, and 0.11 at 10, 25 and 50 mg/L respectively. While in stem extracts after 10 days it was found to be 0.03, 0.02 and 0.01 and after 20 days it was found to be 0.05, 0.04 and 0.03 mg/Kg. Then in leaf extract after 10 days it was found 0.12, 0.09 and 0.05 and after 20 days it was found 0.15, 0.13 and 0.09 at 10, 25 and 50 mg/L respectively. The data represents the preference of *Eichhornia crassipes* to store chromium in roots.

Table 2
showing the absorption of chromium at various plant parts using different chromium concentration by AAS

Chromium Concentration	Plant Parts	Chromium absorption (mg/kg of dry weight) on 10th day	Chromium absorption (mg/kg of dry weight) on 20th day	P value
10 mg/l	Root	0.20±0.010	041±0.015	0.003
	Stem	0.03± 0.010	0.05±0.010	0.566
	Leaf	0.12±0.015	0.15±0.010	0.001
25mg/l	Root	0.12±0.010	0.22±0.010	0.003
	Stem	0.02±0.015	0.04±0.010	0.423
	Leaf	0.09±0.010	0.13±0.010	0.005
50 mg/l	Root	0.07±0.015	0.11±0.010	0.032
	Stem	0.01±0.010	0.03±0.015	0.184
	Leaf	0.05±0.015	0.09±0.010	0.044



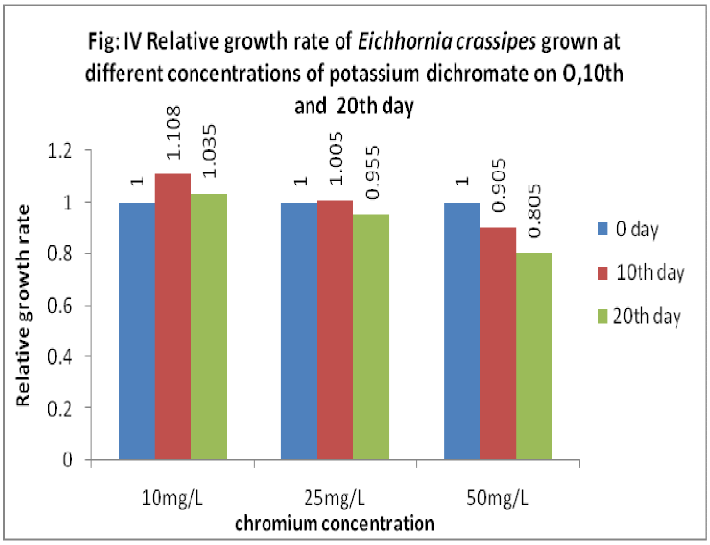
The analysis demonstrated that there was a significant difference observed in plant parts (root and leaf) in chromium accumulation processes (p≤0.005) except for stem part (p≤0.05). Similarly [24] observed that metal taken up by water hyacinth (Eichhornia crassipes) was higher at low concentration (20%) and decreased thereafter with increase in concentration. From the above result it is also concluded that metal accumulation is higher in roots as compare to shoots. The chromium uptake by plants has been found to be positively correlated to chromium application by many workers.[25-31]

(iii) Plant Relative growth (RG)

The relative growth of water hyacinth plant at different concentrations of chromium is shown in table 3. It can be seen that the relative growth of plant decreases with the increase of chromium concentration.

Table 3
Relative changes in growth of plant Vs chromium concentrations

Chromium Concentration	Relative growth on 10th day	Relative growth on 20th day	P value
10 mg/l	1.10±0.008	1.03±0.005	0.008
25 mg/l	1.00±0.005	0.95±0.005	0.013
50 mg/l	0.90±0.005	0.80±0.005	0.578



For water hyacinth plant treated with chromium the plant relative growth significantly decreased ($p \leq 0.005$) from 10,25, and 50 mg/L in 10 and 20 days. The relative growth exhibited a decreasing trend caused by relative increases in toxicity of chromium. The relative growth of water hyacinth decreases with increase in metal concentration, correlating with the investigation.[32]

CONCLUSION

From the present study, the floating hydrophyte *Eichhornia crassipes* has proved as a promising tool for the toxicity of chromium present in the industrial waste water especially below 50mg/L. It is clear that the growth characteristics of *Eichhornia crassipes* were sensitive and affected at higher concentration of chromium in the water medium at the end of the experiment and might be due to higher uptake of chromium. Researchers have demonstrated success in the use of natural water hyacinth in the phytoremediation process and present study also reveals that water hyacinth has a strong potential to uptake chromium from aqueous solution at lower concentration. Hence this is an economically cheap technology for the removal of chromium from the industrial waste water. Future study will examine the accumulation of chromium in *Eichorrnia crassipes* through transverse sectioning of Root,Stem and in Leaves at different concentrations of tannery efluent from different locations of tannery industries.

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