REMOVAL OF CADMIUM FROM WATER WITH NUTRIENT FILM TECHNIQUE (NFT)

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ABSTRACT

Pollution of the environment by heavy metals is a major problem facing the world today. Among the heavy metals, Cadmium is one of the most toxic heavy metal which is being released by several industries. Among the different technologies used for the removal of heavy metals from wastewater, phytoremediation is a promising, low cost and environmental friendly technology. The present study investigated the efficiency of the plant *Axonopus compressus* (Sw.) P. Beauv in removing cadmium from wastewater. Initially a batch experiment was conducted to optimize the operating conditions and later a Nutrient Film Technique (NFT) experiment of 40 day duration was conducted based on the results of the batch experiment. The findings of the NFT experiment shows good removal of Cd in the first day of the treatment followed by a gradual increase in removal efficiency as the experiment progresses. The plant also exhibited increase in biomass during the NFT experiment. The overall results of the study indicates that the plant can be used as an efficient bio-agent for the treatment of low level Cd contaminated wastewater.

Key words: *Phytoremediation, Rhizofiltration, Heavy metals, Cadmium,*

INTRODUCTION

The rapid industrialization in developing countries with an enormous and increasing demand for heavy metals has resulted into a high anthropogenic emission of these pollutants into the biosphere (Bindu et al., 2010). Among the heavy metals Cadmium is one of the most toxic metals along with mercury and arsenic. The natural sources of Cd include volcanic activity, ocean sprays and forest fires. The anthropogenic activities such as mining, smelting, coal combustion, refineries, iron and steel industries, disposal of industrial effluents and sewage sludge as well as application of phosphate fertilizers contribute significant quantities of cadmium into the environment. The industrial uses of cadmium are widespread and increasing in electroplating, paint pigments, plastics, alloy preparation, mining, ceramics and silver–cadmium batteries (Volesky, 1990). Toxicity of Cd may result from its binding to sulfydryl groups of proteins leading to inhibition of activity or disruption of structure, disturbance of cellular redox control (Schutzendubel *et al.*, 2002), and/or inducing the production of reactive oxygen species (Romero-Puertas *et al*., 2004).

Since heavy metals are non-degradable, the contamination of water bodies by these metals causes a serious environmental problem, threatening not only the aquatic ecosystems, but also human health. The removal of these heavy metals from the wastewater to protect the people and the environment deserves top priority. Many methods that are being used to remove heavy metal ions include chemical precipitation, ion-exchange, membrane filtration, electro-chemical treatment, adsorption, phytoremediation etc., with varying degrees of success. However low cost, environmental friendly and sustainable technologies are more preferred over the others.

The term ''phytoremediation'' is a combination of two words: Greek phyto (meaning plant) and Latin remedium (meaning to correct or remove an evil). Green plants have an enormous ability to uptake pollutants from the environment and accomplish their detoxification by various mechanisms. The concept of phytoremediation (as phytoextraction) was suggested by Chaney (1983). It is a novel, cost-effective, efficient, environment - and eco-friendly, *in situ* applicable, aesthetically pleasing and solar-driven remediation method. It takes advantage of the plants and their associated rhizospheric microorganism's natural abilities to take up, accumulate, stabilize and/or degrade contaminants from the environment (Singh *et al*. 2003; Bindu *et al*. 2008).

Despite many years of research and experiments, the application of phytoremediation for the removal of heavy metals is still in its infancy. The commercialization of this technology depends upon the selection of suitable plant species to treat the heavy metal contaminated medium. Hence the present study was conducted with the objective to study the ability of the plant *Axonopus compressus* in removing Cd from wastewater in a Nutrient Film Technique (NFT) System.

MATERIALS AND METHODS

Plant collection and preparation for the experiment: For the removal of Cd from wastewater the grass species *Axonopus compressus* (Sw.) P. Beauv., has been used as a bioagent in this study. The plants were collected from the campus of M.G University. Special attention was given to collect plants without damaging the roots. The plants were washed thoroughly in running tap water to remove clay particles, and then with distilled water. The plants were then transferred to a hydroponic system containing 10% Hoagland solution (Ignatius *et al*., 2014) to get acclimatized for one week. After acclimatization, plants of equal size, weight and equal number of leaves, were selected and used for the experiments.

Experimental design: Initially a batch experiment was conducted to optimize the metal concentration and subsequently the NFT experiment was conducted with the concentration as optimized from the batch experiment. A total of 5 raceways made out of glass (1m length, 0.15m height and 0.15m width) were used in the NFT experiment. Out of the 5 raceways, three were operated as test raceways with plants in Cd spiked water; one raceway as planted control with plants and no Cd in water and one raceway as control without plants but with Cd spiked water. The experiment consists of 2 cycles of 20 days duration each and each cycle consists of 2 runs of 10 days each. Samples were collected on 1st, 2nd, 5th and 10th day of each run. At the end of each run the wastewater was drained out completely from the glass raceways and fresh wastewater was filled immediately in each raceway. At the end of the cycle (after 20 days) the wastewater as well as the plants were removed from the raceways and new plants and fresh wastewater were introduced to start the next cycle. The entire experiment was conducted in the laboratory at room temperature under illumination provided by fluorescents lamps with a light to dark (LD) cycle of 14:10 hours (Ignatius *et al.*, 2006, Bindu *et al.*, 2010). Each raceway was filled with 2.5 liter of wastewater containing 2.5 mg l^{-1} Cd. In each raceway, 25 plants of uniform size and weight were placed. The plants were supported by plastic mesh, in order to prevent the direct contact of areal parts of the plant with the wastewater. The raceways were arranged with gentle slope, so that the wastewater slowly flows from the upstream end – where the wastewater enters into the raceway – through the root system of the plants to the discharge end of the raceway. The wastewater was circulated at a rate of 7 ml min^{-1} with the help of peristaltic pumps (Miclins India, PP - 20EX - 4C). Samples of wastewater were collected on 1^{st}, 2^{nd}, 5^{th} and 10^{th} day of the experiment and analyzed for Cd. The plants were harvested at the end of the experiment and changes in biomass and chlorophyll content were determined.

RESULTS AND DISCUSSION

Percentage removal of Cd: The reduction in Cd concentration from the wastewater during the NFT experiment was monitored during 1^{st}, 3^{rd}, 5^{th} and 10^{th} day of each run and the percentage removal of Cd was calculated (Table 1). From the experiment it was observed that the Cd removal was higher in the 1^{st} run as compared to the 2^{nd} run in both the cycles. It was also observed that more than 60% of the Cd removal takes place within the 1^{st} day in the 1^{st} run. However during the 2^{nd} run, the Cd removal within the 1^{st} day was only 47% (Table 1). After the first day, the Cd removal was observed to be gradual towards the end of each run. In the first cycle in the first run, the percentage removal of Cd increases from 62-74% and in the second run it was from 47 - 60%. In the second cycle, percentage removal of cadmium increased from 60-71% in the first run and from 49-58 % in the second run. Dushenkov et al., (1995) reported that the root of the plants has an intrinsic ability to absorb and precipitate heavy metals from solutions which can exceed even 10% of the root dry weight. They also reported that plant roots utilize several mechanisms for the removal of heavy metals such as absorption, intracellular uptake and translocation.

Changes in Biomass and Chlorophyll: The changes in chlorophyll and biomass of the plant during the experiment were also monitored. Growth changes are often the first and most obvious responses of plants under heavy metal stress. During the experiment, the biomass of the plants exposed to Cd shows a slight increase in biomass of 6%. The chlorophyll of the plants decreased as the experiment progresses. It was also observed that the plant shows partial wilting of leaf when exposed to Cd. Hasan *et al*., (2007) reported that Cd has inhibitory effects on the growth of *Eichhornia crassipes*. Stratford *et al*., (1984) reported that Cd was toxic and caused substantial reduction in *E. crassipes* growth mainlly suppressing development of new roots. However in another study by Phetsombat *et al*., (2006) it was found that *Salvinia cuculla* remained healthy at 2 mg l^{-1} of Cd exposure. Dou (1999) found that although Cd is not generally considered as an essential element, it may stimulate the growth of some plants in small amounts.

Table 1 Percentage removal of Cd during the NFT experiment

Number of Cycles	Number of Runs	1^{st} day	3^{rd} day	5^{th} day	10^{th} day
1^{st} Cycle	1^{st} run	62	63	69	74
	2^{nd} run	47	49	54	60
2^{nd} Cycle	1^{st} run	60	62	67	71
	2^{nd} run	49	51	55	58

CONCLUSION

Heavy metal pollution of aqueous streams is a major environmental problem facing the world today. Among the different technologies available for the removal of heavy metals, phytoremediation has definite advantages such as low cost, environmental friendly and high public acceptance. Hence the present study investigated the efficiency of the plant *Axonopus compressus* (Sw.) P. Beauv in removing cadmium from wastewater. Initially a batch experiment was conducted to optimize the operating conditions and later a Nutrient Film Technique (NFT) experiment of 40 day duration was conducted based on the results of the batch experiment. The result of the NFT experiment shows good removal of Cd within the first day of the treatment followed by a gradual increase in removal efficiency as the experiment progresses. The plant also shows increase in biomass during the NFT experiment. The overall results of the study shows that the plant can be used as an efficient bio-agent for the treatment of low level Cd contaminated wastewater.

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