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REMOVAL OF CADMIUM FROM INDUSTRIAL WASTEWATER - THE POTENTIAL OF EICHHORNIA CRASSIPES

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INTRODUCTION

Removal of heavy metals using living plant is known as phytoremediation. It has been known as an effective technology that uses plants to clean up contaminated soil and ground water. A number of studies indicate that plants have mechanisms to uptake, filter, stabilize, and/or degrade many of the pollutants. The pollutants that have been effectively remediated by phytoremediation include petroleum hydrocarbon, pesticides, solvents and heavy metals. This green technology is often favoured over more conventional methods of clean-up due to its low cost, low environmental impact, and wider public acceptance. Heavy metals are natural elements that are found at various high background levels at different locations throughout the world. They are persistent and cannot be removed from the environment. Cd is non-essential for plants and animals. Excessive levels of cadmium can cause kidney and liver damage. Cadmium ions cause chlorosis and necrosis in plants growing on Cd- containing soil and water. When plants are exposed to cadmium ions, uptake of essential ion is reduced[1]. Heavy metal pollution of soils and freshwater environments is becoming a potential environmental problem in the industrial areas of developing countries due to the disposal of untreated or partially treated industrial wastewaters from various anthropogenic sources such as metal finishing and galvanizing industries[2].

Water hyacinth has been used successfully in reducing the level of heavy metals in drainage water. Furthermore, the quantity of trace elements that can be accumulated by water hyacinth has been shown to correlate well with concentration of heavy metals in the water. Trace element removal by wetland vegetation can be greatly enhanced by selection of appropriate wetland plant species. One such plant is water hyacinth, commonly found in tropical and subtropical regions of the world. It adapts easily to various aquatic conditions and plays an important role in extracting and accumulating metals from water. Hence, water hyacinth is considered to be an ideal candidate for use in the rhizofiltration of toxic trace elements from a variety of water bodies. Biosorption is another alternative technology for the treatment of aquatic environments contaminated with heavy metals. Biosorption utilizes the ability of non-living biological materials to accumulate heavy metals from waste streams by either metabolically mediated or purely physico-chemical pathway of uptake. The uptake of heavy metals by dead biomass takes place by the passive mode. The performance of any biosorbent depends on the anionic ligands present on the biomass, physico- chemical characteristics such as pH and temperature[3].

METHODOLOGY

The plant species *Eichhornia crassipes* were collected from Boralasgamuwa Lake and acclimatized in a fresh water tank in the mesh house in the premises of the Open University of Sri Lanka.

METHODS FOR PHYTOREMEDIATION

A stock solution (1000 ppm) of cadmium was prepared and diluted appropriately. Test

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solutions of Cd concentrations 3, 6, 9, 12, 15, 18 ppm containing 10% nutrient solution were prepared. *Eichhornia crassipes* plants from the tank were introduced into the black basins, each filled with 2 L test solutions.

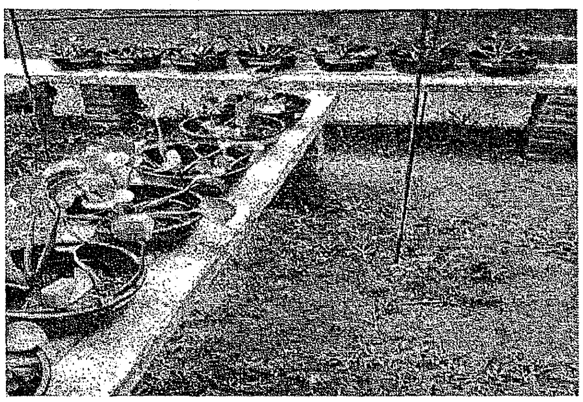

Fig 1: Plants were exposed to test solutions and kept in a mesh house

The pH of the test solutions was from 5.0 to 6.0. The experiment was performed at ambient temperature 30-33 °C in the mesh house for 5 days. Experiments were carried out in triplicates. During the experiment, the test solution was replenished by adding distilled water (about 25 ml) daily. The plant species that was exposed to nutrient solutions only served as control in this experiment. Plant species were harvested on the 5^{th} day, pretreated by washing with distilled water and rinsing with 20 mM EDTA solution and finally washing with distilled water. The root and shoot parts were digested separately by dry ashing. The metal accumulation in root and shoot were determined using Atomic Absorption Spectrometer (VARIAN AA 280 FS)[4].

Translocation ability of shoot and the percentage translocation were also calculated as follows [3].

$$\text{Translocation Ability} = \frac{\text{Absorption by plant root}}{\text{Absorption by plant shoot}}$$

$$\text{Percentage of translocation} = \frac{\text{Absorption by plant shoot}}{\text{Absorption by plant root}} \times 100\%$$

METHODS FOR BIOSORPTION

About 0.3 g of finely ground dry biomass (root) was thoroughly mixed individually in 18 Erlenmeyer flasks (6 sets of 3 flasks) containing 100 ml of Cd(II) solutions of 5 ppm each. The suspensions were shaken for 3 hours at a constant speed (80 r.p.m) on the orbital shaker at room temperature (29 °C), Experiments were performed in triplicates. A set of three flasks was_removed from the shaker at 30 minutes time intervals. The content of each conical flask was filtered through Whatmann No 1 filter paper. A clean dry filter paper was used for each filtration. The filtrate was analyzed for residual cadmium concentration in the solution using an Atomic Absorption Spectrometer (AAS)[5].

RESULTS AND DISCUSSION

Plants were normal and fresh up to 18 ppm of Cd concentration. Average uptake of Cd by *Eichhornia crassipes* in different concentration of Cd solution is shown in Figure 2. As can be seen from Figure 2, the average accumulation of Cd with initial concentrations 3,6,9,12,15, & 18 ppm after 5 days was 371.7, 571.1, 800.7, 734.7, 839 and 1040.8 ppm respectively. Plants treated with 18 ppm accumulated the highest level of Cd. Control plants showed no absorption of Cd. At the same time, Cd content in the shoot has also increased. The higher translocation ability was observed in plants kept in 15 ppm external Cd concentration.

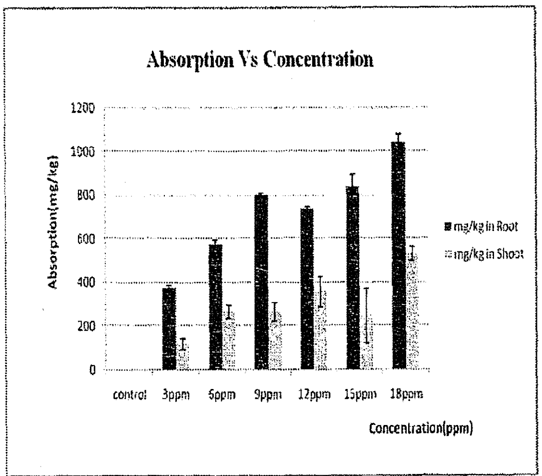

Fig 2: Absorption of Cd metal ion by root of *Eichhornia crassipes* and that translocated to the shoot at various concentration of metal ion solution.

Table1: Translocation ability of *Eichhornia_crassipes*

Concentration of Cd solution (ppm)	3	6	9	12	15	18
Translocation Ability (T_A)	3.2	2.2	3.0	2.1	3.4	2.0
% of translocation	31	46	33	48	29	51

Results show that the roots of water hyacinth accumulated about 2 to 3 times more Cd than did the shoots. A larger value of translocation ability implies poorer percentage of translocation by the plant. In our experiment water hyacinth translocated 30 to 50 % of the Cd absorbed by the roots to the shoot. It has also been reported that water hyacinth absorbs heavy metals mostly from the roots and translocates only 6 - 25% of them to the shoot[3].

BIOSORPTION

During the period under study, concentration of Cd in solution decreases (Fig. 3) while the absorption of Cd by the non-living root biomass of *Eichhornia_crassipes* as given by

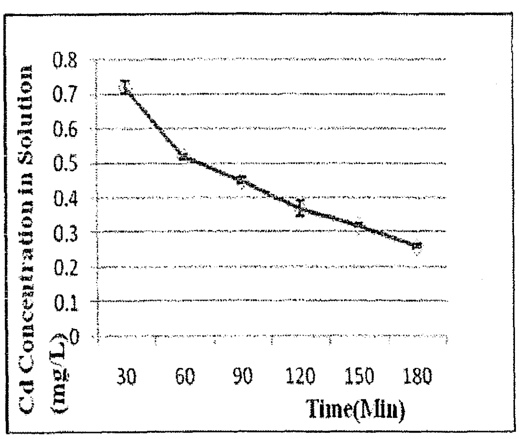

Fig. 3: Effect of contact time on Cd(II) concentration of solution

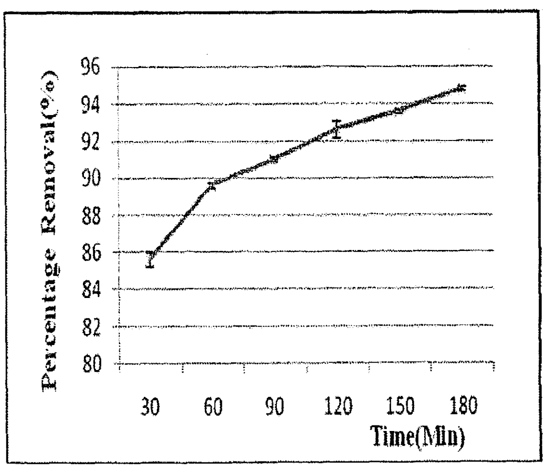

Fig. 4: Effect of contact time on percentage removal of Cd(II)

percentage removal increases with time (Fig. 4), reaching a value of 94.8% in 3 h. These results look promising and therefore further studies need to be done on desorption of Cd from the biomass to which the metal was previously adsorbed, in order to regenerate and reuse the biomass. This is important for the feasible use of root biomass of *Eichhornia_crassipes* as a biosorbent for removal of Cd.

CONCLUSIONS

From the obvious growth of the plant observed during the experiment and its ability to accumulate metals in the plant root structure and also translocate the accumulated metals from the root to the leaf and shoot, we can conclude the whole water hyacinth plant is efficient for phytoremediation. According to the results from this study, the root absorbs and accumulates twice as much Cd as compared to the shoot in most cases. In biosorption study, it was observed that the residual Cd concentration decreases while the percentage removal of Cd by root biomass of water hyacinth increases with increasing contact time. These results offer promise for a suitable biosorbent for removal of Cd and this work deserves further investigation. These results suggest that water hyacinth, both as a living plant and non- living biomass can be used to remove Cd from wastewater in a natural, low cost, clean, and efficient way.

REFERENCES

Uysal, Y. & Taner, T. (2007). The effect of cadmim ion on the growth rate of the freshwater macrophyte duckweed *Lemna minor*. *Ekoloji 16,* 9-15.

Prasad, M.N.V. & Freitas,H.(2003). Metal hyperaccumulation in plants- biodiversity prospecting for phytoremediation technology. *Electronic Journal of Biotechnology, 6(3),* 1-25.

Liao, W.L. & Chang, W.L. (2004). Heavy metal phytoremediation by water hyacinth at constructed wetland in Taiwan. *Journal of Aquat. Plant. Manage. 42,* 60-68

Hoenig, M., Baeten, H., Vanhentenrijk, S., Vassileva, E. & Quevauviier, Ph. (1998). Critical discussion on the need for an efficient mineralization procedure for the analysis of plant material by atomic spectrometric methods. *Analytica Chimica ACTA, 358,* 85 -94.

Mohanty, K., Meicap, M.J.B.C. and Biswas, M.N. (2005). Biosorption of Cr(VI) from aqueous solutions by *Eichhornia crassipes*. *Chemical Engineering Journal, 117,* 71-77.

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