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UPTAKE AND DISTRIBUTION OF Cr (VI) IN *P. STRATIOTES* L.

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Abstract. Pistia stratiotes was cultured in various concentration of Cr (VI) solution (10, 20, 35, 50 µM) for 25 days. The trend of bioaccumulation was high in roots than in the shoots of the experimental organism. Cr (VI) toxicity in the plant caused decrease in phytomass and chlorophyll biosynthesis. Metal uptake rate was also directly proportional to the metal concentration in the culture medium.

Keywords: biomass, chlorophyll, Cr (VI), Enzyme kinetics, Metal toxicity, Pistia stratiotes

1. Introduction

Ecosystem degradation is directly affected by the disposal of sewage, agricultural and industrial pollutants directly in to the aquatic system causing pollution and one of them are, heavy metal pollution. Phytotechnologies involves process of metal removal via physical, biological and biochemical mechanisms taking place in water, biota and suspended solids of the aquatic bodies [1]. Wetland macrophytes function as biofilter agent and their well-developed vascular systems [2] favors the bioaccumulation efficiency [3]. Macrophytes are not only a food and shelter entity for the aquatic organisms [4] but also a reservoir for nutrients and trace metals depending on the plant species metal accumulation ability [5] and the types of metal [6]. Several studies have been performed to explore the efficacy of aquatic macrophytes in assimilation of metals in to the biomass [7], [8] and field studies involving metal distribution and circulation in water, sediment and aquatic biota [9]. Chromium is an important metal used in tanning and dying industry, chemical and alloys production but at the same time considered as most hazardous due to its solubility, mobility, toxicity as well as carcinogenic and mutagenic properties [10]. Cr (VI) toxicity can deter with the biomembranes metabolism [11] and therefore disruption in nitrogen metabolism affects the yield potential of the plants. *Pistia,* a perennial water floating macrophytes in subtropical climates, can absorb the metal directly from the water column through rhizofiltration and release them during the senescence phase. This paper describes the (i) metal uptake efficiency of *Pistia stratiotes* at different concentration of Cr (VI) with experimental time and effect of metal on fresh weight biomass and chlorophyll (iii) metal uptake kinetics.

2. Experimental

Fresh and healthy *Pistia* individuals of approximately same size and weights were selected, and cultured in the experimental tray (volume 24 L) filled with 10 liters of water. Various concentrations of chromium (10, 20, 35, 50 µM) were prepared by adding required aliquots of 1000 µM stock solution using $K_2Cr_2O_7$ to 5 % Hoagland solution [12]. The plants of *P. stratiotes* were washed in 10 µ M/L EDTA to facilitate desorption of adsorbed metals and were oven dried (300 ℃). Dried plant roots and shoots were digested in HNO_3 and H_2O_2 at 70 ℃ for 2h. The metal content of the resulting colorless solution was measured with a Perkin Elmer 2380AAS. Chlorophyll was calculated as per Mackinney [13]. Preferential uptake of metal was determined

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from a metal mixture containing (Cr, Zn, Ni) metals in equal concentrations. Metal uptake competition was also compared by culture of *Pistia* and *Lemna* together in to the metal treated solution. Prism Graph pad software was used to perform the metal kinetics.

3. Result and Discussion

3.1. Chromium uptake by *Pistia* and effect of Cr on Biomass and chlorophyll

Bioaccumulation of Cr (VI) was more in roots than in the shoots. The biotoxicity of Cr (VI) is function of its ability to cross biological membranes, its oxidizing capabilities [14] and its influence in photosynthesis and respiration [15]. Root exudates play a variety of roles in plants [16] including that of metal chelators that may favor the uptake of certain metals. *P. stratiotes* has mechanism of rhizofiltration to help metal pollutants adsorbtion from water and aqueous wastes streams. The accumulation of Cr in roots and foliage tissues was found to be increasing with their respective concentrations as a result of metabolism dependent uptake by the plant tissues. The metal accumulation was reported more in root tissues ($p<0.0001$), this might be because once the macrophytes take up metals; they are translocated and accumulated in different plant parts. This storage pattern of Cr in leaves and roots of *P.stratiotes* is based on partitioning mechanism, a common strategy of plants to store harmful ions more in the roots to protect the leaves, a site for photosynthesis and other metabolic activities, from toxicity [17].

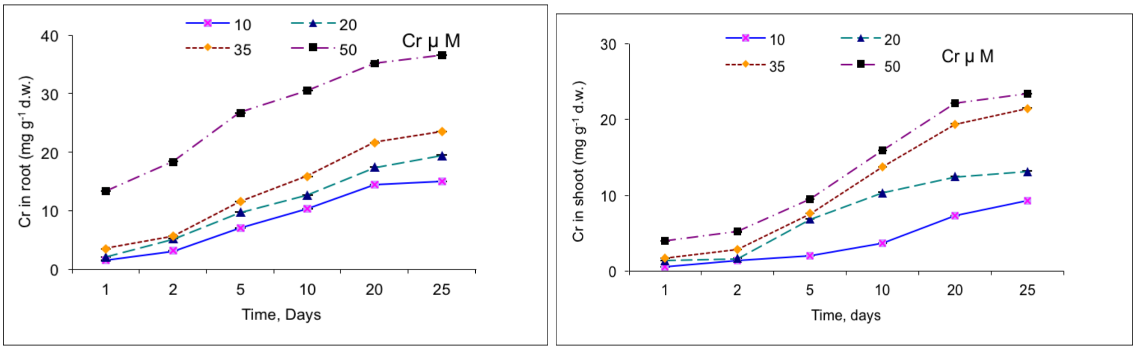

Fig. 1&2: Cr (VI) uptake by Pistia root and shoot

Pistia roots have been shown to accumulate 800 to 1060 mg Kg^{-1} after three and five days respectively [18]. Chromium (III) forms a complex with –COOH groups in the roots preventing its translocation to shoots [19]. This may suggest that Cr (VI) was reduced to Cr (III) in the roots of plants [18]. X-Ray absorbance spectroscopy studies showed that *B.juncea* roots exposed to Cr (VI) contained mainly Cr (III), indicating that *B.juncea* roots effectively reduced chromate [20]. Effect of Chromium (VI) toxicity on *Pistia* caused reduction in phytomass and chlorophyll (Fig. 3, 4). The Cr concentration seemed not to affect the morphological growth and fresh weight biomass ($p<0.001$) of *Pistia* culture at low Cr (10 and 20 μM) concentration.

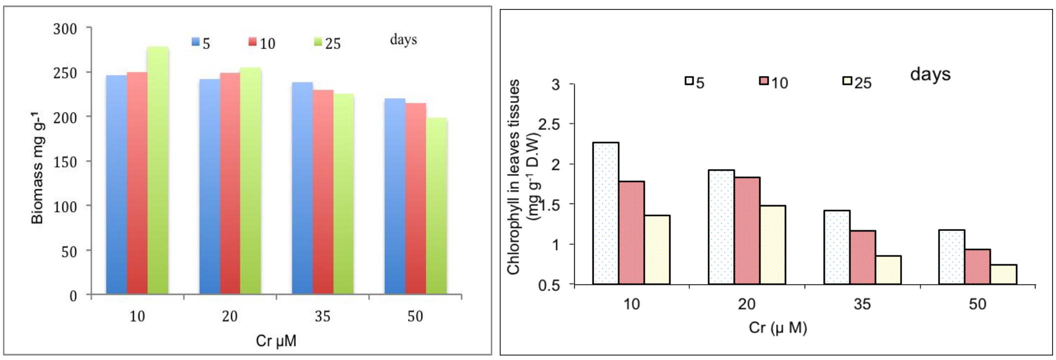

Fig. 3&4: Effect of Cr (VI) toxicity on Fresh weight biomass and chlorophyll

Macrophytes can tolerate high concentration of metals in their body mass without showing negative effect on the growth [21]. But at high Cr (35 and 50 μM) reduction in biomass was observed clearly. There was a direct relation between Cr uptake and chlorophyll reduction ($p<0.001$) in the macrophyte. At high Cr

(50 µM) maximum inhibition (86.5 %) in chlorophyll biosynthesis was found. Chromium toxicity also results in iron and zinc deficiency causing damage to chlorophyll biosynthesis [22].

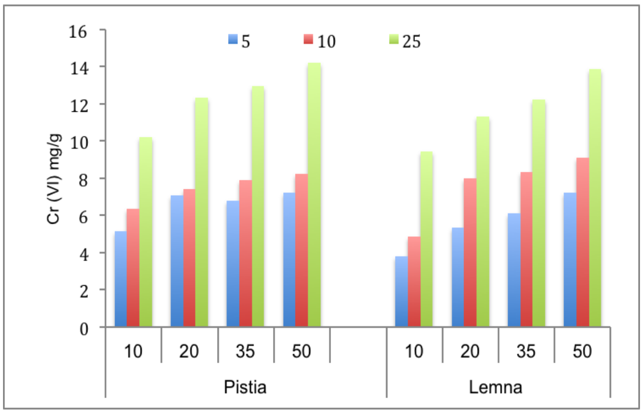

Fig. 5: Metal uptake competition of Cr (VI) between by *P. stratiotes* and *L. minor* together in the metal culture medium.

The uptake of Cr was higher for *Pistia* than *Lemna*. This variation in uptake could be the consequences of different morphological features in both the macrophytes. *Lemna* is a reduced thallus plant body without root and stem differentiation while *Pistia* has a well-developed fibrous root system supporting the concentration of more metals in macrophytes. Metal uptake by *Pistia* root and shoot showed the Michaelis-Menten Kinetics. There was a direct relation between metal uptake and a rise in metal concentration in the culture medium.

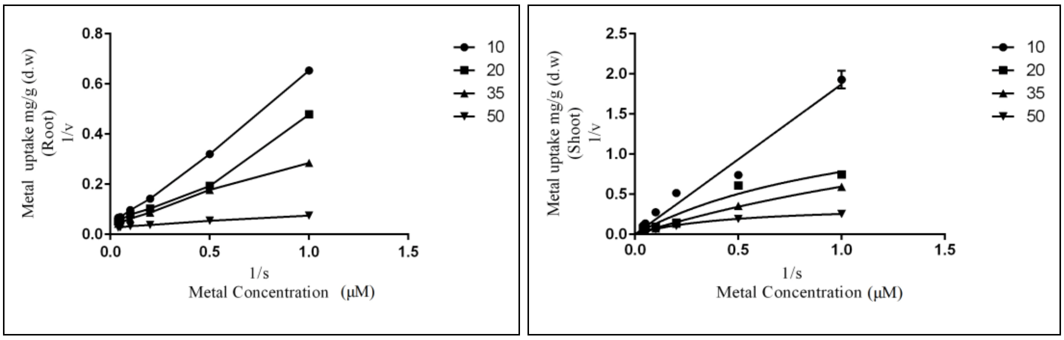

Fig. 6&7: Kinetics of Cr(VI) uptake by *P.stratiotes* root and shoot

At low metal concentrations (Cr 10 and 20 µM), there was rapid uptake of metal in root (10_{Vmax}-22.7, 20_{Vmax}-25.77). Metal adsorption in the root and shoot also increased with more metal substrate in the medium. However, once the turnover was reached, the availability of more metal substrate did not further increase the rate.

4. Conclusion

Heavy metals perform a number of dynamic transformations in the aquatic environment system. The use of phytotechnologies to treat wastewater is a practical approach with in a limited budget. Bioaccumulation of heavy metals can be attributed to the sink effect of macrophytes in water purification process utilizing rhizofiltration mechanism.

5. References

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