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Removal of Arsenic from contaminated wastewater using *Eichhornia crassipes*

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ABSTRACT

Arsenic is a hazardous element which causes several serious ill effects on the living being. Therefore the present study aims to investigate the arsenic uptake rate of *Eichhornia crassipes* from the water samples amended with arsenic concentration 1mg/l, 5mg/l, 10mg/l, 20mg/l, 30mg/l respectively for the experimental period of 10 days. Arsenic concentration was measured in samples using ICP-MS instrument. The stress of arsenic on plant was determined by the analysis of decrement or increment of plant biomass. The result indicates that the *Eichhornia crassipes* had capacity to remove arsenic from the aqueous medium. The maximum removal efficiency was obtained 53.63% at initial concentration 1 mg/L at the end of the 8th day of experiment period. The Removal percentage of arsenic by the plant was found to be decreasing with the increase in the initial concentration in the water sample. Based on the result, it has been concluded that *Eichhornia crassipes* is a good accumulator of arsenic at an initial concentration of 1 mg/L.

Keywords: Arsenic, Phytoremediation, Plant biomass, Eichhornia crassipes

INTRODUCTION

The presence of arsenic, a potentially toxic metal in the drinking water has become a serious worldwide problem. The drinking water contaminated with As and its compounds has potential to cause many severe diseases like cancer in human.[1-2] Millions of people in India, Bangladesh, South America, Australia, and Japan have been reported to suffer from adverse health effects from the use of As polluted drinking water.[3-5] An estimated 200,000 to 270,000 people worldwide have died of cancer caused by drinking As-contaminated water.[6-8] The rapid industrialization and urbanization around the freshwater bodies are the major factor responsible for the arsenic pollution.[9] There are a number of conventional methods that have been developed and investigated like bioremediation, use of treated laterite for adsorption etc. for the removal of arsenic from the contaminated water. Bioremediation involves the use of living organisms like use of plants and microbes for the removal of such potentially toxic metals from the environment.[10-12] It is very efficient and eco-friendly methodology for the treatment of contaminated water as reported by Goswami *et al* .[13-14] The arsenic accumulation capacity of some of the plants has been shown in Table 1.

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Table 1: Some of plants and their Arsenic accumulation capacity

Scientific Names of Plants	Common Name	Arsenic
Lemna minor	Lesser duckweed	430(mg/kg)[15]
A. caroliniana	Carlina mosquito fern	397(mg/kg) [15]
Callitriche brutia	Pedunculate water starwort	523(mg/kg) [15]
Eichhornia crassipes	Water Hyacinth	260 (μg /g) [12-16]
Callitriche stagnalis	Pondwater starwort	4215(mg/kg) [15]

Based on the literature review it has been found that the arsenic removal efficiency of the *Eichhornia crassipes* has been investigated for waste water amended with arsenic concentration >3 mg/l. So, the present study have been undertaken to evaluate the effect of arsenic on the relative growth of plant with five different wastewater samples amended with arsenic concentration

1 mg/L, 5 mg/L, 10 mg/L, 20 mg/L, 30 mg/L concentration respectively and also to investigate the uptake rate of arsenic in the whole plant biomass.

Figure 1. Laboratory cultivation of Water hayacinth

Materials and Methods

[A] Hydroponic System

Preparation of Arsenic solution: The experiments were conducted with commonly available *Eichhornia crassipes*, with waste water samples amended with different initial concentrations of arsenic i.e. 1.0 mg/l, 5.0 mg/l, 10 mg/l, 20 mg/l and 30 mg/l, respectively that were prepared from the arsenic stock solution of 100 mg/L. The arsenic stock solution was prepared by dissolving 0.1734 g of $NaAsO_2$ in 1000 ml of milli-pore water. A control setup was installed to monitor the growth of *Eichhornia crassipes* in the absence of arsenic.[17] All reagents used were of analytical grade. For each concentration of arsenic, duplicate set-ups were installed.

[B] Sample Collection

Eichhornia crassipes was collected from the nearby local freshwater pond near and was adapted to the same pond water in the laboratory for 4 to 5 days. An experiment was carried out on for a period of 10 days in 5 different containers containing 500 ml of working solution of arsenic and pH was noted regularly and maintained up to 7. A water sample was collected at regular interval of every 2 days and further arsenic content was analysed. After the experimental period, the plant was harvested and their fresh weight was measured. The cultivation of plant in laboratory has been shown in Figure 1.

[C] Preparation of sample and its analysis

To check the concentration of arsenic and its exposure on the plant, the samples were collected from the container after every 2 days and filtered by vacuum filter. Further, arsenic accumulation was analysed by Inductively Coupled Plasma Mass Spectrometry ((Perkin Elmer) ELAN DRC-e). Removal efficiency was calculated by using the formula:

$$\%\ \text{removal efficiency} = \frac{Ci - Cf}{Ci} \times 100$$

where C_i is the initial concentration of arsenic in wastewater before treatment and C_f is final concentration of arsenic in wastewater after treatment.

Result and Discussions

The arsenic-uptake kinetics was investigated to recognize how fast the *Eichhornia crassipes* could remove the arsenic from contaminated waste water. The plant was allowed to grow in contaminated wastewater for 10 days. The separate experiments were conducted using five different samples of waste water amended with 1mg/l, 5mg/l, 10mg/l, 20mg/l, 30mg/l concentration respectively. The percentage removal rate of arsenic by *Eichhornia crassipes* from waste water adjusted at 1 mg/l arsenic concentration has been shown in Figure 2.

From the Figure 1, a constant rate of increase in the percentage removal of arsenic was observed within 8 days growth of plant in the wastewater sample. After 8^{th} day, the removal rate was found to be saturated with a decline in the health of the plant due to excess exposure to arsenic. Furthermore, in another experiment, plant species were allowed to grow in wastewater amended with 5mg/L arsenic concentration and the result has been shown in Figure 3.

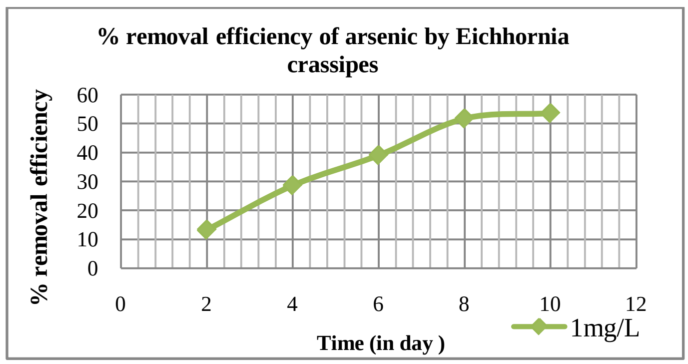

Figure 2. % removal efficiency of arsenic by *Eichhornia crassipes* from contaminated waste water amended with 1mg/L arsenic concentration

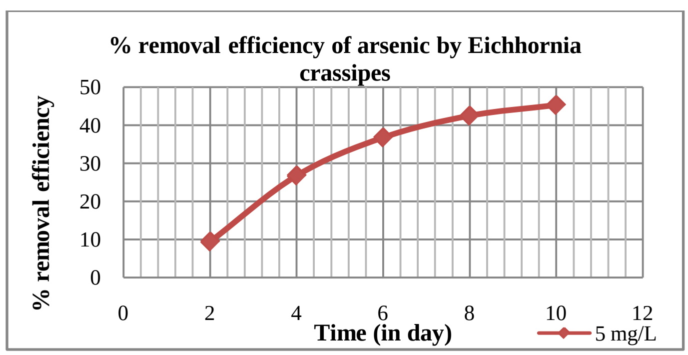

Figure 3. % removal efficiency of arsenic by *Eichhornia crassipes* from contaminated waste water amended with 5 mg/L arsenic concentration

The rate of removal of arsenic of was found to be decreased after the 4^{th} day of the experiment shown in Figure 3. In latter days, a significant change in the plant health was observed, i.e.

leaf colour turns from greenish to brownish appearance. Further, the arsenic removal kinetics were investigated with wastewater amended with 10 mg/L, 20 mg/L and 30 mg/L and the results have been shown in Figure 4, 5 and 6, respectively.

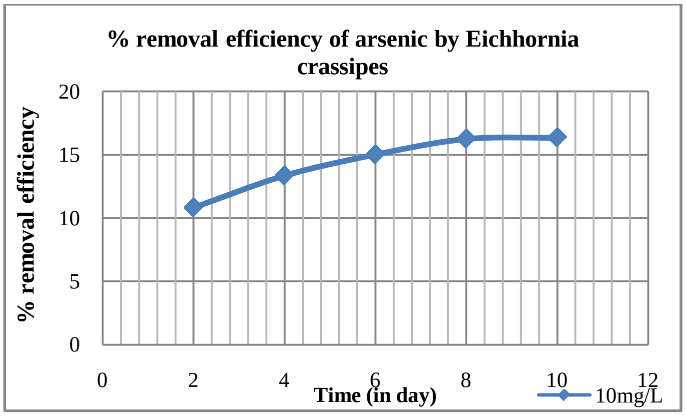

Figure 4. % removal efficiency of arsenic by *Eichhornia crassipes* from contaminated waste water amended with 10 mg/L arsenic concentration

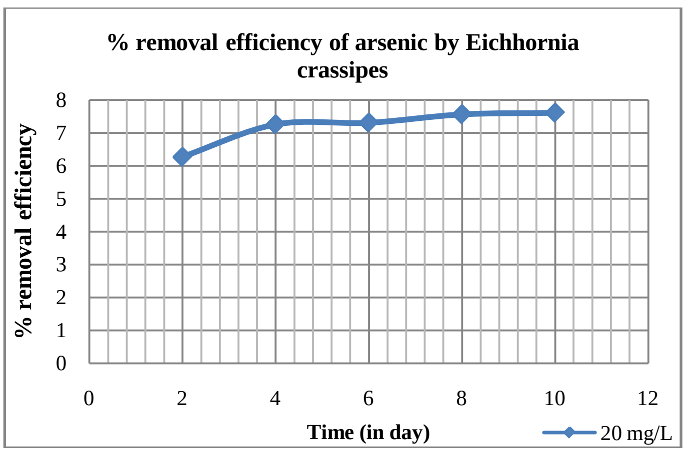

Figure 5. % removal efficiency of arsenic by *Eichhornia crassipes* from contaminated waste water amended with 20 mg/L arsenic concentration

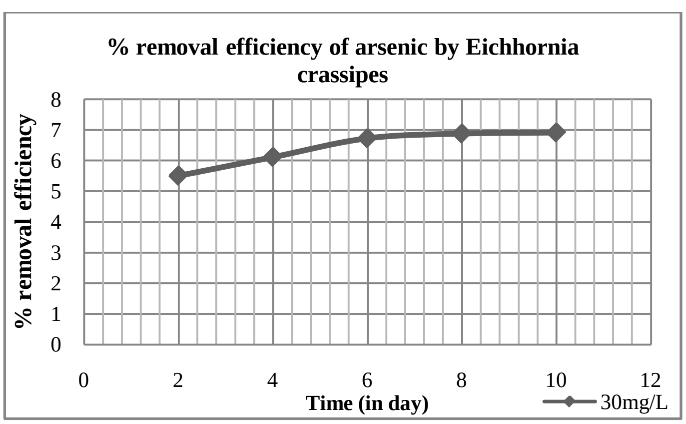

Figure 6. %removal efficiency of arsenic by *Eichhornia crassipes* from contaminated waste water amended with 30 mg/L arsenic concentration

From the above Figure 4, 5 and 6, it can be observed that when the concentration was a further increase above the 10 mg/L to 20 mg/L and 30mg/L, the plant can't bear the arsenic exposure in these exposure ranges of concentration. The plant died after the exposure of arsenic in these ranges and removal efficiency was not significant. A comparative analysis of rate of arsenic removal by the plant species with respect to the wastewater samples amended with the five different concentrations of arsenic has been shown in Figure 8.

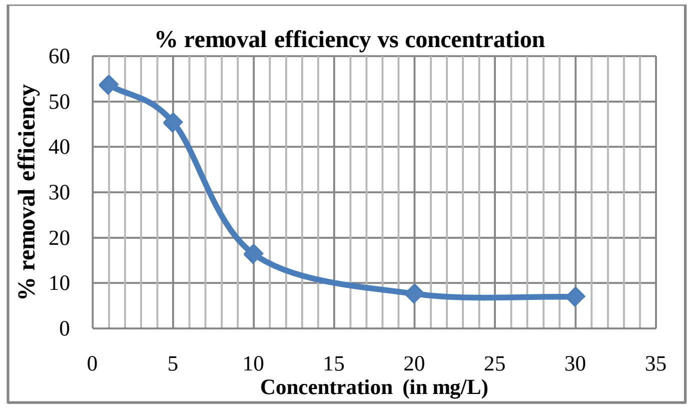

Figure 7. Variation of % removal efficiency by *Eichhornia crassipes* due to increment of initial arsenic concentration

From the above Figure 7, it can be clearly observed that the rate of arsenic removal decreased with increase in arsenic concentration in the wastewater. The plant species were found to be efficient in arsenic removal in the waste water amended with lower concentration of arsenic as shown in Figure 8.

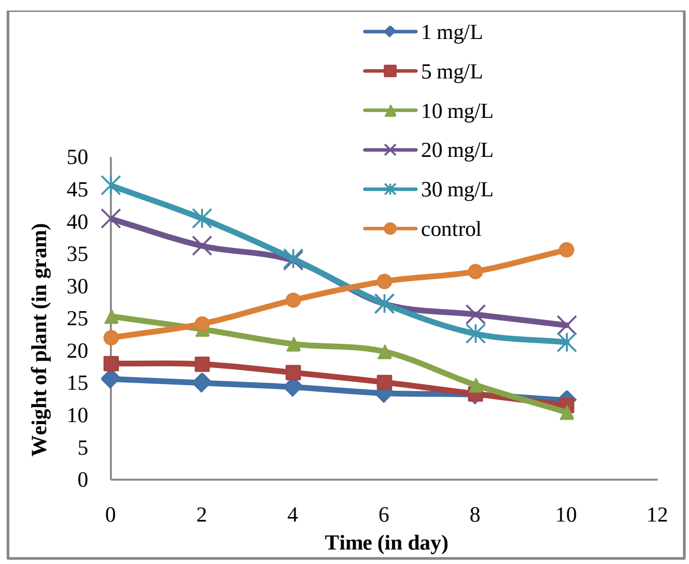

Figure 8. Impact of arsenic stress on aquatic plant *Eichhornia crassipes*

With increase in arsenic concentration in wastewater sample exposed to plant, biomass of the plant species were found to be decreasing, which signifies the toxic effect of arsenic on the plant.

Conclusions

Based on the result obtained during the investigation of the % removal efficiencyof arsenic by the plant *Eichhornia crassipes*, it has been found that the plant effectively remediates arsenic from contaminated wastewater samples amended with arsenic concentration of 1 mg/L and 5 mg/L, while can sustain at 10 mg/L for 6 days. At arsenic concentration 20 mg/l and 30 mg/L, the plant could not manage to grow significantly and died. Therefore, it is concluded that the *Eichhornia crassipes* can suitably be used for the remediation of arsenic from aqueous medium at low concentration.

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