INVESTIGATION OF THE EFFECT OF AMBIENT CONDITIONS ON BIOSORPTION OF Cd FROM AQUEOUS SOLUTION BY *Salvinia molesta*

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Introduction

The discharge of industrial effluents loaded with heavy metals into aquatic ecosystems has become a serious environmental pollution due to the non-biodegradability, toxicity and tendency for bio accumulating these heavy metals in aquatic organisms, and these undergo biomagnifications through food chain. Cadmium (Cd) is highly toxic to human, hence WHO limit of Cd in drinking water is 0.003 mg/L. Cd accumulates in kidneys where it damages the filtering mechanism. Other health effects of Cd are diarrhoea, vomiting, stomach pain and bone fracture.

Conventional methods used to remove Cd from wastewater are effective, but more expensive, not eco-friendly and inefficient particularly when heavy metals are present in low concentrations. Therefore, it is very important to develop an alternative method to remove heavy metals from wastewater.

Biosorption is a process in which living or non-living biomass is used to adsorb metals from aqueous solutions. It is an efficient, cost effective and eco-friendly method. However, it is highly dependent on many external conditions such as pH, dosage of biosorbent, initial concentration of Cd in the solution, contact time, temperature etc. Hence, it is essential to study ambient conditions to design a successful and effective biosorption system. *Salvinia molesta* had been identified to adsorb Cd(II) from aqueous solutions.

The objectives of this study are to investigate the effect of ambient conditions on biosorption of Cd from aqueous solution by *Salvinia molesta* and to find out the feasibility of recovering the loaded Cd from the biomass as $Cd^{2+}_{(aq)}$.

Methodology

All the experiments were carried out by using analytical grade chemicals and distilled water was used for all dilutions.

Preparation of biosorbent – *Salvinia molesta;* Healthy and mature *Salvinia molesta* were thoroughly cleaned and air dried. Dried samples were ground into a powder and were sieved through a sieve with pore size 800 *µm*.

Batch experiments;

i. **The effect of pH on biosorption of Cd**
   The experiment was carried out with 0.3 g of biosorbent in a 5 mg/L Cd (II) aqueous solution at varying pH (1, 2, 3, 4, 5, 6 and 7) for 180 minutes (Varma et al., 2010).
ii. **The effect of dosage of biosorbent on biosorption of Cd**

Varying weight (0.05, 0.1, 0.2, 0.3, 0.5, 0.7, 0.9, 1.0 and 1.2 g) of biosorbent was equilibrated with 5 mg/L Cd (II) solution at the optimized pH 5 for 180 minutes.

iii. **The effect of contact time on biosorption of Cd**
In a similar manner, the above experiment was carried out with the optimized weight (0.4 g) of biosorbent for varying time intervals (3, 6, 15, 30, 45, 60, 90, 120 and 180 minutes) at pH 5 to determine the time taken to reach equilibrium.

iv. **The effect of initial concentration of Cd (II) ion on biosorption of Cd**
The experiment was carried out with 0.4 g biosorbent for varying concentrations of Cd (II) ion (10, 25, 35, 45, 55, 65, 80, 100 and 120 mg/L) at pH 5 for 45 minutes.

v. **Desorption experiment was carried out using HNO_3, HCl, H_2SO_4, EDTA and distilled water as desorbing agents.**

All experiments were performed in triplicate at room temperature and agitated with 100 rpm on a mechanical shaker (GSW 4655). Cd content in the filtrate was analysed by Atomic Absorption Spectrophotometer (Varian – AA 280FS).

Results and Discussions

The effect of pH on biosorption of Cd

Figure 1 shows that at low pH (1 – 2), the adsorption capacity (q_e) of Cd is low due to competition between H^+ ions and Cd (II) for the binding sites of biosorbent. When pH was increased, q_e of Cd also increased up to pH 3. Biosorption was maximum (1.73 mg/g) and independent of range of pH 3 to 5. Above pH 5, Cd (II) started to precipitate as $Cd(OH)_2$ The pH 5 was taken as optimum pH for other experiments. It has been reported that *Hydrilla verticillata* showed the maximum adsorption of Cd (II) at pH 5 (Haung et al., 2010).

The effect of dosage of biosorbent on biosorption of Cd

Figure 2 shows both q_e of the biomass and percentage removal of Cd from aqueous solution. Adsorption capacity decreased with increasing biosorbent dosage. Percentage adsorption of Cd increased up to 0.5 g and it remained almost constant at dosage higher than 0.5 g as there were not enough biosorbate for available binding sites of biosorbent. The maximum adsorption obtained at 0.4 g which was taken as the optimum biosorbent for further experiments. A similar result has previously been reported for *Ceratophyllum demersum* (Jayaratne *et al.,* 2015).

The effect of contact time on biosorption of Cd

The Figure 3 shows that the q_e of Cd ions increased rapidly until contact time reached 45 minutes at room temperature. Further increase in contact time did not enhance biosorption process. This process is rapid in which the maximum q_e 1.298 mg/g obtained within 45 minutes. It has been reported that optimum contact time that was obtained for biosorption of Cd (II) by *Utricularia aurea* was 80 minutes (Yoonaiwong et al., 2011).

The effect of initial concentration on biosorption of Cd (II) ion

The Figure 4 shows that the q_e increased significantly with increasing initial concentration of Cd(II) up to 100 mg/L.

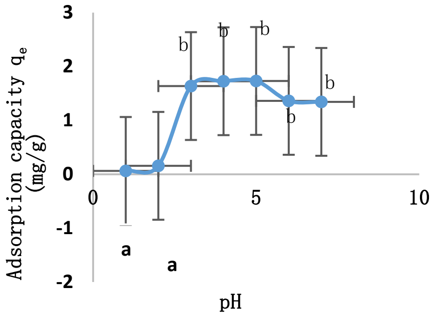

Figure 1. The effect of pH on biosorption of Cd [0.3 g biomass; C_o = 5 mg/L; t = 180 minutes]

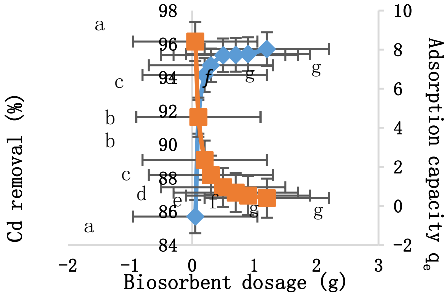

Figure 2 The effect of dosage of biosorbent on biosorption of Cd [pH = 5; C_o = 5 mg/L; t = 180 minutes]

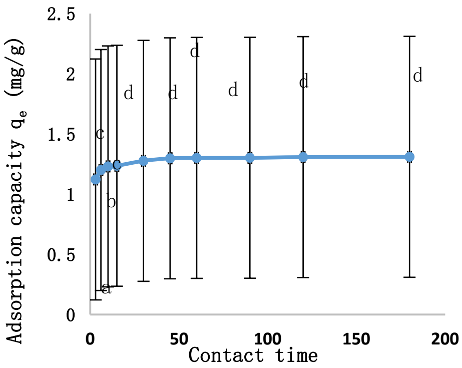

Figure 3. The effect of contact time on biosorption of Cd [pH = 5; 0.4 g biomass; C_o = 5 mg/L]

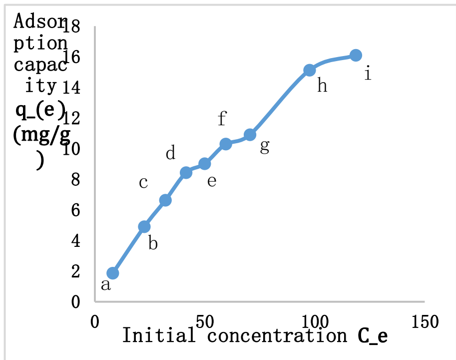

Figure 4. The effect of initial concentration on biosorption of Cd [pH = 5; 0.4 g biomass; t = 45 minutes]

The means with the same letter did not significantly differ at P ≤ 0.05 by Tukeys 95% simultaneous confidence intervals.

Desorption Experiment

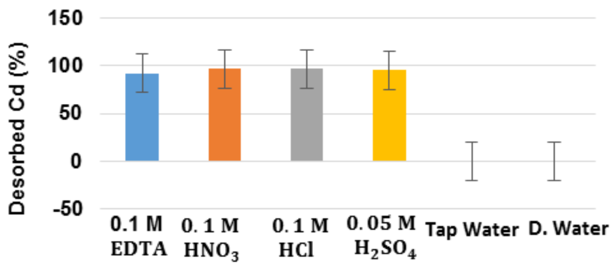

Figure 5. Desorption experiment [pH = 5; 0.4 g biomass; C_o = 8 mg/L; t = 45 minutes]

The Figure 5 shows that all mineral acids HNO_3, H_2SO_4, HCl and EDTA efficiently desorbed more than 90% of biosorbed Cd as $Cd^{2+}_{(aq)}$ from the biomass of *Salvinia molesta* .

Conclusions and Recommendations

The effective working range of pH for the adsorption of Cd by *Salvinia molesta* was found to be 3 - 5. *Salvinia molesta* is an effective and efficient biosorbent as 0.4 g of biomass biosorbed 93% of Cd from 5 mg/L Cd solution at pH 5. This process was rapid and reached equilibrium within 45 minutes. The adsorption capacity increased significantly with increasing initial concentration up to 100 mg/L of Cd(II). There is a possibility of recovering adsorbed Cd from the biomass as $Cd^{2+}_{(aq)}$ by mineral acids and EDTA.

References

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