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Biosorption of Aluminium by the Aquatic Plant *Ipomea aquatica*

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Abstract

Environmental contamination due to heavy metals is a critical problem in environmental and public health as they tend to accumulate in food chain and are not biodegradable creating everlasting burden on ecosystems. Aquatic ecosystems are more prone to the heavy metal contamination and are predominantly susceptible and becoming final receptor of heavy metals. These ecosystems supposed to be more sensitive to contaminants because of small biomass in different trophic levels. Therefore, many aquatic plants are considered as first link with respect to the heavy metal content in an aquatic ecosystem. Present study planned to suggest role of aquatic plant *Ipomea aquatica* in Al (III) ions removal by biosorption process. The biosorption characteristics of Al (III) ions from aqueous solution using *Ipomea aquatica* dead biomass (stem) were investigated as function of pH, temperature, quantity of biosorbent, contact time and initial metal ion concentration. The optimize values for all these parameters were found to be pH 6, temperature 30°C, biosorbent quantity 16.8 mg/g, contact time 120 min.

Keywords: Heavy metals, Aluminium (III) ion; Ipomea aquatica; Biosorption

Introduction

Environmental contamination due to heavy metals is a severe problem because of their increased accumulation in food chain. Since these contaminants are not biodegradable this tends to accumulate in living organisms, disturbing ecosystems (Bailey et al. 1999). Industrial effluents, particularly those containing heavy metals, are thus a cause of serious hazard to human health and other forms of life.

The demand of human needs creates huge pressure on limited natural freshwater resources globally. Increased population and rapid industrialization resulted into generation of wastewater discharge into water environment like lakes, rivers, reservoirs etc. which contains mainly non-biodegradable heavy metal concentrations along with many other toxic pollutants causing serious hazards to human populations. Efforts to educate, communicate the population globally on the concerns of water pollution by amendments in the law, policies and regulations have been prepared and implemented by developed countries to reduce the environmental pollution. Also, the development of eco-friendly technologies for the remediation of pollutants started as a need of the future. Ion exchange, reverse osmosis, electrolysis, precipitation and adsorption are the conventional technologies used so far for the waste water treatment which are inefficient, expensive and generates large amount of waste thus there is need of an alternative cost-effective technology.

Heavy metal pollution becomes a serious problem nowadays. The discharge of heavy metals into water from various chemical industries fade harmful effect on living organisms and have to eliminate early to minimize risk of uptake by plants, animals and human. Several methods have been developed and monitored on site in the last few decades and extensive investigations and research were carried out for heavy metal removal technologies. There are several methods like chemical precipitation, adsorption, ion exchange, membrane filtration, coagulation-flocculation and floatation for heavy metal removal.

Heavy metal pollution in an aquatic environment has become major problem globally and there is need to utilize the diverse group of aquatic macrophytes by means of phytoremediation as these groups of plants can hyperaccumulate many heavy metals pointing their potential and an alternative way to deal with remediation of heavy metal from aquatic environment (Rai, 2008). Aquatic macrophytes possess ability to remove and recover the nutrient anions and metal cations present in water and waste waters (Kadlec, 2000).

Therefore, biosorption of metal ions using biological materials such as algae, bacteria, fungi and yeast have established better consideration due to its advantages over conventional methods (Arica et al. 2001). It has been defined as the property of biomass to bind with metal ions from aqueous solutions (Dursun, 2006; Wang and Chen, 2006; Volesky, 2007). Biosorption process could involve several mechanisms such as ion-exchange, physical adsorption, complexation and precipitation (Veglio and Beolchini, 1997; Beolchini et al. 2005). According to Ahalya et al. (2003) and Sag et al. (1998), biosorption mechanisms can be divided into metabolism dependent and non- metabolism dependent. Metabolism dependent is a slow process include of transport across cell membrane and precipitation. While non-metabolism dependent is a rapid process include of precipitation, physical adsorption, ion exchange and complexation (Sannasi et al. 2006). The process is classified as i) extracellular accumulation / precipitation ii) cell surface sorption / precipitation and iii) intracellular accumulation (Ahalya et al. 2003; Sag et al. 1998). The major advantages of biosorption process over conventional technologies comprise (Kratochvil and Volesky, 1998; Ahalya et al. 2003).

2. Materials and Methods

2.1 Collection of plant material

Aquatic macrophytes *Ipomea aquatica were* selected for present study and collected from the river Chandrabhaga near village Mahuli (Dhande) Ta- Daryapur, Dist- Amravati (M.S.).

2.2 Biosorbents

Dried biomass of collected plant species of aquatic macrophytes *Ipomea aquatica* Linn. used for the biosorption study and were tested for their biosorptive capacity for heavy metals selected, Aluminium (Al). The biosorbents (dead dried biomass) employed in this study were obtained as a whole plant *Ipomea aquatica* Linn.

2.3 Pretreatment of Biomass

The collected biomass of aquatic macrophyte species from river water were thoroughly washed with distilled water to remove all the extraneous material and placed on a filter paper to reduce the water content prior to treating the biomass with 0.02 M HNO_3. It was then dried overnight at 50°C until a constant weight was achieved and the final weight of the biosorbent was recorded. The biosorbents were then very well crushed and allowed to passed through a 300 nm sieve in order to obtain uniform particle size of each biosorbent used for further studies.

2.4 Preparation of Heavy Metal Ions Solutions

Aluminium Solution

For Al (III), a stock solution of Alluminiuml sulphate (Al_2 (So_4) $_3$ 18 H_2O) was prepared by dissolving 24.70 grams of Al_2 $(So_4)_3 18H_2O$ (Analytical grade) in 100 ml of distilled deionized water to make a concentration of 1000 mg/l, and from this stock solution, serial dilutions were made to obtain 10, 20, 30, 40, 50, 60, 70, 80, 90 and 100 mg/l concentrations of Zn (II).

2.5 Methods

2.5.1 Biosorption Studies

2.5.1.1 Glassware and Apparatus

All biosorption experiments and batch mode studies related to biosorptive potential of dried biomass of aquatic macrophytes were performed by using 125 ml Erlenmeyer flasks. The flasks were baked at 70°C for 4 hours prior to use, followed by one wash with concentrated HNO_3 and then with distilled water.

2.5.1.2 Biosorption Evaluation

For evaluation of rate of metal ion biosorption by dried biomass, 20 ml of each metal ion (Al) solutions in 125 ml Erlenmeyer flasks were taken. The values of pH of all the solutions were monitored by pH meter throughout the experiment and adjusted according to the experiment by using 0.2 N HNO_3 , 0.1 N NaOH and buffer solutions (KCl-HCl buffer for pH 2, citric acid- sodium citrate buffer for pH 3-5, Na2HPO4-NaH2PO4 buffer for pH- 6-8 and glycine-NaOH buffer for pH 9-10).

Dead dried biomass of *Ipomea aquatica* each in the amount of 0.5, 1.0, 1.5, 2.0, 2.5, and 3.0 gm (0.5gm/l, 1gm/l, 1.5 gm/l, 2gm/l, 2.5 gm/l and 3gm/l, respectively) of dried biomass were introduced in the flasks of the above mentioned metal ion concentrations separately. All the five biosorbents under investigation were also introduced to flasks filled with pure distilled water with no metal ion (control). The flasks were maintained at temperature 25ºC on a rotary shaker (200 rpm) under constant agitation for a period of 3 hours.

The values of pH for the biosorption capacity of dried biomass of aquatic macrophytes for the metal ions considered in the study were optimized by a series of initial experiments and the effect of pH on metal sorption was determined by equilibrating the sorption mixture at different pH values of 2, 3, 4, 5, 6, 7, 8, 9 and10. Finally, studies for all the metal ions biosorption were carried out at obtained pH values with maximum biosorption.

The optimum sorbate (metal ions) and biomass (dried biomass of aquatic macrophytes) were also optimized and finally, subsequent studies relating to all metal ion solutions were performed at 20 mg/l of sorbate concentrations. The biosorbents (dried biomass of aquatic macrophytes) under investigation were used in the concentration of 1 gm/l for all metal ions unless otherwise mentioned. All the studies were carried out at 30°C for 120 min. after optimizing the temperature and time required for sorption of all metal ions considered in the study.

2.6 Analysis by Atomic Absorption Spectrometer (AAS)

All the samples were tested for metal ion concentration by using Atomic Absorption Spectrometer at Department of Biotechnology, North Maharashtra

3. Results and discussion

The aquatic macrophytes *Ipomea aquatica* Forssk showed good biosorptive capacity in removal of heavy metal ions Al (III). The results obtained on the effect of influential factors of biosorption process were interpreted and discussed separately and the optimized values of pH parameters used in biosorption were given in (Table 1 and Fig 1) which summarizes the whole biosorption study carried out on the aquatic macrophyte plant species in present investigation.

Ipomea aquatica Forssk reported with optimum biosorption at a pH value 6.0 for all the metal ions and the time required to occur maximum biosorption was recorded as 120 min. (4.1.21, 4.1.22, 4.1.23, 4.1.24, 4.1.25 & Fig. 4.1.21, 4.1.22, 4.1.23, 4.1.24, 4.1.25). Remarkable biosorption by *Ipomea aquatica* Forssk was recorded for Zn (II) ions (17.8 mg/g) followed by Cu (II) ion (16.8 mg/g), Pb (II) ion (16.3 mg/g), Ni (II) ion (15.9 mg/g) and Al (III) ion (15.3mg/g) at pH 6.0. Highest percent removal was observed for Zn (II) ions (92.70 %) and lowest for Al (III) ion (79.27%) by *Ipomea aquatica* Forssk.

4. Conclusion

The biosorption capacity of aquatic plant *Ipomea aquatica* for the removal of Al (III) ions based on batch mode studies, equilibrium and kinetic modeling revealed that pH 5, temperature 30°C, biosorbent quantity 2.0 gm/l, contact time 120 min. and initial metal ion concentration 50mg/l were optimum for biosorption of Al (III) ions.

Thus, the present study concludes that *Ipomea aquatica* may employ as an economic and environment friendly biosorbents and can be a good option to the expensive methods currently used in removing Al (III) ions from polluted water.

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Table: 1 Effect of pH on equilibrium Al (III) sorption capacity *Ipomea aquatica* Forssk.

Time (min.)	**pH**								
	2	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
	qe mg/g	**qe mg/g**	**qe mg/g**	**qe mg/g**	**qe mg/g**	**qe mg/g**	**qe mg/g**	**qe mg/g**	**qe mg/g**
5	6.2	6.8	7.6	9.8	10.7	10.1	9.7	8.5	7.4
10	6.5	7.3	8.4	10.1	11.6	10.9	10.1	8.8	8.1
15	7.1	7.8	8.6	10.7	12.2	11.4	10.3	9.4	8.6
30	7.5	8.3	9.1	11	12.8	11.8	10.8	9.7	9.5
45	8.1	8.8	9.7	11.5	13.6	12.6	11.3	10.4	10.2
60	9.6	9.4	10.2	12.1	14.1	13.2	12.5	10.9	10.4
90	10.2	10.6	11.3	12.8	14.8	13.8	13.1	11.4	10.6
120	10.8	11	12.5	13.3	15.3	14.1	13.5	12.8	11.2
150	10.4	10.9	12.2	13.1	15.1	13.9	13.3	12.5	11.1
180	10.3	10.8	12.1	13.1	14.9	13.8	13.2	12.5	11.1

C'_0 = 20 mgm/l; initial estimated Al concentration, C_0 = 19.3 mgm/l.

Fig.1: Biosorption of Al (III) ions by *Ipomea aquatica* Forssk at varying pH