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Effect of pH on equilibrium Al (III) sorption capacity *Pistia stratiotes* Linn..

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Abstract:

In the present study, metal ion uptake seems to be optimum at pH value of 5.0 and pH 6.0 in case the aquatic macrophyte *Pistia stratiotes* . The biosorption of metal ions was reduced when pH value was reduced from 5.0 to 1.0 and 6.0 to 1.0 respectively. There seems to the improvement in metal metal sorption with higher pH might be due to the increase in the amount of ligands for metal ion binding. Due to low pH, competition occurs between protons and metal ions, results in to less metal uptake as low pH generates higher concentration of H^+ ions. Hence metal ions must compete with H^+ ions for attachment to the surface of functional groups of the biomass (Zouboulis et al. 1999). With the rise in pH, fewer H^+ ions exist, and consequently, metal ions have a better chance to bind to the free binding sites. with the declining pH (<6.0) and (<5.0) decrease in biosorption of all the metal ions was observed respectively. Whereas, with the increase in pH above (>6.0) and (>5.0), decrease of biosorption was observed among all the metal ions studied, respectively. The optimum biosorption by *Pistia stratiotes* Linn. was recorded at a pH value of 5.0 (16.1 mg/g) and the time required to occur maximum biosorption was recorded as 120 min.

Keywords: Heavy metals, Alluminium(III) ion; Pistia stratiotes; Biosorption;pH

Introduction

Water supports life on earth and around which the complete fabric of life is woven. The necessity of water altogether lives, from micro-organism to man, is major problem nowadays as a result of all water resources are reached to some extent of crisis because of unplanned urbanization and industrialization as expressed by Singh et al.(2002).

Water is one of the most indispensable resource and is the elixir of life. Water constitutes about 70% of the body weight of almost all living organisms. Without water life is not possible on this planet. It exists in three states namely solid, liquid and gaseous state. It acts as a media for both chemical and biochemical reactions and also as an internal and external medium for several organisms. About 97.2% of water on earth is salty and only 2.8% is present as fresh water from which about 20% constitutes groundwater which is highly valued because of certain properties not possessed by surface water (Goel 2000).

Since it is a dynamic system, containing living as well as nonliving, organic, inorganic, soluble as well as insoluble substances. Due to presence of these substances its quality is likely to change day by day from source to source creating disturbance in the equilibrium system and would become unfit for designated uses. Only 1% part of surface and ground water resources is available on land for various purposes like drinking, agriculture, domestic power generation, industrial consumption, transportation and waste disposal (Mishra et al. 2002, Gupta et al., 2008 and Tahir et al. 2008). According to Leonard (1971); Rognemd and Fjeld (2001) the unequal distribution of water on the surface of earth and the fast declining availability of fresh usable water are the major concerns in terms of water quality and quantity.

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).

Therefore in present investigation *Pistia stratiotes* an herbaceous trailing aquatic plant found in muddy stream banks, freshwater ponds, riverside and marshes is used for the removal of Al (III) by checking its biosorptive capacity on the basis of different pH.

Materials and Methods

Collection of plant material

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

Biosorbents:

Dried biomass of collected plant species of aquatic macrophytes Eichhornia crassipes (Mart) Solms, Pistia stratiotes Linn. used for the biosorption study and were tested for their biosorptive capacity for Aluminium (Al) heavy metals. The biosorbents (dead dried biomass) employed in this study were obtained as a whole plant Pistia stratiotes Linn.

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.

Preparation of Heavy Metal Ions Solutions

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).

Methods

Bisorption Studies

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.

Biosorption Evaluation (PLATE IX)

For evaluation of rate of metal ion biosorption by dried biomass, 20 ml of each metal ion (Cu, Zn, Al, Pb and Ni) 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 *Pistia stratiotes* Linn.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 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 the metal ions biosorption were carried out at obtained pH values with maximum biosorption.

Results and discussion

Effect of pH

The biosorption of metal ions was studied at varying pH values, such as 2.0, 3.0, 4.0, 5.0, 6.0, 7.0, 8.0, 9.0 and 10 pH units (initial sorbate concentration of 20 mgm/l; sorbent concentration of 0.5 gm/l) at a time interval of 5, 10, 15, 30, 45, 60, 90, 120, 150 and 180 min..

The optimum biosorption by *Pistia stratiotes* Linn. was recorded at a pH value of 5.0 and the time required to occur maximum biosorption was recorded as 120 min.

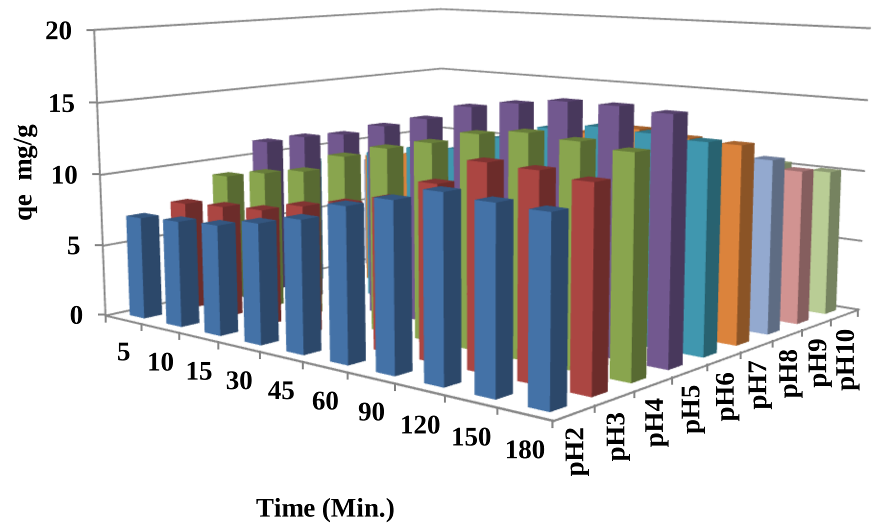
for a the metal ions Remarkable biosorption by *Pistia stratiotes* Linn. was recorded for Al (III) ions (16.1 mg/g) at pH 5.0 (Table 1, Fig 1). Highest percent removal was observed for Al (III) ions (83.41 %) and lowest by *Pistia stratiotes* Linn.

Table :1. Effect of pH on equilibrium Al (III) sorption capacity *Pistia stratiotes* Linn.

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	7.1	7.6	9.1	11.2	9.4	9	8.5	8	7
10	7.3	7.8	9.7	11.9	10.1	9.6	9.1	8.5	7.4
15	7.5	8	10.2	12.4	10.6	10.1	9.7	9.4	7.7
30	8.1	8.7	11.6	13.3	11.3	10.8	10.3	9.6	8.3
45	8.8	9.3	12.5	14.1	11.6	11	10.5	10	8.7
60	10.1	10	13.2	15.2	12.7	12.3	10.8	10.4	9.4
90	10.9	11.4	14.1	15.7	13.7	13	12.4	11	9.7
120	11.8	13.1	14.5	16.1	14.1	13.6	12.5	11.4	10.4
150	11.6	13	14.3	16.1	14	13.3	12.2	10.9	10.3
180	11.5	12.7	14	15.9	13.8	13.2	11.8	10.6	10.1

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

Fig.1 Biosorption of Al (III) ions by *Pistia stratiotes* Linn. at varying pH



Conclusion:

The biosorption capacity of aquatic plant *Pistia stratiotes* Linn for the removal of Al (III) ions based on pH 5, temperature 30°C, biosorbent quantity 2.0 gm/l, contact time 120 min. and initial metal ion concentration 16.1mg/g 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) from polluted water.

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