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Effect of Contact Time on Biosorption of Different Metal Ions by *Eichhornia Crassipes* (Mart) Solms

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Abstract

Exposure of the biosorbent in terms of contact time for the sorbate was of importance showing the biosorption efficiency of metal ions by different aquatic macrophyte species as a function of contact time (initial sorbate concentration of 20 mgm/l; sorbent concentration of 0.5 gm/l, pH 5.0 and pH 6.0). It was observed that the efficiency of biosorption for all aquatic macrophyte species increased significantly with the increase in contact time during the first 30 min., followed by slower uptake up to 120 min. of contact time and thereafter, equilibrium was probably achieved as there was no significant uptake in case of metal ions studied after 120 min., of exposure. It has been observed in present study that the optimum adsorption of all metal ions occurs at 120 min. on to the dried biomass of aquatic macrophytes as a biosorbent. *Eichhornia crassipes* (Mart) Solms reported with optimum adsorption of metal ions at a period of 120 min.(Table 4.2.1, & Fig. 4.2.1) for Cu(II) ion (15.6 mg/g) followed by Zn(II) ion (13.7 mg/g) , Ni (II) ion (12.9 mg/g), Pb(II) ion (12.8 mg/g)and Al (III) ion (12.4 mg/g). Highest percent removal for Cu (II) ions (80.41%) and lowest for Al (III) (80.20%) was reported by *Eichhornia crassipes* (Mart) Solms.

Keywords: Heavy metals; Eichhornia crassipes; Biosorption; Contact time.

1. Introduction

According to Ayibatele (1992) natural resources are the necessary wealth of our country, water is one amongst them. Water is marvel of nature. “No life without water” could be a common language relying upon the actual fact that it's naturally occurring essential requirement of all life supporting activities.

Water quality, defined as the suitability of water to sustain various uses or processes (Meybeck et al., 1996), seems to be influence by a wide range of natural factors (biological, geological, hydrological, meteorological, and topographical). Human influence on water quality is also wide-ranging and may be due to hydrological influence via flow diversion, water abstraction, and wetland drainage or dam construction activities. However the discharge of sewage, agricultural, industrial and urban wastewater, and the diffuse run-off of agricultural fertilizers and pest-control chemicals into water bodies are more obvious influence of human activity on water quality which increases the pollutional load of the water resources and deteriorates the water quality.

Almost all of earth’s organisms need certain metals in order to maintain health and biological functions, with around 15 of these elements found naturally in rocks and soils, in general in very small amounts some of these required by humans for nutrition are copper (Cu), zinc (Zn), iron (Fe), cobalt (Co), manganese (Mn), molybdenum (Mo). However, in large amounts these are carcinogenic or toxic, affecting, amongst others, the central nervous system (manganese, mercury, lead, arsenic), the kidneys or liver (mercury, lead, cadmium, copper) or skin, bones, or teeth (nickel, cadmium, copper, chromium) (Freedman and Hutchinson,1981). The most common human deficiency in a heavy metal is zinc, for which over two billion humans, frequently in developing countries, suffer from insufficient amounts of zinc in their diet (Prasad 2003).

Heavy metals can be sourced from both natural and anthropogenic influences; in some areas anthropogenic inputs are proportionately greater than those from natural sources. Some academics (Ahmad 2005; Holdgate 1979 and Alloway 1994) proposed that it's often the by-products of mining, manufacturing, disposing of industrial metals and domestic waste that accounts for almost all environmental pollution. It's without argument higher levels of heavy metals are found in urban landscapes and industrial sites which far exceed natural levels.

The biosorbent exposure in terms of contact time for the sorbate was of importance in the process of biosorption. Present study revealed 120 min. of contact time for the achievement of equilibrium of the solution by aquatic macrophytes namely *Eichhornia crassipes* (Mart) for the sorption of metal ions studied. It has been observed from the results during the first 5 to 30 min., rapid uptake of cations from biosorption by the biomass takes place which slows down significantly after the first 90 min.. This was probably due to large number of vacant surface sites available initially for adsorption and after some time, the remaining vacant surface sites may have been difficult to be occupied because of forces between the solute molecules of the solid and bulk phase. Also, the diminishing removal of metal ions with increasing time may have been due to intraparticle diffusion process dominating over adsorption (Volesky 2003; Deo and Ali 1993).

2. Materials and Methods

2.1. Collection of plant material

Plant material *Eichhornia crassipes* (Mart) selected for present study was collected from the river Chandrabhaga near village Mahuli (Dhande) Ta- Daryapur, Dist- Amravati (M.S.).

2.2. Preparation of biosorbent and synthetic solution

The harvested plant biomass (stem) of *Eichhornia crassipes* (Mart) from river water was 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 biosorbent were then crushed and passed through a 300 nm sieve to obtain uniform particle size of biosorbent used for further studies.

Synthetic stock solution of Nickel was prepared by dissolving 4.47 grams of $NiSO_4$ $6H_2O$ (Analytical grade) in 100 ml of double distilled water to make a concentration of 1000 mg/l, and serial dilutions from of this stock solution were prepared to obtain10, 20, 30, 40, 50, 60, 70, 80, 90 and 100 mg/l concentration of Ni (II) ion solution. All the experiments were conducted at desired pH using 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).

2.3 Preparation of Heavy Metal Ions Solutions

2.3.1 Copper Solution

For Cu (II), Copper sulphate ($CuSO_4$ $5H_2O$) as a stock solution was prepared by dissolving 3.93 grams of $CuSO_4$ $5H_2O$ (Analytical grade) in 100 ml of double distilled water to make a concentration of 1000 mg/l, and serial dilutions from of this stock solution were prepared to obtain10, 20, 30, 40, 50, 60, 70, 80, 90 and 100 mg/l concentration of Cu (II) ion solution.

2.3.2 Zinc Solution

For Zn (II), a stock solution of Zinc sulphate ($ZnSo_4$ $7H_2O$) was prepared by dissolving 4.397 grams of $ZnSo_4$ $7H_2O$ (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).

2.3.3 Lead Solution

For Pb (II), a stock solution of Lead nitrate (N_2 O_6 Pb) was prepared by dissolving 1.598 grams of N_2 O_6 Pb (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).

2.3.4 Nickel Solution

For Ni (II), a stock solution of Nickel sulphate ($NiSo_4$ $6H_2O$) was prepared by dissolving 4.47 grams of $NiSo_4$ $6H_2O$ (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).

2.3.5 Aluminium Solution

For Al (III), a stock solution of Aluminium 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).

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.

3. Results and discussion

It was observed that the efficiency of biosorption for all aquatic macrophyte species increased significantly with the increase in contact time during the first 30 min., followed by slower uptake up to

120 min. of contact time and thereafter, equilibrium was probably achieved as there was no significant uptake in case of metal ions studied after 120 min., of exposure. It has been observed in present study that the optimum adsorption of all metal ions occurs at 120 min. on to the dried biomass of aquatic macrophytes as a biosorbent.

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4. Conclusion

To overcome the issues related with water pollution , bioremediation seems to good option in which treatment involve naturally occurring organisms to break down hazardous substances in to less toxic or non toxic substances. It includes phytoremediation, bioaccumulation and biosorption. Phytoremediation mainly concern with the natural and direct use of green plants to uptake/ adsorption of pollutants.

The purpose of the present study was to find out the biosorption capacity of aquatic macrophyte plant species namely *Eichhornia crassipes* (Mart) Solms, collected from river water for phytoremediation of heavy metals. These aquatic macrophyte plant species (dead biomass) were taken under investigations for the removal of toxic metal ions, such as Cu (II), Zn (II), Ni (II), Al (III) and Pb (II) ions in order to propose low cost eco-friendly biosorbents for waste water treatment. The findings were based on biosorption capacity. Experiments were performed as a function of contact time. The solution pH, temperature and initial metal ion concentration played a significant role in affecting the capacity of biosorption.

Thus, the present study concludes that *Eichhornia crassipes* (Mart) may employ as an economic and environment friendly biosorbents and can be a good option to the expensive methods currently used in removing such as Cu (II), Zn (II), Ni (II), Al (III) and Pb (II) ions from polluted water (Table 1 and Fig 1)

Table :1 Effect of contact time on biosorption of different metal ions by *Eichhornia crassipes* (Mart) Solms

Time (Min.)	**qe (mg/g)**				
	Cu	*Ni*	*Al*	Zn	*Pb*
5	7.4	5.2	6.1	7.3	5.9
10	7.7	5.7	6.5	7.9	6.3
15	8.1	6.6	8.8	8.5	7.2
30	8.8	8	9.5	9.8	10.1
45	11.5	10.4	10.3	10.5	11.6
60	12.4	11.7	10.9	11.2	12
90	13	12.4	11.5	12.2	12.3
120	15.6	12.9	12.4	13.7	12.8
150	14.8	10.8	12.1	12.4	12.1
180	14.3	9.5	11.5	11.6	11.8

$C'_0 = 20$ mgm/l; initial estimated Cu concentration, $C_0 = 19.4$ mgm/l.

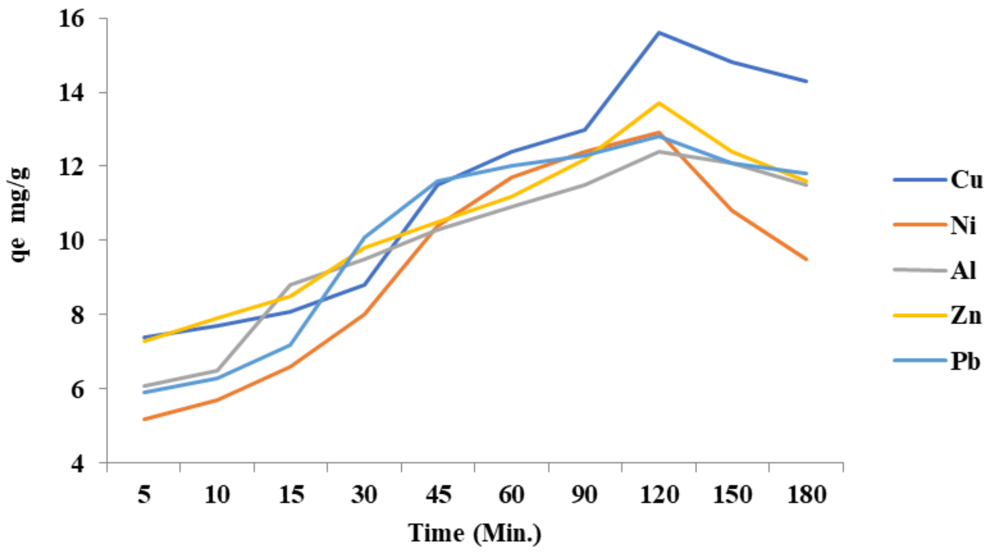
$C'_0 = 20$ mgm/l; initial estimated Ni concentration, $C_0 = 19.2$ mgm/l.

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

$C'_0 = 20$ mgm/l; initial estimated Zn concentration, $C_0 = 19.2$ mgm/l.

$C'_0 = 20$ mgm/l; initial estimated Pb concentration, $C_0 = 19.4$ mgm/l.

Fig.1: Effect of contact time on biosorption of different metal ions by *Eichhornia crassipes* (Mart) Solms.



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