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Biosorption of Cu (II) by *Eichhornia Crassipes* a Novel Bio sorbent

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Abstract

Biological materials for the removal of heavy metal ions from waste water are important due to their extreme toxicity towards aquatic life and humans. Microorganisms and low cost natural biosorbents are being increasingly studied for the removal of heavy metal ions from aqueous solution. In this work, *Eichhornia Crassipes leaf* powder was taken as a low cost biosorbent for the sorption of Copper(II). The various parameters like Initial metal ion concentration, Initial pH, Temperature and Biosorbent dosage were studied in a batch reactor. Equilibrium was reached after 24 h of contact time. The optimum values of initial Copper concentration, initial pH, temperature and biomass loading are found to be 50mg/l, 4,30°C and 5g/l . Under this optimised condition a maximum percentage removal of 92% and specific uptake of 10mg/g was obtained for Cu(II) sorption.

Keywords: Biosorption, *Eichhornia Crassipes* , Initial concentration, pH and Biomass load.

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1. Introduction

Biosorption of heavy metals from aqueous solutions is a quite new technology for the treatment of industrial wastewater, which utilized naturally occurring waste materials derived from biomass(Wang & Chen, 2006). The heavy metal ions are stable and persistent environmental contaminants since they cannot be degraded and destroyed. These metal ions can be harmful to aquatic life and water contaminated by toxic metal ions remains a serious public health problem for human health. Numerous methods exist to remove heavy metals ions from aqueous solutions by chemical precipitation or by activated carbon as the most used adsorbent, nevertheless it is relatively expensive (Demirbas, 2008). The toxicity of heavy metals is apparent in reducing growth and development in microorganisms and plants, and seriously harming the health of animals and humans. In particular, heavy metals may disrupt the normal function of the central nervous system and cause changes in the blood

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content, and adversely affect the function of lungs, kidneys, liver and other organs. The long-term action of heavy metals may cause the development of cancer, allergy, dystrophy, physical and neurological degenerative processes, Alzheimer's and Parkinson's diseases. However, in small amounts, heavy metals are essential for many organisms, but their enhanced doses induce acute or chronic poisoning (Kvesitadze *et al*., 2006). Adsorbent materials derived from Biomass can be used for the effective removal and recovery of heavy metal ions from wastewater: from algae, fungi, bacteria, sea-weeds, some higher plants, and agricultural wastes.(Abdelkrim Cheriti *et al.*,2011). While choosing the biosorbent for metal sorption its origin is a major factor to be taken in to account. Fast growing plants that are specifically cultivated for biosorption of heavy metals eg. Weeds can be used(Regime and Volesky,2000). Verma.*etal*.,2008, studied that ion exchange during metal sorption(Cd, Ni, Cu, Cr, Zn and Pb) by dried biomass of Water hyacinth(*Eichornia Crassipes)* because of their relatively small size and large surface area. This feature was a convenient basis for the selection of biosrbent suitable for the sorption of heavy metals. They contain many poly functional groups ,that binds cationic and anionic metal complexes. Potential metal cation binding sites of algal cell components includes Carboxyl, Amine, Imidazole Phosphate, Sulphate , Sulfhydryl, Hydroxyl and chemical functional groups contained in cell proteins and sugars(Alluri *etal.*,2007) .

2. Materials and methods

2.1 Preparation of sorbate solution

A 1000 mg/l stock solution of Copper was prepared by dissolving 3.93 g of copper sulphate in double distilled water. The required concentrations of copper ions were prepared from the stock solution by dilution method.

2.2 Preparation of the biosorbent

Eichhornia Crassipes leaf powder was used in this study. The *Eichhornia Crassipes* leaf was obtained from local area; was washed, dried, and crushed in primary crusher and air dried in sun for several days until its weight remains constant. After drying, it was crushed in roll crusher and hammer mills. The material obtained through crushing and grinding was screened through BSS meshes. Finally the products obtained were stored in glass bottles for further use.

2.3 Batch biosorption studies

Batch experiments were carried out in Erlenmeyer flasks by adding known amount of biomass (*Eichhornia Crassipes* leaf powder) in 100 ml aqueous Copper sulphate solution.

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The flasks were gently agitated on a shaker with a constant shaking rate at 150 rpm for 240 min until equilibrium sorption was obtained. Samples were taken from the solution at regular time intervals for the residual metal ion concentration in the solution. The residual concentration of Copper ions in the solutions was determined spectrophotometrically at 457 nm using Neocuproine as the complexing agent (APHA, 1994).

The effect of initial Copper ion concentration on percentage removal of Copper was studied by conducting experiments with different initial copper ion concentrations namely 50 mg/l, 100 mg/l, 150 mg/l, 200 mg/l and 250 mg/l under identical conditions of temperature, pH and biomass loading and the experiment was carried out as described above.

The effect of initial pH on percentage removal of Copper was studied by conducting experiments with different initial pH namely 2,3,4,5 and 6 under identical conditions of initial Cu(II) ion concentration , temperature and biomass loading and the experiment was carried out as described above.

The effect of temperature on percentage removal of Copper was studied by conducting experiments with different temperature namely 25°C,30°C,35°C and 40°C under identical conditions of initial Cu(II) ion concentration, initial pH and biomass loading and the experiment was carried out as described above.

The effect of biomass loading on percentage removal of Copper was studied by conducting experiments with different biomass load namely 2g/l, 3g/l, 4g/l,5g/l and 6g/l under identical conditions of initial Cu(II) ion concentration, initial pH and temperature and the experiment was carried out as described above.

3. Results and Discussion

The biosorption of Cu(II) using *Eichhornia Crassipes* leaf powder as a biosorbent in a batch process depends on both contact time between the adsorbate and adsorbent particles and initial metal ion concentration. The effect of initial metal ion concentration on contact time, percentage removal and specific uptake of Copper was given in Fig 1 and Fig 2 respectively. Fig 1 shows that equilibrium is attained in 24 h, also the sorption of Copper on *Eichhornia Crassipes* leaf powder increases with increasing contact time. The Copper removal efficiency was affected by the initial metal ion concentration, with decreasing removal percentages as concentration increases from 50 mg/l to 250 mg/l. As the initial Copper concentration increases from 50 mg/l to 250 mg/l, the percentage removal of Copper decreases from 91 % to 81 % and the specific uptake of Copper increases from 12 mg/g to 53 mg/g respectively(fig. 2). At lower initial metal ion concentrations, the ratio of sorptive

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surface to the total Copper ions available is high and nearly all Copper ions in solution can be bound and removed.

The percentage of metal sorption vary with pH of the medium which is given in Fig.3. The percentage removal of Copper increases from 76% to 92% as the pH increased from 2.0 to 4.0 and thereafter increasing pH up to 6, the percentage removal of Copper decreased to 86%. Biosorption of Copper was low at alkaline condition. The maximum percentage removal is found to be 92% at pH 4.0 and selected as the optimum pH . The percentage removal of Copper by immobilized biosorbent was very less at low pH . The result seems to suggest that the biosorption of Copper by *Eichhornia Crassipes* leaf powder is mainly due to ionic attraction. This can be explained based on at low pH, highly mobile H^+ ions are adsorbed at the active sites, preventing Copper ions from getting sorbed . At pH values higher than 5.0, percentage removal of Copper decreases because of the increase in concentration of OH^- ions in the biosorption medium causes the precipitation of Copper. Hence, biosorption studies should not be carried out at higher pH levels which cause precipitation of metal ions. Optimum metal biosorption at pH 4-6 has also been reported for several other biomass types (Wang and Chen, **2009**), and is likely due to deprotonation of metal binding anionic sites, such as carboxylic groups at this pH range (Singh *et al*., **2007**).

The effect of temperature on percentage removal of Copper was studied in Erlenmeyer flasks with 100 ml of aqueous Copper solution at different controlled temperatures namely 25ºC, 30ºC, 35ºC and 40ºC. The effect of temperature on percentage removal of Copper by immobilized biosorbent was given in the Fig.4. A maximum Copper removal of 78% is obtained at 30ºC because the number of binding sites is more at this temperature. The percentage removal of Copper by immobilized biosorbent is higher at room temperature and it decreases with further increase in temperature due to the destruction of the cell walls expected, and a reduction in Copper removal is observed.

The effect of biomass loading on percentage removal of Copper was studied by conducting the experiments in Erlenmeyer flasks with 100 ml of aqueous Copper solution with different biomass loading namely 2g/l, 3g/l, 4g/l,5g/l and 6g/l. The results of effect of biomass loading on contact time and percentage removal of Copper during the biosorption process are given in Fig.5. It was observed that the percentage removal of Copper increased from 71 to 85% as the biomass loading increased from 2 g/l to 6 g/l. At low Copper concentration, the ratio of sorptive surface to the total Cu(II) ions available is high and nearly

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all Copper ions in solution can be bound and removed. A maximum Copper removal of 85% was observed at a biomass loading of 6 g/l.

4. Conclusion

Biosorption experiments were performed as a function of initial metal ion concentration, pH, temperature and biosorbent dosage. Biosorption was influenced by initial Copper ion concentrations and it was found that as the initial Copper concentration increases from 50 mg/l to 250 mg/l, the percentage removal of Copper decreases from 91 % to 81 % and the specific uptake of Copper increases from 12 mg/g to 53 mg/g respectively. The effect of initial pH was also influence the sorption efficiency. The optimum conditions were found to be Initial concentration 50mg/l, pH 4, Temperature 30°C and Biomass loading of 6g/l. The obtained results showed that *Eichhornia Crassipes* leaf powder was a good adsorbent for the removal of metal ions and had high adsorption yields for the treatment of aqueous solutions containing copper ions.

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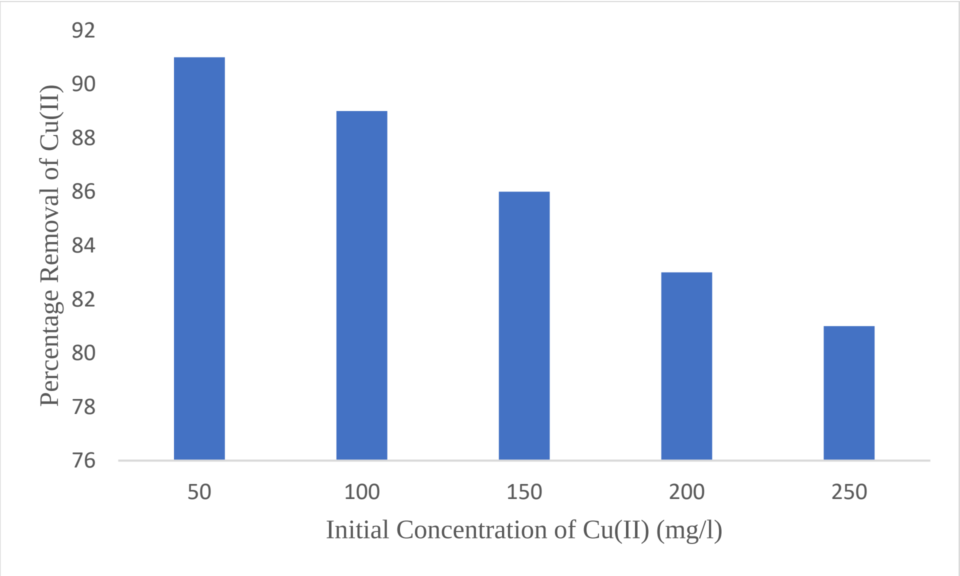

Fig. 1. Effect of initial Copper concentration on Percentage Removal of Copper by *Eichhornia Crassipes* leaf powder

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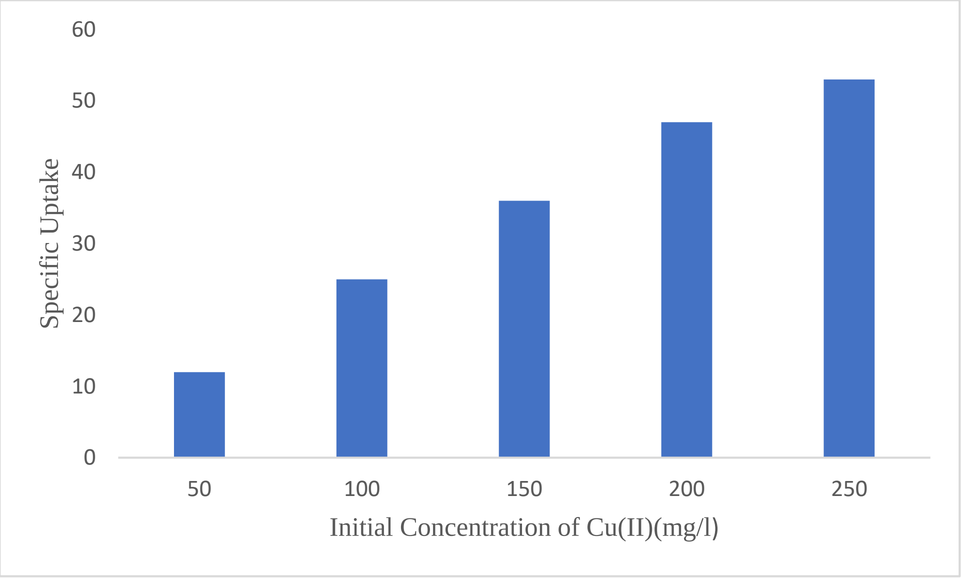

Fig. 2. Effect of initial Copper concentration on Specific uptake of Copper by *Eichhornia Crassipes* leaf powder

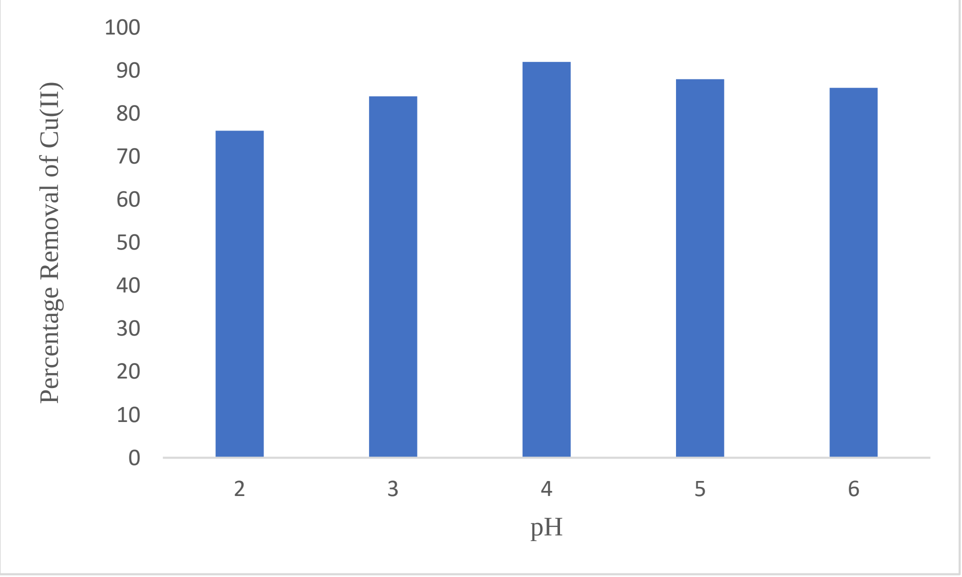

Fig. 3. Effect of initial pH on Percentage Removal of Copper by *Eichhornia Crassipes* leaf powder

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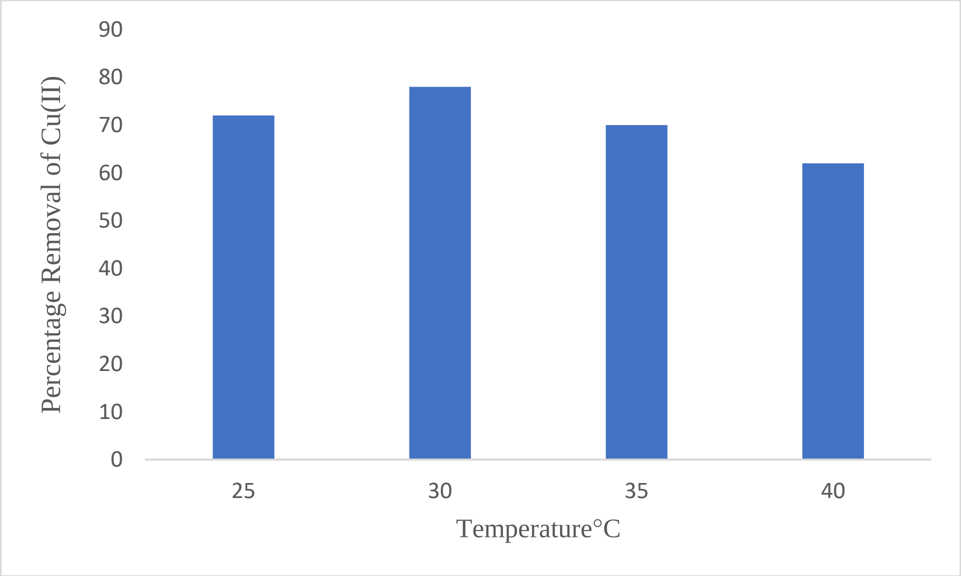

Fig. 4. Effect of Temperature on Percentage Removal of Copper by *Eichhornia Crassipes* leaf powder

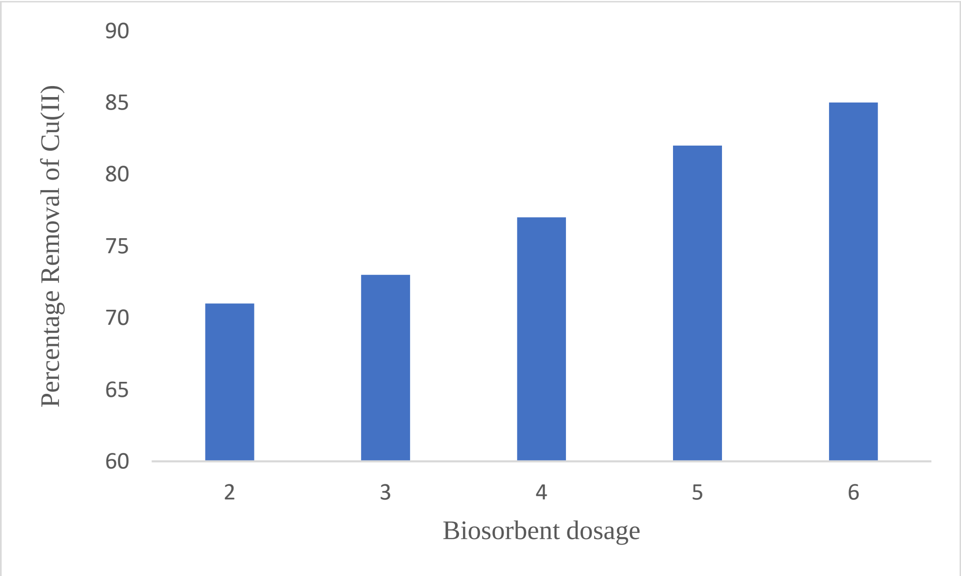

Fig. 5. Effect of Biosoebent dosage on Percentage Removal of Copper by *Eichhornia Crassipes* leaf powder