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PH-Dependent Interactions between Copper (II) and Biomass in the Biosorption Process for Removal of Copper (II) from Water.

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Abstract. Removal of heavy metals from water by biosorption is an attractive approach. In this work, the interactions between Copper and biomass, a cost-effective biosorbent, were investigated. Batch experiments were performed to study the adsorption of copper on biomass surface. Two parameters the effect of pH and contact time were studied. It was found that the interactions between Copper and biomass were complex, and the solution pH was a key factor governing such interactions. Maximum adsorption of Copper was observed at optimum conditions of pH 5.0 and contact time of 90 min was enough to achieve equilibrium. Additionally, a simple method was explored to estimate the contributions of different interactions between the biomass and copper.

Keywords: *Copper (II), Biomass, Biosorption, pH.*

1. Introduction:

Heavy metals cause serious threat to the environment, animals and humans for their extreme toxicity. Toxic heavy metal ions enter water through discharges from various industrial activities such as fertilizer, mining, metal plating, batteries, paper, alloy making, and pesticide industries and cause a serious threat to the environment (1). Copper usually occurs in nature as oxides and sulfides. Copper is one of the most toxic heavy metals, attracting much attention from environmentalists due to its acute and chronic toxic effects in animal and human health. Copper in trace amounts may be beneficial as an activator of some enzyme systems, but Cu (II) intake over the permissible levels leads to severe mucosal irritation, hepatic and renal damage, widespread capillary damage, and central nervous system problems (2). The World Health Organization (WHO) recommended a maximum acceptable concentration of Cu (II) in drinking water of 2.0 mg/L (3). As a result, it is essential to remove Cu (II) from water before disposal.

The main techniques currently used for metal removal include chemical precipitation, electrochemical deposition, evaporation, cementation, membrane process, ion-exchange and activated carbon adsorption (4-7). However, the application of these conventional techniques is often limited due to their inefficiency, high capital investment or operational costs. Consequently, there is an emerging requirement for novel, efficient and cost-effective techniques for the remediation of metal bearing waters before their discharge into the environment.

Biosorption is one of the potentially promising technology for the removal and recovery of heavy metal ions from water. It can be an alternative to the above conventional processes.

The objective of this work is to investigate the pH-dependent interactions between copper (II) and biomass in the biosorption process, so that it can be used for removal of Cu (II) from water.

2. Material and Methods:

2.1. Materials:

All the chemicals used for the experiment were of analytical grade and were used without further purification.

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The plant leaves were collected from the different sites located in the region of Raipur, Chhattisgarh, India. The leaves were washed with Milli-Q ultrapure water several times to remove surface impurities, sun-dried and subsequently dried in an electric oven at 60 ℃ for 3 days. The dried biomass was ground and sieved through 250- µm mesh Tyler screen and stored in an air-tight container in order to avoid moisture. The fine biomass obtained was used for further adsorption studies.

The Cu (II) ions in the solution are analyzed using Atomic adsorption spectrophotometer AAS4129D, ECIL India which operates in flame mode. A high precision electronic balance was used for weighing and a digital pH meter was used for the measurements of pH. Shaking was done with an orbital shaker.

2.2. Batch Experiments:

Batch adsorption experiments of the biomass were carried out in 250 ml Erlenmeyer flasks at 30 ℃. A 0.5 g portion of biomass and 50 mL of Cu (II) solution in the desired concentration were mixed in the flasks and shaken in an orbital shaker. The effect of pH on metal uptake by biomass was studied by varying from pH 2.0 to pH 7.0 with either 0.1 M NaOH or 0.1 M HCl. The effect of contact time was investigated in the range 15-180 min at pH 5.0 at 30 ℃.

The amount of metal bound by the biosorbent was calculated from the difference between the initial and equilibrium concentrations of the metal ions in solution. The amount of Copper adsorbed by the biomass at equilibrium was calculated using equation 1.

$$q_e = \frac{(Co - Ce)V}{w} \quad (1)$$

Where qe (mg g-1) is the adsorption capacity at equilibrium,
Co (mg L-1) is the initial and Ce (mg L-1) is the equilibrium concentration of metal ions,
W (g) is the weight of adsorbent used and V (ml) is the volume of sample.
Copper removal efficiency (R) was calculated using the equation 2.

$$R = \frac{Co - Ce}{Co} X\ 100\% \quad (2)$$

Where Co (mg L-1) is the initial and Ce (mg L-1) is the equilibrium concentration of metal ions, respectively.

3. Result and Discussions:

3.1. Effect of pH: The greatest removal efficiency of 85.6 % biosorption was obtained at pH 5.0 and it was shown in Fig.1.

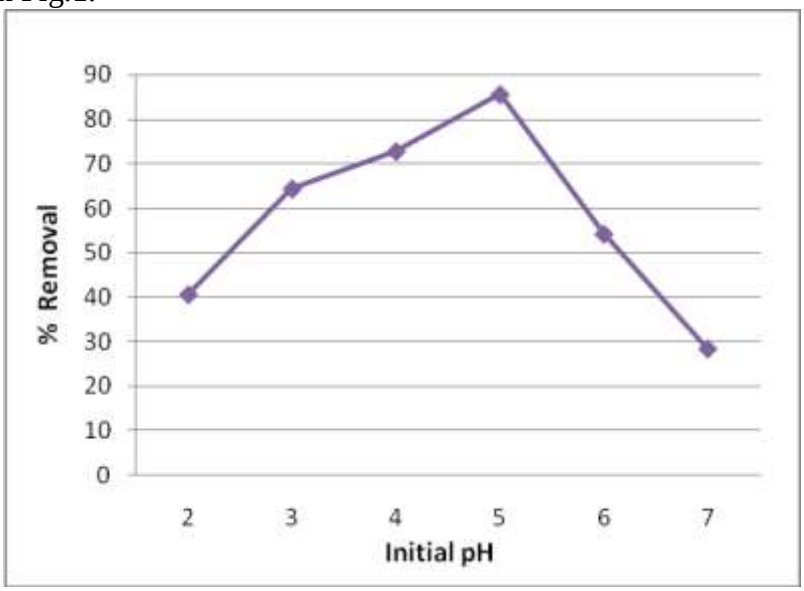

Fig.1. Effect of pH on Biosorption of Cu (II) onto biomass.

3.2. Effect of contact time: It was observed (Fig.2.) that efficiency of Cu (II) uptake increased with increase in contact time upto 90 min and remained nearly constant afterwards. Therefore 90 min was the optimum time required by the biomass to achieve equilibrium.

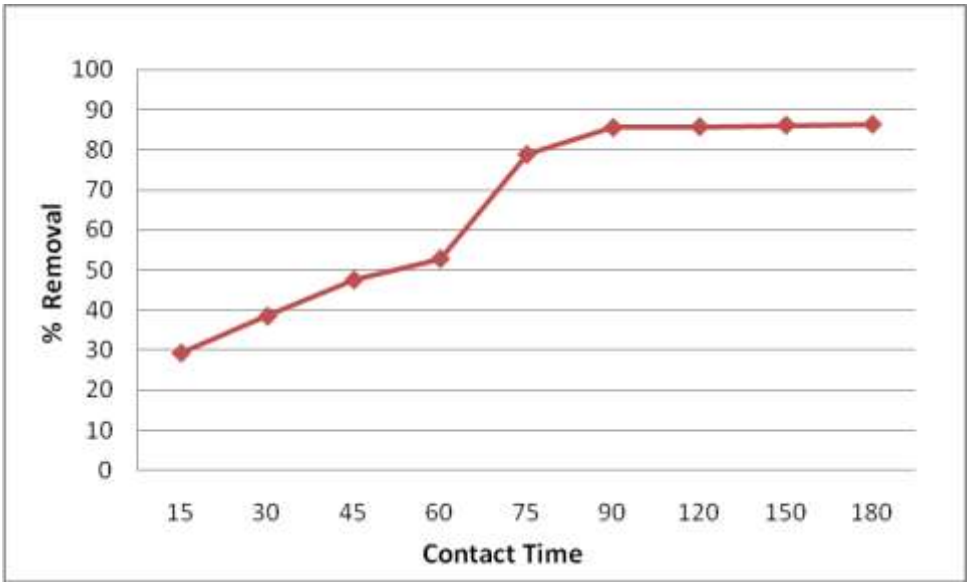

Fig.2. Effect of Contact time on Biosorption of Cu (II) onto biomass.

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