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Heavy Metal Biosorption Using Cheap Biomass

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ABSTRACT

The metal taking capacity of several types of biomass, agro products and by-products has gained attention during recent years. In the present study, one such material i.e., coconut shell powder was chosen as the biosorbent for the removal of Cu(II) from aqueous solutions. The adsorption capacity of this sorbent was investigated by batch experiments. High adsorption (>90 %) is achieved in the present study.

***KEYWORDS**: Biosorption, Copper, Coconut shell powder*

I. INTRODUCTION

In recent years contamination of aquatic bodies by various pollutants has intensified the deterioration of several ecosystems. Among these heavy metals cause severe damage to the living systems at various levels. Exposure of the aquatic systems to heavy metal pollutants from various industrial operations like metal ore refining, electroplating, pigments, mining, battery and accumulator manufacturing has been a serious threat to the environment. The uptake of both metal and non-metal species by biomass is termed as biosorption. Work on the metal binding capacity of some type of biomass and agroproducts [1-3] has gained momentum recently. A number of agricultural waste and by-products like coffee beans, rice husk, cellulose extracted from rice husk (RH-cellulose), cellulose and lignin extracted from coirpith, tea waste, aspergillus niger, spent-grain, litter of natural trembling poplar (*Populus tremula*) forest, nutshells of walnut, hazelnut, pistachio, almond, and apricot stone [4-10] are studied in literature for their removal capacity Cu(II) ions and other heavy metals from aqueous solutions.

The use of coconut shell powder as an adsorbent material presents strong potential due to its high content of lignin, around 35-45% and cellulose around 23-43%. Because of its low cost, powder of coconut shell- *Cocos nucifera* is an attractive and inexpensive option for the biosorption removal of dissolved metals. Various metal binding mechanisms are thought to be involved in the biosorption process including ionexchange, surface adsorption, chemisorption, complexation, and adsorption complexation. [11-13]. Coconut shell powder is composed of several constituents, among them lignin acid and cellulose bear various polar functional groups including carboxylic and phenolic acid groups which are involved in metal binding [11, 14]. Cellulose and lignin are biopolymers and are considered appropriate for the removal of heavy metals. In the current work, coconut shell powder as biosorbent for Cu (II) ions from aqueous solutions was studied. The influence of parameters like pH and particle size is presented. The Scanning Electron Microscope (SEM) analyses are used for characterising coconut shell powder and experimental data obtained was correlated using adsorption equilibrium isotherms and kinetic models.

II. METHODS

2.1 Biosorbent material

The powder of coconut shell powder used in the present work was prepared in our laboratory using mechanical unit operations equipment like jaw crusher, hammer mill, rotap sieve shaker and standard sieves by the method described by Coconut Board of India.

2.2 Biosorption Experiments

Biosorption experiments were performed batch wise at (27^o C) in Erlenmeyer flasks, stirred in reciprocal shaker for 4 h. In all sets of experiments, accurately weighed coconut shell powder was thoroughly mixed in to 250 ml of aqueous metal solution. At regular intervals of time (15 min), a sample of the mixture is filtered to remove the fine particulates and the filtrate was analyzed by atomic adsorption spectrometer (AAS) for the concentration of metal species. The solution of metal species was prepared dissolving $CuSO_4.5H_2O$ (analytical grade supplied by Merck) in deionised water and pH adjustments were made using HCl and NaOH solution.

III. RESULTS AND DISCUSSIONS

3.1 Effect of pH

pH is an important parameter in determining biosorption levels. The effect of pH (in the range 5-9) on the uptake levels of powder of coconut shell from an aqueous solution is evaluated. The effect of initial pH is presented in Fig 1. The Cu (II) removal increased from 42 % at pH 5 to 96% at pH 9. There is no significant increase from pH 7 onwards. Both the surface functional groups present on the coconut shell powder and metal chemistry in solution relate to the dependence of metal uptake on pH. At low pH, the surface ligants are closely associated with the hydronium ions (H_3O^+) and restricted the approach of metal cations as a result of repulsive force [20]. Further, the pH dependence on the metal ion uptake by coconut shell powder can be justified by association-dissociation of certain functional groups like carboxylic and hydroxyl group present on biomass. At low pH, most of carboxylic group are not dissociated and cannot bind the metal ions, though they take part in complexation reactions. With these observations, further experiments are performed at pH 7 only.

3.2 Effect of particle size

Influence of the particle size of coconut shell powder used for uptake of Cu (II) was studied. The results presented in Fig. 2 show a gradual decrease and then increase in removal of Cu(II) with decrease in particle size. It is important to note that larger particles with spherical surfaces, present higher external mass transfer. In this case, higher metal adsorption from these particles is attributed to mass transport inside the sorbent particles [12]. At the same time as the particle size decreases the surface area for adsorption increases which in turn contribute to high adsorption at fine particle size. Optimum particle size can be obtained if precise contributions of mass transport and surface diffusion are ascertained. This has been not formed part of this work.

IV. CONCLUSIONS

Coconut shell powder was confirmed as a potential biosorbent in the removal of copper from aqueous solutions. Investigations showed that pH and particle size influence the uptake of Cu (II). The micrographs obtained by SEM analyzes before and after the uptake by coconut shell powder do not show any significant difference indicating the Cu bands and absence of Cl, K bands in EDS after metal uptake indicate that a possible ion exchange mechanism.

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