16

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Removal of Cu(II) from synthetic textile effluent using *Tamarindusindica* bark: A kinetic and thermodnamicy study

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Abstract
Discharge of untreated industrial effluents containing heavy metals is hazardous to the environment as they are highly toxic and accumulates throughout the food chain. The present study attempts to analyse the biosorption trend of biosorbent Tamarind bark (TB) biomass for removal of copper from synthetic textile effluent as a function of initial metal ion concentration, contact time, sorbent dosage. Desorption experiments with 2M NaOH, inferred the reusability of the biomass for five times with high efficiency.
Keywords- Biosorption, Copper, TamarindusIndica Bark.

INTRODUCTION:

The contamination of water by toxic heavy metals is a worldwide problem, since this group of pollutants may have potentially toxic and carcinogenic effects on human health and living organisms[1]. Copper is one of the most contaminants found in polluted soils and surface or ground waters. Its application in various industries such as electroplating, tanning, pulp production, metal finishing, textile industries etc. has gained a negative impact in the society with respect to its pollution potential[2].

Jaipur, a city located at the central part of Rajasthan, is undergoing rapid industrialization and urbanization. In last two decades, large no of industries have come up in adjacent areas of Jaipur viz. Sanganer, Sitapura, VishwaKarma etc. Of these, Sanganer region is worldwide famous for its dyeing and textile industries. During dyeing processing, large no. of mordants (colour fixing agents) are used, of which $CuSO_4$ is most commonly used in large quantity. These textile units discharge tones of effluent directly, without any treatment; thus, considerable amount of dyes and the heavy metals are disposed into nearby drainage system. These effluents are directly used for crops cultivation which affects the nearby agricultural land.

If these metals are continuously introduced into our environment without been treated, the lives on earth are in danger. There are several conventional methods used for removing heavy metals from industrial waste water. These include: chemical precipitation, ion exchange, coagulation, solvent extraction, ultra filtration, reverse osmosis, electro dialysis etc.[3] However, a major disadvantage of this method is the undesirable production of chemical sludge in a significant amount[4].

New technologies involving the removal of metal ions from waste water have directed attention to biosorption based on 'metal binding capacities of various biological materials'. So biosorption can be a promising alternative method to treat industrial effluents because of its low cost, high metal binding capacity, high efficiency in dilute effluents and environmental friendly[5]. The removal of metal ions from aqueous streams using plant materials is based upon metal biosorption[6]. The basic component of plant material biomass include hemicelluloses, lignin, lipids, proteins, simple sugars, hydro-carbons, starch containing variety of functional groups that facilitates metal complexation which helps for the sequestering of heavy metals[7]. Various agricultural waste materials have been used such as oat biomass[8], wheat bran[9], coconut shells[10], Rubber wood saw dust[11], Raw rice bran[12], etc for the removal of Cu(II) ions.

The present study explores the use of *TamarindusIndica Bark* as sustainable

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adsorbent for copper removal from aqueous system under different experimental conditions. In India, *TamarindusIndica* is an economically important tree which grows abundantly in dry tracts of Rajasthan. It is traditionally important medicinal plant. Its fruit is chief acidulant used in the preparation of foods.

Thus, the objective of the work is to investigate and explore the possibility of utilizing *TamarindusIndica Bark* powder as a sorbent for removing Cu(II) from synthetic waste water. The effect of various experimental parameters such as initial metal ion concentration, contact time, pH, shaking speed, biosorbent dose and temperature were investigated.

MATERIAL AND METHODS:

The *TamarindusIndica Bark* (TB) were collected from tamarind trees. The collected bark was crushed into small size pieces, washed thrice using demineralised water for the removal of surface debris, particulate matter and salts. After washing, the pieces of bark were dried in a hot air oven at 70 °C for two days. A domestic mixture was used to reduce the particle size of the bark. The powdered (TB) biomass was sieved into 30 mesh size and was preserved into a bottle. Batch biosorptionexperiment were carried out for removal of copper metal ion.

RESULT AND DISCUSSION:

Batch Mode Adsorption Studies Parameters which influence the extent of adsorption such as pH, biosorbent dose, shaking speed, contact time, initial metal ion concentration and temperature were investigated.

Effect of initial concentration of metal ion

Biosorption of Cu(II) by TB biomass was measured at five different initial metal ion concentrations (5, 15, 25, 35,50 mg/L) for a given time at an adsorbent dose of 0.02 g/100ml. The effect of initial metal ion concentration on the removal percentage (% R) by the biomass is shown fig.1. The adsorption capacity (q_e) of the biomass increased from 1.94 mg/g to 17.86 mg/g with increasing initial metal ion concentration from 5 mg/L to 50 mg/L. It is evident from the fig 1 that the percent removal of Cu(II) at 5 mg/L is 97.03 % while at 50 mg/L is 89.32 %, therefore the optimum initial metal ion concentration was taken as 50 mg/L for further experiments. The initial concentration provides an important driving force to overcome all mass transfer resistance of metal ion between the aqueous and solid phases[13].

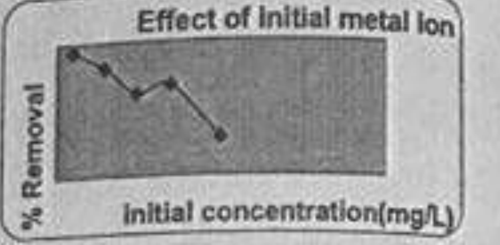

Fig.1. Effect of initial metal ion concentration on percentage removal of Cu(II)

The increase in metal ion concentration also enhances the interaction between metal ion and adsorbent therefore, adsorption uptake of metal (q_e). Though an increase in metal uptake was observed, the decrease in percentage biosorption can be attributed to lack of sufficient surface area to accommodate more metal available in the solution.

Effect of Contact Time

The percentage removal of Cu(II) ion as a function of contact time shown in fig.2 indicates that the percentage of metal removal increases with an increase in contact time and the uptake of Cu(II) was rapid for first 30 min and after 60 min amount of metal ions adsorbed were almost constant; hence, in the present work 60 min was chosen as an equilibrium time. In the initial stages of contact, large numbers of vacant sites are available, and hence the uptake is faster. Percentage adsorption increased from 70.1 to 89.32 % during a contact time period from 10 to 60 min. The rapid initial adsorption was likely due to extra cellular polymeric sites (ionisable) binding, and the slower sorption resulted from intracellular binding[14].

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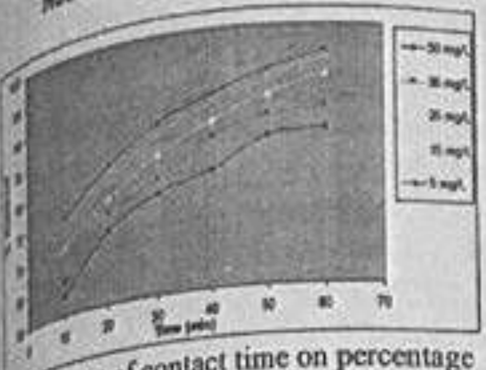

Fig.2. Effect of contact time on percentage removal of Cu(II)

Effect of Biosorbent Dose

In order to study the effect of adsorbent dosage on Cu(II) removal from the metal solution of 50 mg/L, experiments were conducted by varying the adsorbent dosage (0.05, 0.1, 0.2, 0.3, 0.4, 0.45 g/100 mL). The % removal values, obtained after agitation for a period of 1 h, were plotted against the quantity of biomass used. The adsorption increases with increase in the biomass dose shown in fig.3. It could be seen that the % removal increases from 24.8 to 98.28 % when biomass dose was increased from 0.05 to 0.45 g/100 mL, respectively, therefore the optimum biosorbent dosage was taken as 0.45 g/100 mL for further experiments. The increase in percent removal could be attributed to the fact that as adsorbent dosage increases, more adsorption sites are available for Cu(II), thus enhancing the uptake[34].

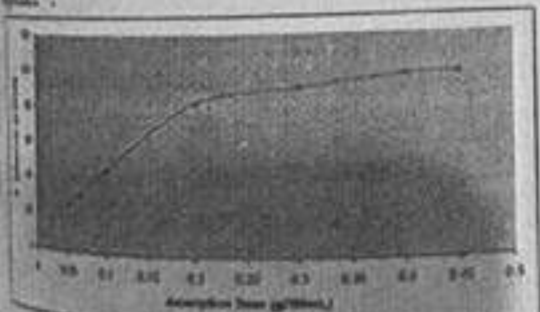

Fig.3. Effect of adsorbent dose on percentage removal of Cu(II).

Desorption

For any sorbent to be feasible, it must combine high and fast adsorption capacity with inexpensive regeneration. In order to assess the reusability of Cu(II)-loaded TB biomass, desorption studies were carried out. The results showed that as the strength of NaOH increases from 0.5 M to 2 M the desorption percent of Cu(II) increased from 31.15 % to 83 %. Thus a significant amount of chromium is being desorbed and after desorption same TB biomass can be reused with equal efficiency for 5 times. Also the total cost of removal of Cu(II) metal from TB biomass was found to be Rs 2.5 per kg of biosorbent (the cost is an assessment from the process used)

CONCLUSIONS:

The potential use of Tamarinda Bark as a biosorbent for sequestering of Cu(II) was studied. This new biosorbent proves to be highly efficient, cost-effective for the removal of Cu(II) ions from aqueous solutions. The biosorption capacity (q_e) of Cu(II) is 17.86 mg/g on TB biomass. Desorption of copper-bearing biomass with 2M NaOH resulted in metal recovery of about 83%. The Copper-loaded biomass can be desorbed and reused 5 times, thereby recycling the sorbed copper and preventing its leaching into the environment. Also, the presence of only one metal ion is very rare in real wastewaters. So, it requires further research to investigate the effects of the presence of other toxic metal ions on the biosorption of a certain metal ion before applying on the actual waste waters. Further, the chemical modification of biomass may be done and its removal capabilities can be compared.

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