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Removal of Cu(II) ions from synthetic waste water by using a novel biocarbon

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ABSTRACT

The current research is focused on the need to find an economical adsorbent for the removal of heavy metals from industrial wastewater. The research was performed to assess the potential of a biocarbon generated from medicinal plant called *Phyllanthus niruri* (Phyllanthaceae) as an adsorbent in the removal of heavy metals from solution. Results from batch adsorption studies on the effect of pH, contact time, different concentration of Cu metal ions were used to estimate the optimum adsorption conditions. The obtained results showed that, the adsorption of the metal ions was dependent on adsorbent dosage, contact time and pH. The optimum adsorbent dosage, and pH, was found to be at 2.5 g and pH 4.4 respectively. The effective contact time was 150min at 30 ^{0}C. The study also showed that activated carbon produced from *Phyllanthus Niruri* biomass can be efficiently used as low cost alternative for removal of metal ions.

Introduction

Water pollution caused by heavy metals is a global problem and has received worldwide attention. Water containing heavy metals used for drinking purpose, if not treated properly can cause serious health problem to human being and severe damage to the environment. Industrial wastewaters may contain many toxic heavy metals such as Cr, Cu, Pb, Zn, Ni, etc. The toxic metals, probably existing in high concentrations, must be effectively treated/ removed from the wastewaters (Dimple**,** 2014).

In recent years, the removal of toxic heavy metal ions from domestic sewage and industrial waste effluents have been widely studied. The presence of heavy metals in the environment is of major concern because of their toxicity, bio-accumulating tendency, threat to human life and the environment (Igwe and Abia, 2006)**.** Therefore, industrial wastewater containing heavy metal should be treated before discharge to the water stream but its treatment is very costly. There are several techniques to remove heavy metals from wastewater such as biosorption, filtration and adsorption of heavy metal but there are some limitation such as long treatment time (Chaudhari and Tare 2008, Thakur and Parmar, 2013).

Although all the heavy metal wastewater treatment techniques can be employed to remove heavy metals, they have their inherent advantages and limitations (Fu and Wang, 2011). Among all these methods, biosorption process is considered better than other methods because of convenience and effective operation. Further to be this process can remove/ minimize different types of pollutants and thus has wider applicability in water pollution control. This article presents an overview of t various innovative biosorpion parameters for removal of heavy metals from the industrial wastewater.

Materials and Methods

Metal solution

Synthetic wastewater samples were prepared by using analytical grade Copper sulphate. For pH adjustment throughout the experiment, 0.1 N Hydrochloric acid and/or sodium hydroxide solutions were used as necessary. The stock solutions contained 100 mg/l of Cu(II).

Biocarbon preparation

Phyllanthus niruri plant leaves were collected and air dried for 48 h. The dried leaves were grounded in ball mills and the screened homogeneous powder was used for the preparation of biocarbon. Activated biocarbon of the *Phyllanthus Niruri* was prepared by treating the leaves powder with the concentrated sulphuric acid (SG 1.84) in a weight ratio of 1:1.8 (biomaterial: acid). The resulting black product was kept in an air-free oven maintained at 160±5 °C for 6 h followed by washing with distilled water until free of excess acid, and then dried at 105±5 °C. The particle size of activated carbon between 85 and 130 µm was used. Batch experiments were performed at 30±2 °C. The samples were mechanically agitated at 200 rpm. The concentrations of Copper is estimated using ICPES. The proportion of heavy metal removed from solution was calculated from $(C_0 - C_e)/C_0$ where C_0 and C_e are, respectively, the initial and final concentrations of heavy metal. The amount of adsorbed metal ions per unit mass of biocarbon was obtained from $q_e = (C_0 - C_e)V/m$, where V is the volume of the aqueous solution, and m is the mass of biocarbon (Singanan, 2011).

Results and Discussion

In batch experiments, the influence of pH, dosage of biocarbon, contact time and initial metal ion concentration on the removal of Cu(II) ions on the surface of activated biocarbon of *Phyllanthus Niruri* was studied.

Effect of pH

The removal of metal ions from aqueous solution by adsorption is related to the pH of solution. From the present investigation (Fig. 1), it is observed that, the percent removal of Cu(II) metal ion is low at lower pH. This fact might be due to protonation of the binding sites resulting from a high concentration of protons, the negative charge intensity on the sites is reduced, resulting in the reduction or even inhibition of the binding of metal ions. Similar findings were reported by other researchers (Desi et al., 1998; Emani et al., 2003).

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Lower solubility of hydrolysed metal ions species may be another reason for the maximum adsorption at a higher pH. Since, in lower pH range, metal is present predominantly as metal ions in the adsorptive solution, there is a competition between H+ and M+ ions for adsorption at the ion exchangeable sites, leading to a low removal of metal. The extensive repulsion of metal ions due to protonation of the adsorbent surface at lower pH may be another reason for decrease in adsorption of metal in lower pH range (Al-Asheh and Duvnjak, 1997).

The removal rate is significantly good (89%) at pH 4.4 and the decreases with further increase of pH. Removal of metal ions takes place by adsorption as well as precipitation, due to formation of metals hydroxide. This can be explained by the fact that, as the pH of the solution increased the OH ions in the solution increase and form some complexes with metal ions and precipitate as metals hydroxide (Mohammed Ali et al., 2013).

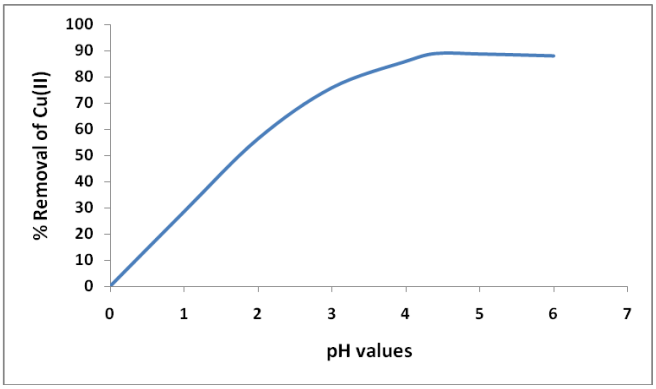

Fig 1. Effect of pH

Effect of amount of biocarbon

It is an important parameter for an optimal removal of metal ions in the wastewater. The effect of amount of biocarbon on adsorption of Cu(II) at a constant adsorbate concentration (100mg/L) was studied with the incremental addition 0.5 g to 3.5g for the purpose of determining the optimum adsorbents dosage. The equilibrium time was 150min at 30^0C. Results of experiments are shown in Figure 2. It is observed that, 89% metal ion removal was achieved at the biocarbon dose of 2.5g. The removal rate of metal ion increases with a further increase in the quantity of adsorbent. The optimum sorbent amount required for efficient treatment can be well noticed. It is apparent that the percent removal of heavy metals increases rapidly with increase in the dose of the adsorbents. This is due to the greater availability of the exchangeable sites or surface area. Moreover, the percentage of metal ion adsorption on adsorbent is determined by the adsorption capacity of the adsorbent for various metal ions.

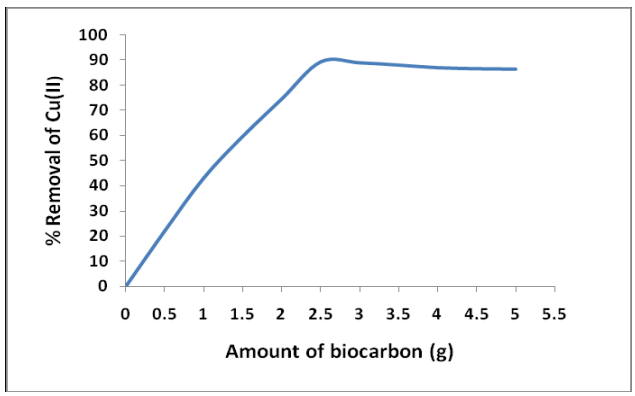

Fig 2. Effect of amount of biocarbon

Effect of Contact time

Kinetics of the metal ion removal is an essential parameter for the wastewater treatment. In this study, for the purpose of optimization of contact time, the initial concentration of 100 mg/L of Cu(II) ion was used. The kinetics of metal removal by biocarbon of *Phyllanthus Niruri* was relatively increases and it was observed that, the maximum amount of metal ion was removed at 150min. The equilibrium time was taken as 150 min for further experimental measurements the results are shown in the figure 3.

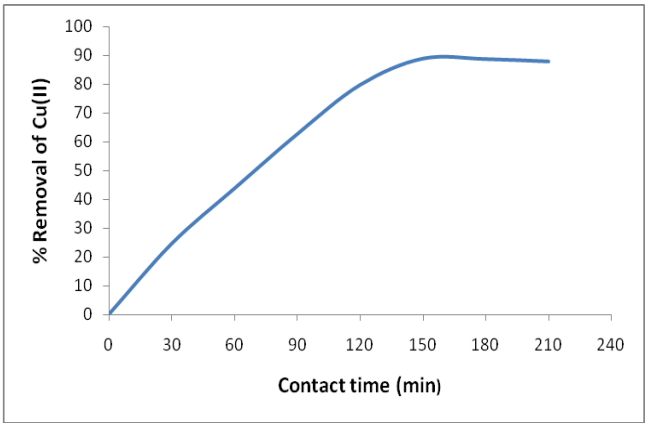

Fig 3. Effect of contact time

Effect of initial concentration

The effect of initial metal ion concentration on the biosorption of metal ion was investigated. The change in initial metal ion concentration will have a significant effect on the biosorption process. Experiments were done at two different initial concentrations of copper ions (50, 75 and 100 mg/L), with the biocarbon dose of 2.5g, contact time of 150 min at 30^0C The effect of initial concentration on the percentage removal of heavy metals by *Phyllanthus niruri* is shown in Fig. 4. It can be seen from the figure that the percentage removal decreases with the increase in initial heavy metal concentration for Cu (II), the percentage removal is highly effective on the 50ppm initial concentration after which percentage removal decreases gradually to below 89% for 100mg/L. At lower initial metal ion concentrations, sufficient adsorption sites are available for adsorption of the heavy metals ions. Therefore, the fractional adsorption is independent of initial metal ion concentration. However, at higher concentrations the numbers of heavy metal ions are relatively higher compared to availability of adsorption sites.. Relatively, the contact time required for the removal of 50, 75 and 100 mg/L are 90, 110 and 150min respectively. The maximum percent removal of Cu(II) ion was 93, 90 and 89 respectively.

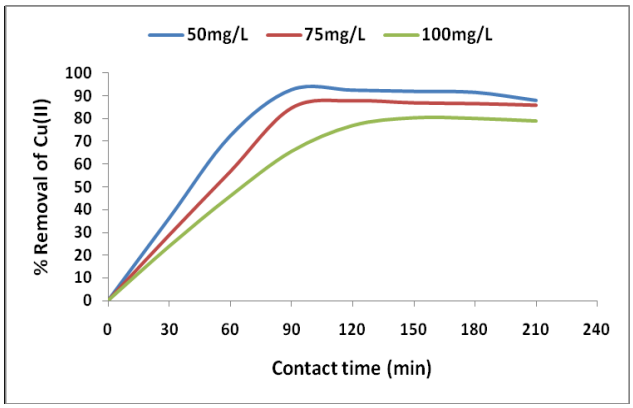

Fig 4. Effect of initial metal ion concentration

Conclusions

Phyllanthus Niruri is a cheap and effective adsorbent for the removal of Cu ions from wastewater with a preliminary treatment. Experiment results showed that maximum removal of Cu ion on bio carbon at optimum condition (4.4 pH, 150 min. contact time, 2.5g/100ml adsorbent dose and 100mg/L of initial concentration of copper ion) is 89%. These experimental results on the removal of Cu(II) on biocarbon would be quite useful in developing an appropriate technology for the removal of heavy metal ions from contaminated industrial effluents.

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