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Applications Of Ecofriendly Economical Tibac Adsorbent In Water Pollution Control

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Abstract
The research work reported in this article includes generation and characterization of activated carbon derived from bark of Tamarindus indica, 'TIBAC'; and its applications as eco-friendly adsorbent in water pollution control, that is, for removal of toxic cadmium from polluted water. Self generated activated carbon was characterized using techniques like FTIR and SEM. Adsorption efficacy of 'TIBAC' for Cd(II) abetment was investigated employing batch equilibration method; in which the studies on effects of various parameters like contact time, initial adsorbate concentration, pH and adsorbent dosage etc. have also been reported. At optimum conditions approximately 94% abatement of Cd(II) has been noted using TIBAC under optimal conditions. It is concluded that the self-prepared activated carbon, 'TIBAC', under investigation is an excellent economical eco-friendly adsorbent material for cadmium removal from contaminated water and hence has potential application in pollution control.
Keywords: cadmium toxicity, water contamination, adsorption, batch experiment, pollution control.

Introduction

Cadmium, the heavy metal, is rare and uniformly distributed element in the earth crust with an average concentration of 0.15 to 0.20 mg/kg. It occurs in the form of inorganic compounds and complexes with chelating agents(1). Cadmium is one of the most toxic environmental and industrial pollutants because it can damage almost all important human organs(2). Cadmium and its compounds are also used in paints, pigments, plastics, electroplating, equipments, machineries, baking channels and photography(3). Even small quantity of Cadmium assimilation by the body can cause severe high blood pressure, heart diseases and can lead to even death(4). The commonly used methods used for removal of metal ions from waste water include chemical reduction(5), nano-filtration(6), bioaccumulation(7), ion exchange(8) and adsorption on silica composites(9,10)/activated carbon materials(11). Use of surface modified/chitosan coated bio-sorbent as low cost materials for abatement of heavy metals have been reported in the literature(12). The low cost activated carbon derived from *Cassia fistula* has also been reported as an excellent adsorbent for removal of heavy metal like Chromium(13). Literature reveals adsorption method for simultaneous removal of Cadmium and Chromium Ions from waste-water using activated carbon derived from *Datura stramonium* fruit(14). Though a few methods have been reported for cadmium removal from contaminated water, still it is need of the present era to investigate new and new eco-friendly/economical/convenient methods/materials for water treatment with special reference to Cd(II) abatement. Keeping this view in mind objective of the present research work is framed to generate/characterize *Tamarindus indica bark based* activated carbon followed by testing its applicability as eco-friendly economical adsorbent in water pollution control, that is, for removal of toxic cadmium from polluted water.

Materials and Methods

Chemicals

The chemicals used in the investigation were of either analytical or chemically pure grade and procured from Merck, Mumbai, India.

Generation of Activated Carbon from the bark of *Tamarindus indica* (TIBAC)

The bark of *Tamarindus indica* tree was collected from the local area. The bark was cut into small pieces, washed with tap water to remove the sand particles. Then, it was washed several times with deionized water and sun dried for 6 days. After drying, the bark was subjected to pyrolysis process for carbonization using Muffle Furness at 800-900^{0}C for 7 to 8 hrs so that volatile constituents were removed and residue was converted into a char. The char was then subjected to microwave activation in microwave oven. The input power of microwave equipment was set at 360 W for 30 min. The resulting activated carbon particles were ground and sieved in 120-200 mm size. This activated carbon was then washed with double distilled water and dried at 105^{o}C for 3 hrs and stored in air tight bottle.

Characterization of TIBAC

Characterization of TIAC was done by FTIR (Fig.1) and SEM (Fig.2)

Adsorption Studies

Progressive dilution method was used to prepare solutions of required working standards from stock solution of Cd(III). Removal of Cd(III) using TIBAC was carried out by batch equilibrium method. The influence of various parameters such as effect of pH, contact time, adsorbent dosage and initial Cd(III) ion concentration were studied. The effect of pH and effect of contact time was studied by taking 50 ml of Cd(III) aqueous solution having concentration 25 mg/l. The adsorbent dose of 7g/l was taken during the experiment. The effect of adsorbent dosage was studied by varying adsorbent amount from 1to10g/l with Cd(III) concentration 25mg/l while effect of initial concentration of Cd(III) was studied by changing concentration from 10-100mg/l with adsorbent dose of 7g/l at 30^{0}C. The subsequent cadmium concentrations were measured using UV-Visible spectrophotometer.

Results and Discussion

Characterization of TIAC

Fig.1 represents FTIR of TIBAC. The broad band between 3100 -3700 cm^{-1} indicates the presence of dissociated or associated –OH groups on the adsorbent surface. The band at 3443.16 cm^{-1} is indicating -OH stretching due to the existence of surface hydroxyl groups and chemisorbed water. The position and asymmetry of this band at a lower wave number indicates the presence of strong hydrogen bonds. The peak at 1632.64 cm^{-1} appears to be due to stretching vibration of C=O in carboxylic acid group (-COOH). The band observed at lower wave number i.e. at 584.16 cm^{-1} may be due to aliphatic C-I stretching.

Fig 2 represents SEM image of TIBAC. It is evident from the picture that TIBAC has highly porous structure. The presence of significant number of pores seems to be a result of proper activation of TIBAC. It can be noticed that activation process was successful in creating well-developed pores on the surface of the material having finely defined walls surrounding the pores. The SEM micrograph indicates that the pores were made up of cylinder like tubes which would easily capture and retain the metal ions from aqueous solution. The pore size was found to be 3.82µm. Therefore it can be concluded that TIBAC may be classified as meso-porous type of activated carbon.

Adsorption Studies

Effect of pH on adsorption

Effect of pH on Cd(II) adsorption using TIBAC as an adsorbent has been studied in the pH range 1 to10 and presented graphically in Fig.3. It is seen that solution pH plays a very important role in the adsorption of Cd(II). The percentage removal increases steadily from 63 to 94 when pH is increased from 1 to 6 in Cd(II) adsorption and slowly decreases on further increases in pH.

Effect of contact time on adsorption

Adsorption experiments were conducted as a function of contact time and results have been shown in Fig.4. The rate of Cd(II) binding with adsorbent was greater in the initial stages then gradually increases and remains almost constant, after optimum time period of 140 min.

Effect of adsorbent dosage

The effect of adsorbent, 'TIBAC', doses on percent removal of Cd(II) in the range 1 to 10gm is represented in Fig.5. The initial Cd(II) concentration was taken to be 30ppm. It can be seen that after certain adsorbent dose(7gm/lit) % adsobtion becomes constant and it is treated as an optimum adsorbent dose, which is found to be 7 gm/lit. for the TIBAC adsorbent.

Effect of the Initial concentration of Cd(II) solution.

The experimental studies were carried with varying initial concentration of Cd(II) ranging from10 to 100 ppm using 7gm/lit. of adsorbent dose. The results have shown in Fig.6. The results demonstrate that at a fixed adsorbent dose the percentage of Cd(II) removal decreases with increasing concentration of adsorbate.

Conclusions

The activated carbon derived from the bark of *Tamarindus indica* (abbreviated as 'TIBAC') was successfully prepared and characterized employing FTIR and SEM techniques. The newly developed activated carbon has highly porous structure and, therefore, possessing excellent surface area. TIBAC has been found to be most effective for Cd(VI) removal. At pH 6.0, 94% of Cd (III) was removed from aqueous solution. Adsorption was found to pH dependent. Above pH 6.0, decline in Cd(III) removal was noticed. The increase in percent removal capacity for Cd(III) was observed with increase of adsorbent dose and contact time. Maximum removal is 94% for 7.0 g/l adsorbent dose, 6.0 pH and 140 min. of contact time. The activated carbon under present investigation can be successfully employed for Cd(III) abatement from contaminated water and thus can be used for water/ wastewater treatment, that is, in water pollution control.

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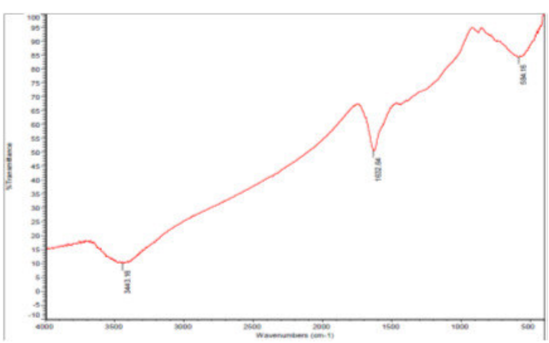

Figure 1: FT-IR Spectrum of *Tamarindus Indica Bark Activated Carbon* (TIBAC)

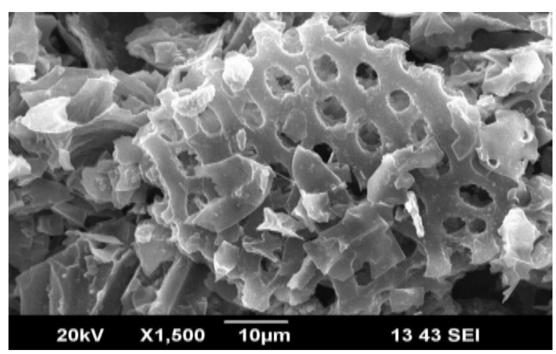

Figure 2: Scanning electron micrograph of the TIBAC at 1500 x

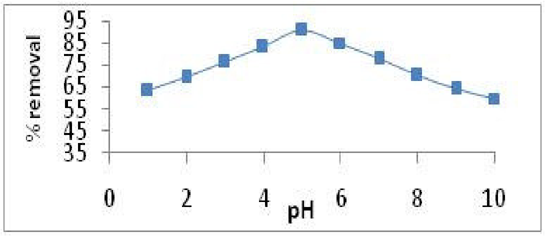

Figure 3: Effect of pH on Cd(II) removal by TIBAC

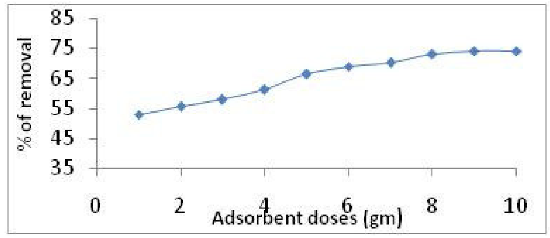

Figure 5: Effect of adsorbent doses on Cd(II) adsorption by TIBAC

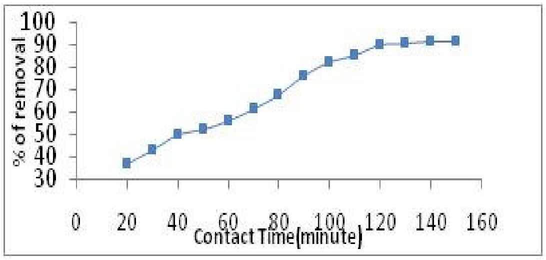

Figure 4:Effect of Contact time on Cd(II) removal by TIBAC

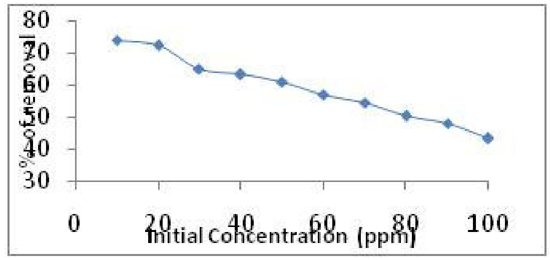

Figure 6-Effect of initial concentration on Cd(II) adsorption by TIBAC

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