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Abetment of toxic divalent cadmium using BMWAC

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ABSTRACT

Cadmium is toxic to living systems and therefore it is essential to remove it from water resources. The present research article reports Cd(II) abetment efficacy of activated carbon derived from Butea monosperma wood (BMWAC) from aqueous solution. The self generated activated carbon was characterized using techniques like FTIR and SEM. Adsorption capacity of BMWAC for Cd(II) abetment was investigated employing batch equilibration method. The effect of various parameters like contact time, initial solute concentration, pH and adsorbent doses has also been studied and reported. The adsorption data were found fit well with the Langmuir model. The percent removal of Cd (II) was found to be increase with adsorbent doses from 1-8 gmdm^{-3}. At optimum condition nearly 92% abatement of Cd(II) has been noted using BMWAC. Thus the self-prepared activated carbon under investigation has been proved to be an excellent economical adsorbent material for Cd(II) removal from contaminated water/wastewater.

Keywords: Activated carbon, Butea monosperma, Cadmium toxicity, Wastewater treatment, Langmuir isotherm.

INTRODUCTION

Different industrial discharge effluents containing toxic metals can cause severe contamination of ground and surface water. However environment become polluted not only by rapid industrialization, deforestation, and unplanned urbanization, but also some natural phenomenon like weathering of rock and volcanic activities also play a crucial role for enriching the water reservoirs with heavy metal pollutants[**1-2**]**.**Cadmium 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 agent[**3**]**.** Cadmium is one of the most toxic environmental and industrial pollutants because it can damage almost all important organs[**4**]**.** It is a human carcinogen[**5**]**.** Cadmium and its compounds are used in paints, pigments, plastics, electroplating, equipments, machineries, baking channels and photography[**6**]**.** Even small quantity of Cd assimilation by the body can cause severe high blood pressure, heart disease and can lead to death[**7**]**.** The acute over exposure to Cd fumes can cause pulmonary diseases while chronic exposure causes renal tube damage and prostate cancer[**8**]**.** The commonly used methods for removing metal ions from waste water include precipitation, lime coagulation, reduction, electrolytic removal, ion-exchange, reverse osmosis, membrane filtration and solvent extraction[**9-14**]**.** Bio-sorption, a technically feasible and economical process, has gained increased creditability during recent years[**15**]**.** A number of biosorbents have been used such as tree barks, saw dusts, activated rice husk, coconut shell, almond shell etc. for the adsorption of heavy metals. Use of surface modified/chitosan coated bio-sorbent as low cost material for abatement of Cr(VI) has been reported in the literature[**16-17**]**.** The low cost activated carbon derived from *Cassia fistula* has also been reported as an excellent adsorbent for removal of Cr(VI)[**18**]**.** The objective of the present study is to investigate the possible use of activated carbon derived from *Butea monosperma* wood (BMWAC) as an alternative economical adsorbent material for removal of Cd(II) employing batch experiments.

MATERIALS AND METHODS

All the chemicals used were of analytical or chemically pure grade. Distilled water was used throughout the investigation.

Preparation of Activated Carbon from the *Butea monosperma* wood

Butea monosperma wood was collected from local area and cut into small pieces and washed several times with tap water followed by distilled water. The clean biomass so obtained was sun dried for 5 days. The biomass was subjected to pyrolysis process using Muffle Furness. During slow carbonization of raw material in absence of air at temperature range 600-700^{0}C, volatile products were removed and residue was converted into char. The char was then subjected to chemical activation process using 25% zinc chloride solution. This activated carbon was then washed with distilled water and dried at 105^{0}C for 2hrs. and stored in air tight bottle. The material has been characterized by FTIR and SEM studies. This newly obtained activated carbon material is abbreviated as **BMWAC.**

Preparation of stock solution

Synthetic stock solution of Cd(II) was prepared by dissolving required quantity of cadmium sulphate salt in the distilled water. This solution was diluted to proper proportions to obtain various standard solutions ranging their concentrations 10-100mgl^{-1}. Adjustment of pH was done using 0.5N HCl and 0.5N NaOH solution.

Batch Experiment

Batch equilibrium studies were conducted with different parameters such as pH, agitation time, initial concentration of Cd(II) solution and effect of adsorbent doses. The systems were agitated on rotary shaker at 200 rpm, filtered through Whatman no.42 filter paper and filtrate was analyzed for Cd(II) concentration using UV-Visible Spectrophotometer. From experimental data, the applicability of Langmuir model was judged. Linear regression coefficient (R^2) and isotherm constant values (qm, b & R_L) were determined from the model.

Characterization of BMWAC

Scanning Electron Microscopy (SEM) Analysis

Fig.1 shows the SEM image of BMWAC which is obtained using an accelerating voltage of 20 KV at x 1000 magnification. SEM micrograph clearly revealed that wide variety of pores are presents on the surface of activated carbon (BMWAC) accompanied with fibrous structure. It can also be noticed that there are holes and caves type opening on the surface of the adsorbent, which would have created greater surface area available for adsorption.

FTIR Studies

FTIR spectrum of BMWAC has shown in Fig.2. The peak at 3838cm^{-1} indicates N-H stretching. The band at 3628cm^{-1} indicates the presence of dissociated or associated –OH on the adsorbent surface. The band at 2343cm^{-1} shows more strongly hydrogen bonded –OH group. The weak peaks appeared in the range 1450 cm^{-1} to 1580 cm^{-1} indicate the presence of C=C bond stretching and N-O stretching. The weak peaks noticed in the range 540cm^{-1}to 700cm^{-1} shows presence of carbon- bromine stretching in alkyl halide.

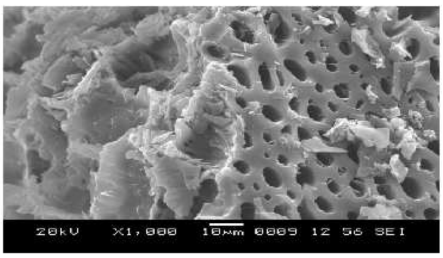

Fig. 1 SEM of BMWAC

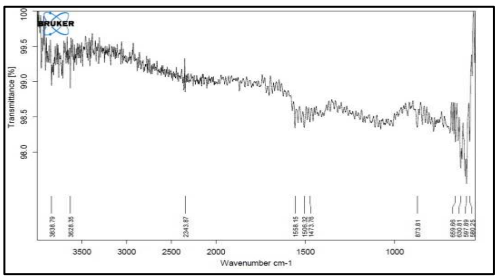

Fig.2 FTIR spectrum of BMWAC

RESULTS AND DISCUSSION

Effect of pH on adsorption

Effect of pH on Cd(II) adsorption using BMWAC as an adsorbent has been studied in the pH range 1to10 and presented 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 64 to 92% when pH is increased from 1 to 5.5 in Cd(II) adsorption and slowly decreases on further increases in pH.

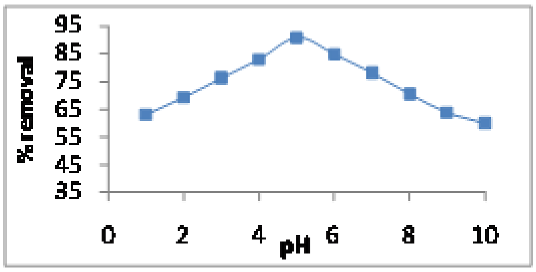

Fig. 3 Effect of pH on Cd(II) removal by BMWAC

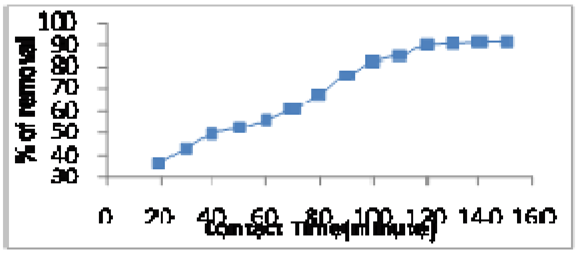

Fig.4 Effect of contact time on Cd(II) removal by BMWAC

Effect of contact time on adsorption

Adsorption experiments were conducted as a function of contact time and results have 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 period of 140 min.

Effect of adsorbent doses

The effect of adsorbent (BMWAC) 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. However after certain adsorbent dose it becomes constant and it is treated as an optimum adsorbent dose, which is found to be 8 gm/lit. for the BMWAC adsorbent.

Effect of the Initial concentration of Cd(II) solution

The Experimental studies were carried with varying initial concentration of Cd(II) ranging from 10 to 100 ppm using 8 gm/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.

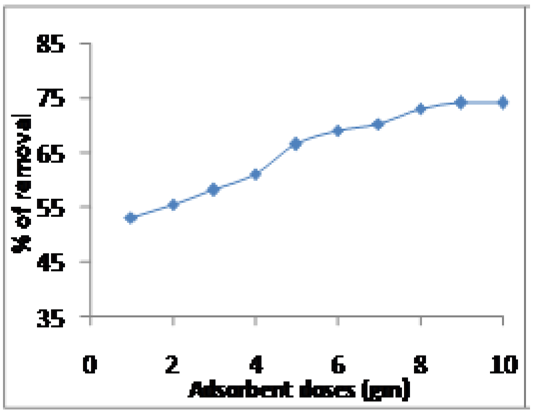

Fig.5- Effect of adsorbent doses on Cd(II) adsorption

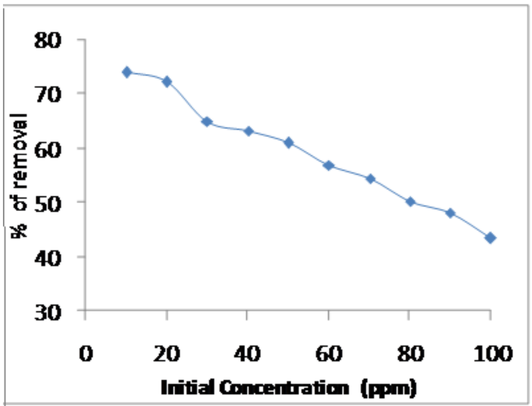

Fig 6-Effect of initial concentration on Cd(II) adsorption

Adsorption Isotherm

The isotherm data have been linearized using Langmuir equation and is plotted between Ce/qe versus Ce. The Langmuir constant 'qm' which is measure of the monolayer adsorption capacity of BMWAC is obtained as 11.73. The Langmuir constant 'b' which denotes adsorption energy is found to be 0.054. The high value (0.9943) of regression correlation coefficient (R^2) indicates good agreement between the experimental values and isotherm parameters and also confirms the monolayer adsorption of Cd(II) onto BMWAC. The dimensional parameter 'R_L' which is a measure of adsorption favorability is found to be 0.3808 ($0< R_L< 1$) which confirms the favorable adsorption process for Cd(II) on BMWAC adsorbent.

CONCLUSION

i) Activated carbon has been obtained successfully from Butea *monosperma* wood which is abbreviated as BMWAC.
ii) The activated carbon under investigation has been characterized by FTIR and SEM studies.
iii) BMWAC has been found to be most effective for Cd(II) removal. At pH 5.5, 92 % of Cd(II) was removed from aqueous solution and adsorption was found to be pH dependent.

iv) The increase in percent removal capacity was observed to be increased with increase in adsorbent doses and contact time. Maximum Cd (II) removal was found to be 92 % for 8.0 gm/lit. of BMWAC dose(optimum adsorbent dose) and at 140 min.(optimum contact time).
v) The newly obtained activated carbon i.e. BMWAC under present investigation can be successfully employed for Cd(II) abatement from contaminated water and thus can be used for water/wastewater treatment in pollution control.

Scope for further work
The BMWAC can be tested for its practical applicability towards removal of other pollutants inclusive of toxic metals, pesticides/insecticides and organic contaminants.

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