

ADSORPTIVE REMOVAL OF CD (II) USING ACTIVATED CARBON PREPARED FROM BARK OF FICUSRACEMOSA

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ABSTRACT

Cadmium is toxic to living being and therefore it is essential to remove it from wastewater. Adsorption capacity of activated carbon derived from Ficus racemos bark (ACFRB) for Cd(II) abatement was investigated through batch adsorption experiments. The effects of contact time, pH and adsorbent dose on the removal of Cd(II) have been studied and reported. Adsorption isotherms of Cd (II) on adsorbent were determined and compared with the Langmuir and Freundlich isotherm models. The percent removal of Cd (II) was found to increase with adsorbent doses from 1 to 6 gm and maximum efficacy was found at 6 gm. At optimum condition nearly 96.47% abatement of Cd(II) has been noted using ACFRB. Maximum adsorption capacity was found at optimum pH 5 and optimum contact time was 110 minutes. The result indicates that the adsorption process is favorable for Langmuir and Freundlich models. 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.

Key words: Adsorption, waste water, adsorbent

1. INTRODUCTION

In the past few years environmental pollution is increased exponentially and reached alarming levels in terms of its effects on living creatures.[1] However environment become polluted not only by rapid industrialization, deforestation and unplanned urbanization, but also some natural phenomenon of anthropogenic activities such as weathering of rock and volcanic activities also play a crucial role for enriching the water reservoirs with heavy metals[2,3]. Toxic heavy metals are considered one of the pollutants that have direct effect on man and animals. It is well known that heavy metals are toxic and they can damage nerves, liver and bones, and they can block functional groups of vital enzymes too. Metal ions such as Cd, Cr, Co, Cu, Zn, Pd, Hg, Ni, Ag, and Sr and metalloids such as Se, As, and Sb are toxic if consumed beyond permissible limits.[4,5] Cadmium is one of the most toxic environmental and industrial pollutant because it can damage almost all important organs. [6] Cadmium and its compounds are also used in paints, pigments, plastics, electroplating, equipments, machineries, baking channels and photography. [7] Even small quantity of Cd assimilation by the body can cause severe high blood pressure, heart disease and can lead to death.[8] The acute over exposure to Cd fumes can cause pulmonary diseases while chronic exposure causes renal tube damage and prostate cancer.[9] The Conventional methods for removing dissolved heavy metal ions include chemical precipitation, chemical oxidation /reduction, filtration, ion exchange, electrochemical treatment and membrane technology. Most of them involve high capital costs with recurring expenses, which are not suitable for smallscale industries. Adsorption method is considered to be one of the preferable methods for the removal of heavy metal ions from aqueous solution due to its

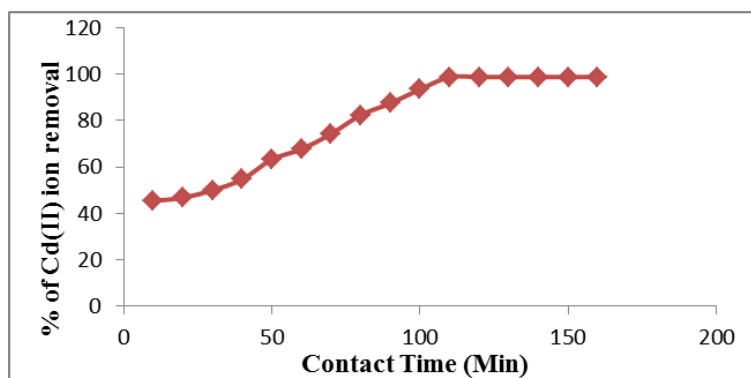
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significant advantages such as low operational cost, wide applicability and creation of relatively low sludge.[10-14] The objective of the present study was to determine Cd(II) ion removal efficiency from aqueous solution using activated carbon derived from the *Ficus racemosa* bark (ACFRB) as an adsorbent; and analysing the data using Langmuir/Freundlich isotherms.



2. MATERIALS AND METHODS

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

2.1. Preparation of Activated Carbon from the *Ficus racemosa* bark

Ficus racemosa bark was collected from the nearby local forest area and it was cut into small pieces. It was washed with distilled water and dried in sunlight to remove the moisture. Then it was treated with formaldehyde to avoid the release of color by bark into the aqueous solution during the adsorption process. The above treated bark was carbonized by slow heating over a wide range of temperature (400-700°C) in the absence of air in a muffle furnace. The char obtained was subjected to thermal activation in the absence of air at elevated temperature 900 °C and held at that temperature for 1½ hour. The adsorbent so obtained was ground and sieved through 200 mesh sieves. The dried sample was stored in airtight bottles for further use.[15-17]

2.2. Preparation of stock solution

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 10-100mg l⁻¹. pH adjustment was done using 0.5N HCl and 0.5N NaOH solution.

3. RESULTS AND DISCUSSION

Effect of contact time on adsorption

For a fixed concentration of heavy metals and a fixed adsorbent mass, the retention of heavy metals increased with increasing contact time before equilibrium is reached. It can be seen that Cd(II) removal efficiency of activated carbon derived from *Ficus racemosa* bark (ACFRB) increased upto 98.77 %, when contact time was increased from 10 min to 110 min. Thus optimum contact time was found to be 110 min.

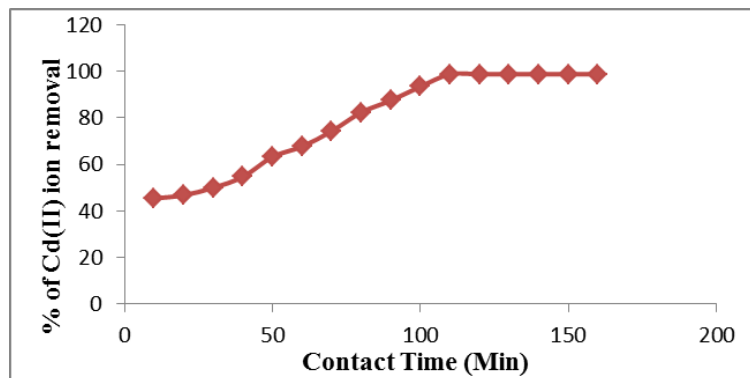


Fig. 1: Effect of contact time on Cd(II) ion removal by activated carbon derived from *Ficus racemosa* bark

Effect of pH on adsorption

Effect of pH on Cd(II) adsorption using activated carbon derived from *Ficus racemosa* bark (ACFRB) as an adsorbent has been studied in the pH range 1 to 10 and presented in Fig.2. It is seen that solution pH plays a very important role in the adsorption of Cd(II). The percentage removal increases up to 96.27% when pH is increased from 1 to 5 in Cd(II) adsorption and slowly decreases on further increases in pH.

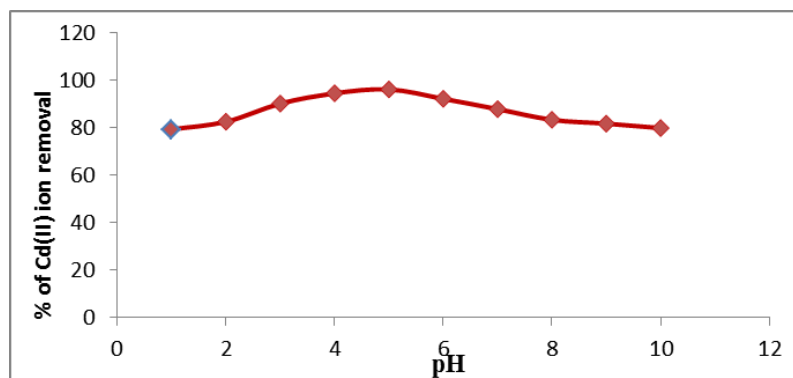


Fig. 2: Effect of pH on Cd(II) ion removal by activated carbon derived from *Ficus racemosa* bark

Effect of Adsorbent Dosage:

The effect of adsorbent doses on percent removal of Cd(II) in the range 1 to 10 gm is represented in Fig.3. The obtained results reveal that the percentage removal of Cd(II) ions increased with an increase in the adsorbents dose but after certain adsorbent dose it becomes constant and it is treated as an optimum adsorbent dose. Maximum adsorption was observed at 6 gm/lit i.e. 96.47%.

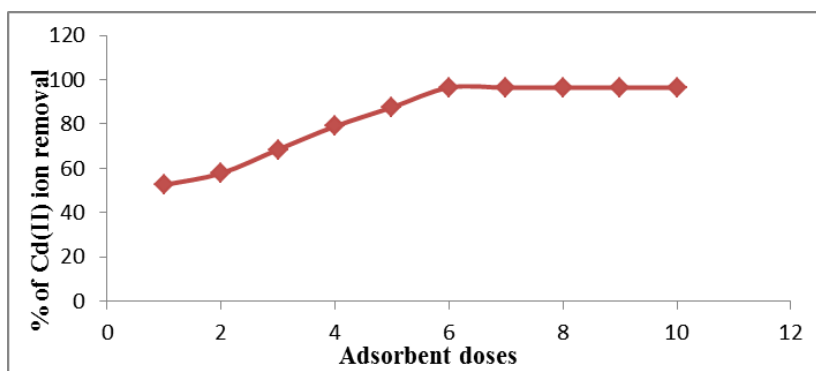


Fig.3: Effect of adsorbent dose on Cd(II) ion removal by activated carbon derived from *Ficus racemosa* bark

Adsorption Isotherm:

Langmuir adsorption Isotherm:

The results obtained from Langmuir model for the removal of Cd(II) by ACFRB has been represented in Fig.4. The values of square of the correlation coefficient (R^2) is found to be 0.9895 for Cd(II), which show the best fitting of equilibrium data. The adsorption efficiency 'Qm' value for Cd(II) was found to be 12.82mg/g while values of 'b' was 0.229. The lower values of b (less than one) implies an excellent the affinity between solute and sorbent sites. To confirm the adsorbility of the adsorption process, the equilibrium parameter also called separation factor 'RL' for Cd(II) was calculated. The value of RL lies between 0 and 1 for favourable adsorption, while $RL > 1$ represents unfavourable adsorption and $RL = 1$ represents linear adsorption while the adsorption process is irreversible if $RL = 0$. The dimensionless parameter RL values lies between 0.466 is consistent with the requirement for favourable adsorption.

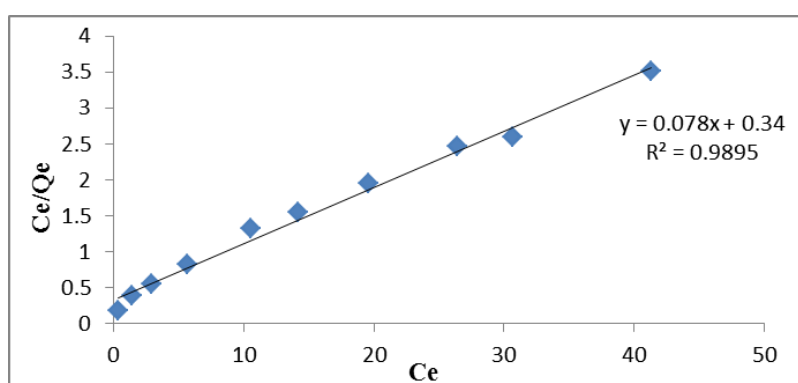


Fig. 4: Langmuir isotherm for the adsorption of Cd(II) ion on activated carbon derived from *Ficus racemosa* bark

Freundlich adsorption isotherm:

The plot of $\log C_e$ versus $\log Q_e$ for Cd(II) is presented in Fig.5 which show linear curve and hence the adsorption process obeys Freundlich adsorption isotherms. Freundlich constants 'n' and 'kf' for Cd(II) were found to be 2.665 and 3.213mg/g respectively. The square of the correlation coefficient (R^2) values was found to be 0.9761 for Cd(II) which shows well-fitting of the Freundlich isotherm. The 'n' values are in between 1 to 10 which indicate the favorable adsorption of Cd(II) on ACFRB.

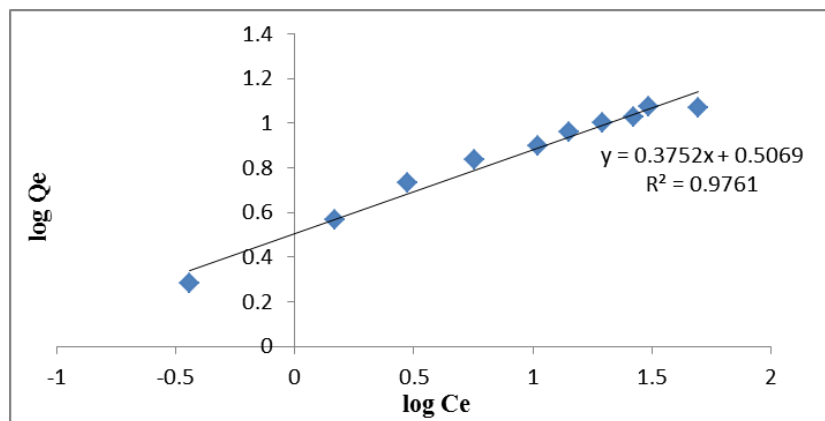


Fig.5: Freundlich isotherm for the adsorption of Cd(II) ion on activated carbon derived from *Ficus racemosa* bark

4. CONCLUSIONS

Activated carbon successfully generated from naturally available raw material that is the *Ficus racemosa* bark, which is abbreviated as “ACFRB”. The ACFRB was found to be most effective for Cd(II) ion removal. At pH 5, 96.27% of Cd(II) was removed from aqueous solution and adsorption was found to be pH dependent. Maximum Cd(II) removal is 96.47 % for 6gm/lit optimum adsorbent dose at 110 min of optimum contact time. The experimental data for the adsorption process were well fitted by the Langmuir adsorption isotherm model and Freundlich adsorption model too. Thus the newly generated *Ficus racemosa* bark based activated carbon (ACFRB) reported in this research article has been proved to be an excellent eco-friendly and low-cost adsorbent material which can be successfully used for elimination of Cd(II) from contaminated water.

ACKNOWLEDGEMENTS

Authors are thankful to the Principal and Head of the Chemistry Department, Priyadarshini College of Engineering, Nagpur, India for providing the necessary laboratory and library facilities.

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