Application of CFFSAC as a New Adsorbent Material for Cd(II) Removal

VILAYATKAR N.D.[1], GADEGONE S.M.[2] AND RAHANGDALE P.K.[3]

[1]S.S.Jaiswal college Arjuni/Morgoan-441701, India
[2] Kamla Nehru College Nagpur-440024, India
[3]Bhawabhuti College Amgoan-441902, India
Corresponding author: pralhadrahangdale@gmail.com

Abstract

Activated carbon derived from *Cassia fistula* Fruit shell has been used for the adsorption of Cd(II) from aqueous solution. Cadmium is toxic to living systems and therefore it is essential toremoveit from wastewater. Activated carbon was characterized using techniques like FTIR and SEM. Adsorption capacity of *Cassia fistula* fruit shell activated carbon (CFFSAC) for Cd(II) abetment was investigated employing batch equilibration method. The effects of various parameters like contact time, initial adsorbate concentration, pH and CFFSAC doses have also been studied and reported. The adsorption data were found to fit well with the Langmuir model.The percent removal of Cd (II) was found to be increase with adsorbent doses from 1 to 7 gm.andmaximum efficacy was found at 7gm. whenpH was 6.0. Atoptimum condition nearly 90% abatement of Cd(II) has been noted using CFFSAC. Thus the self-prepared activatedcarbon under investigation has been proved to be an excellent economical adsorbent material for Cd(II) removal from contaminated water/wastewater.

Keywords: Cassia fistula, activated carbon, cadmium toxicity, wastewater treatment, Langmuir isotherm.

Introduction

The problem of water pollution arises due to the disposal of heavy metals from industries from the last few decades. It is well known that cadmium has harmful effects on many lifeforms. This problem has received considerable attention in recent years. Therefore,itbecomes necessary to remove cadmium from wastewater by using appropriate treatment before releasing it into the environment. The acute over exposure to cadmium fumes can causes pulmonary diseases and chronic exposure can causes renal tube damage and prostate cancer[1].Cadmium and their salts are used in electroplating, paint pigments, plastics, silver cadmium batteries [2], smelting, cadmium nickel batteries, stabilizer, phosphate fertilizer, mining and alloy industries [3-5].The commonly used methods for removing metal ions from waste water includeprecipitation, lime-coagulation, reduction, electrolytic removal, ion-exchange, reverse osmosis,membrane filtration, and solvent extraction[6-12].Bio-sorption a technically feasible and economical process, has gained increased creditability during recent years [13]. A number of biosorbent 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[14-15]. The low cost activated carbon derived from *Tamarindusindica* bark has also been reported as an excellent adsorbent for removal ofCr(VI)[16]. The objective of the present study is to investigate the possible use ofactivated carbon derived from *Cassia fistula*FruitShell(CFFSAC) as an alternative 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 theCassiafistula.

Cassia fistula fruit shell 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 6 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.

Preparation of stock solution

Synthetic stock solution of Cd(II) was prepared by dissolving required quantity of cadmium sulphatesalt in the distilled water. This solution was diluted to proper proportions to obtain various standard solutions ranging their concentrations 10-100mgl^{-1}. pH adjustment 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 Whatmman no.42 filter paper and filtrate was analyzed for Cd(II) concentration using Atomic Absorption Spectrophotometer(AAS). From

Experimental data, the applicability of Langmuir model was judged. Linear regression coefficient (R^2) and isotherm constant values were determined from the model.

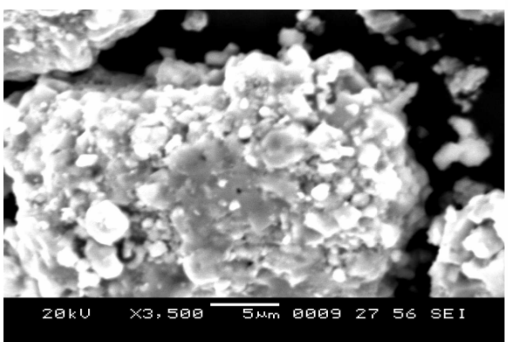
Characterization of CFFSAC

Scanning Electron Microscopy (SEM) Analysis:

The surface morphology of activated carbon under investigation was examined using scanning electron microscopy (SEM: Fig.1). At x3500 magnification, SEM micrograph clearly revealed wide varieties of holes and caves type openings on the surface of the adsorbent which would have created more surface area available for adsorption.

.***FTIR analysis***

FTIR of CFFSAC is presented in Fig.2. The band at 3639cm^{-1}indicates the presence of dissociated or associated –OH on the adsorbent surface. The band at 2342cm^{-1}shows more strongly hydrogen bonded –OH group.The band at 1507 cm^{-1}is indicative of carbon carbon double bond stretching.The low band at 573 cm^{-1}which indicate the C-I stretching.



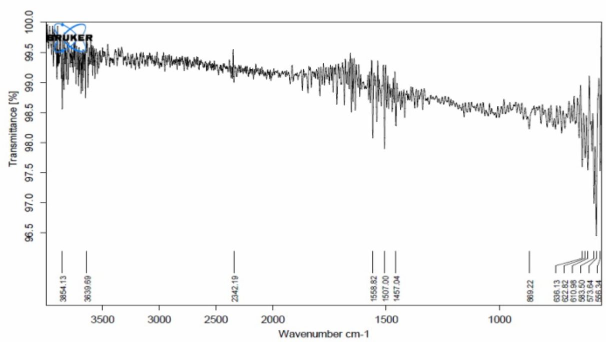


Fig.1 SEM of CFFSACFig.2 FTIR of CFFSAC

Results and Discussion

Effect of pH on adsorption

Effect of pH on Cd(II) adsorption using CFFSAC 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 removalincreases steadily from 44 to 80% when pH is increased from 1to 6 in Cd(II) adsorption and slowly decreases on further increases in pH.

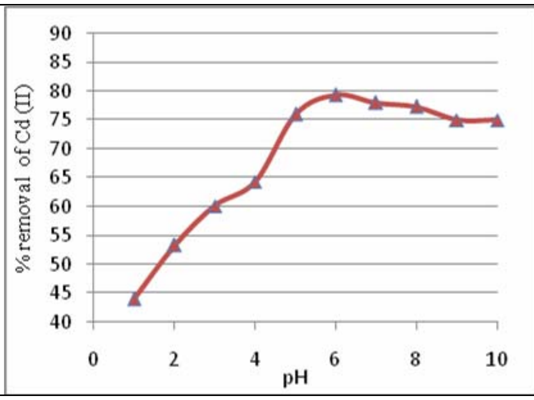


Fig. 3- Effect of pH onCd(II) adsorption

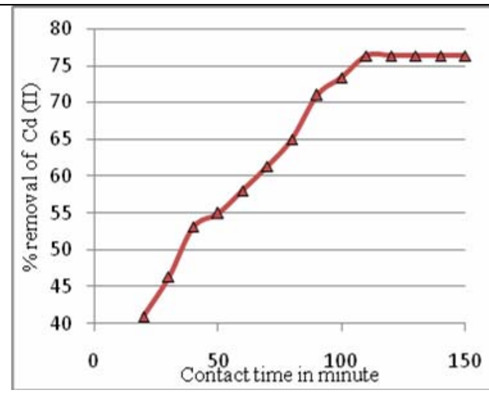


Fig. 4- Effect of contact time on Cd(II) adsorption

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 110 min.

Effect of adsorbent doses

The effect of adsorbent (CFFSAC) 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 7gm/lit. for the CFFSACadsorbent.

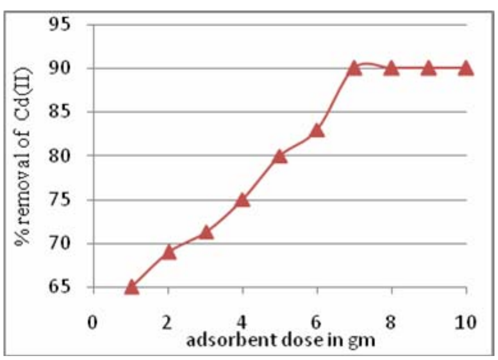


Fig.5- Effect of adsorbent doses on Cd(II) adsorption

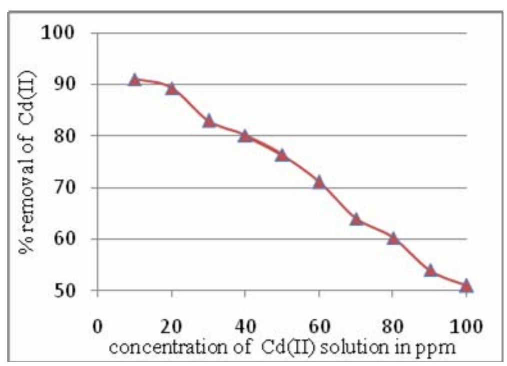


Fig 6-Effect of initial concentration on Cd(II) adsorption

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 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.

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 CFFSAC is obtained as 2.0129. The Langmuir constant b which denotes adsorption energy is found to be 0.4478. The high value (0.9693) 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 CFFSAC. The dimensional parameter, R_L, which is a measure of adsorption favorability is found to be 0.0693 ($0< R_L< 1$) which confirms the favorable adsorption process for Cd(II) on CFFSAC adsorbent.

Conclusion

i). Activated carbon (CFFSAC) has been obtained and activate successfully.

ii). The activated carbon derived from the Fruit Shell ofCassia fistula has been characterized by FTIR and SEM studies.

iii). CFFSAC was most effective forCd(II) removal. At pH 6, 80% of Cd(II) was removed from aqueous solution and adsorption was found to be pH dependent.

iv). The increase in percent removal capacity wasobserved with increased adsorbent doses and contacttime. Maximum Cd (II)removal is 90% for 7.0 gm/lit.dose and 77% at 110min. of contact time respectively.

v). The newly obtained activated carbonunder present investigation can be successfully employedforCd(II)abatement from contaminated water and thuscan be used for water/ wastewater treatment and pollution control.

Acknowledgment

Authors are highly thankful to Dr. R.B. Kharat, Ex- Director, Institute of Science, Nagpur for his valuable guidance, moral support, timely help and constant encouragement during the course of this investigation. Thanks are also due to the Principal, Kamla Nehru College, Nagpur for providing necessary laboratory facilities. Thanks are also due to Managing Director of Deenee Chemical Research Laboratory (DCRL), Chandrapur for access of atomic absorption spectrophotometer and other instrumental facilities as and when required.

Reference

[1]. Jarup L. and Akesson A. Current status of cadmium as an environmental health problem, toxicology and applied pharmacology *2009 238, 3, 201-208.*

[2]. M. Sitting, Handbook of Toxic and Hazardous Chemicals, Noyes Publications, Park Ridge, NJ, 1981, pp. 119–120, 185–186.

[3]. B. Volesky, Biosorption of Heavy Metals, vol. 24, CRC press, Boca Raton, FL, 1992, pp.13–14.

[4]. A.K. Meena, G.K. Mishra, K. Satish, C. Rajagopal, P.N. Nagar,Adsorption of cadmium ions from aqueous solution using differentadsorbents, Indian J. Sci Ind. Res. 63 (2004) 410–416.

[5]. Singh I B and Singh D R. Cr(VI) removal in acidic aqueous solution using iron-bearing industrial solid wastes,Their stabilization with coment, Environ Technol, 2002, 23,85-95.

[6]. Chakravarti A K , Choudhary S, Chakrabarty S and Mukharjee D C, liquid membrane Multiple emulsion process of chromium Cr(VI) separation from waste-water colloids, surf

[7]. A: Physio Chem. Engg. Aspects, 1995, 103, 59-71.

[8]. Cimino G, Passerini A and Toscano G, Removal of toxic cations and Cr(VI) from aqeuos solution by hazelnut shell water Res, 2000, 34(11) 2955-2962.

[9]. Gode F and pehlivan E, removal of Cr(VI) from aqueous solution by two lewatit-anion exchange resin, J Hazard Mater, 2005,119 175-182.

[10]. Juang RS and ShiauRC , Metal removal from aqueous solution using Chitosan enhanced membrane filtration, J Membr Sci. 2000, 21(10), 1091-1097.

[11]. Lalvani SB, Hubner A and Wiltowski TC, Chromium adsorption in lignin, Energy Sources, 2000, 22, 45-46.

[12]. Lu A, Zhong S, Chen J, Shi J, Tang J and luX.Removal of Cr(VI) and Cr(III) from aqueous solution waste water by natural lino-pyrrhotiteEnviron Sci. Technol, 2006, 40(9), 3064-3069.

[13]. Rengaraj S: Yeon KH and Moon SH, Removal of Chromium from water and waste water by ion exchange resin J. Hazard Mat. 2001, 87,(1-3) 273-287.

[14]. Loukidou, M.X., A.I.Zouboulis,T.D. Karapantsios and K.A. Matis,2004. Equilibrium andKinetic modeling of chromium (VI) biosorption by Aeromonascaviae. Colloids and surfaceA: Physiochemical and Engineering Aspect, 242: 93-104.

[15]. Hunge S.S., Rahangdale P.K., Lanjewar M.R.; Removal of Hexavalent Chromium from Aqueous Solution using Pretreated Bio-Sorbent, Int. Arch. App. Sci. Technol; Vol 5 [1] March 2014; 06- 10.

[16]. Hunge S.S., Rahangdale P.K., Lanjewar M.R.; Adsorption of Chromium (VI) From Aqueous Solution Using Bio-Sorbent, International Journal of Current Research Vol. 6, Issue, 05, Pp.6787-6791, May, 2014.

[17]. Hunge S.S., Rahangdale P.K., Lanjewar M.R.; Adsorption of Hexavalent Chromium on Newly Generated Activated Carbon, International Journal of Recent Scientific Research Vol. 5, Issue, 5, pp.1014-1017, May, 2014.