Application of Activated Carbon Derived From *Acacia Nilotica* Fruit Shell

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Abstract:

This research paper reports the applicability of low-cost activated carbonderived from *Acacia nilotica*fruit shell which could be an alternate against the existing expensive methods for removal of chromium (VI) from wastewater/industrial effluents. Hexavalent chromium is toxic to living systems and its removal is essential from wastewater. The self-generatedactivated carbon was characterized using techniques like FTIR and SEM. Adsorption capacity of*Acacianilotica*fruitshellactivated carbon (ANFSAC)for Cr(VI) abetment was investigated by batch equilibration system. The effects of various parameters like contact time, initial adsorbate concentration, pH and ANFSAC doses have also been studied and reported.The data were in well agreement with Langmuiradsorption isotherm. Cr(VI) removal is pH dependent and maximum efficacy of about 87% was found to be at pH 4.0. The results suggest that the *Acacia nilotica*fruit shell activated carbon under present investigation could be employed as an efficient adsorbent for the removal of hexavalent chromium from industrial wastewater.

Keywords-Acacia nilotica, activated carbon, industrial wastewater, Langmuir isotherm.

Introduction:

Chromium is a ubiquitous element not only because of its occurrence in nature but also due to many anthropogenic sources resulting from its widespread industrial applications. Martinezet al.(2001)Chromium (hexavalent) is toxic and carcinogenic to living system. In addition, the toxic nature ofCr(VI) ions attributed to their oxidation potential and their relatively small size which enable them to penetrate through biological cell membranes.Balaramaet al. (2005)Cr(VI) has been recognized as a probable agent causinglung cancer and it also leads to gastrointestinal disorder, dermatitis and ulceration of skin in human.Balasubramanianet al. (1999)Extensive use of Cr(VI) in industries such as electroplating, glass, ceramics, fungicides, rubber, fertilizers, tanning, mining, metallurgical processes etc. Namasivayamet al. (1995); Radovic et al. (2000) and Malkocet al. (2007)results in the increased Cr(VI) concentration in theeffluents ranging from tenths to hundreds mg/lit. which is much above the permissible limit. Several procedures have been purposed for the removal of chromium from industrial wastewater, which are chemical reduction, membrane separation, electrochemical treatment, ion-exchangeand bioaccumulation etc.Chen.et al. (2007); Preetha et al.(2007) andCvacoet al.(2007)Although the effectiveness of these methods have been proved, but they suffer from major disadvantage of high expensive nature. Activated carbon(AC)has been recentlyused as an adsorbent due to its capacity as an adsorbent in drinking water purification, air pollution controlin gas and liquid phase and wastewater treatmentDaifullahetal.(2003)andHeijemanet al.(1999)Use of surface modified/chitosan coated bio-sorbent as low cost materials for abatement of Cr(VI) have recently been reported in the literature. Hunge et al.(2014)The low cost activated carbon derived from *Tamarindusindica* bark has also been reported as an excellent adsorbent for removal hexavalent chromium.Hunge et al.(2014)Researchers are being investigating new and new cheaper raw materials for preparation of activated carbon. Use of *Acacia nilotica*fruit shell as raw material for generatinglow cost activated carbon (ANFSAC) and its application for removal of Cr(VI) from wastewater has been investigated and reported in the present research article.

Material and Methods:

Procedure of adsorbent preparation and activation

*Acacia nilotica*fruitshellwas collected from the local field, they were cut into small pieces, washed several times with deionized/ doubly distilled(DI) water and left to dry. After drying it was subjected topyrolysis process for carbonization using Muffle Furness at 300-400^{0}C for 5 to 6 hours, so that volatile constituents were removed and residue was converted into char. Then char was subjected to chemical activation by using 25 % of $ZnCl_2$ solution.

Chemicals

The chemicals used in the investigation were of analytical or chemically pure grade. Chromium stocksolution(100ppm)was prepared by dissolving 2.8287 gm.of$K_2Cr_2O_7$ in 1000ml of DI water. The solution was diluted to proper proportions to obtain standard solutions ranging their concentrations 10-100 mg/lit.

Estimation of Chromium

Amount of chromium in given solution was determined by spectrophotometricallyusingAtomic Absorption Spectrophotometer and 1,5-diphenylcarbazide as complexing agent. The sample containingCr(VI) ion was mixed with 3N $H_2SO_4$and 0.25% 1,5-diphenylcarbazide solution and made up toknown volume. The absorbance was measured after 10 minutes ageing. A calibration curve drawn in the range between 5 to 50ppm,plotting absorbance against concentration of chromium.

Characterization of ANFSAC

FTIR of ANFSAC

FTIR of ANFSACis presented in Figure.1. The band at 2998.61 cm^{-1} indicates the presence of C-Hstretching vibration in methyl group. The band at 2357.43cm^{-1} shows more strongly hydrogen bonded –OH group. The band at 1432.43 cm^{-1}shows α-CH_2 bending. The peak at 871.71cm^{-1}

corresponding to –C-H bending vibration.

SEM of ANFSAC

SEM micrograph of ANFSACis presented in Figure.2. The surface morphology of activated carbon was examined using scanning electron microscopy. At x5000 magnification, SEM micrograph clearly revealed that wide varieties of pores are present in activated carbon and multifold surface which would have created more surface area available for better adsorption.

Batch experiments

Batch equilibriumstudies were conducted with different parameter such as pH, agitation time, initial concentration of Cr(VI) and effect of adsorbent doses. The reaction mixture was agitated on rotary shaker at 300 rpm, filtered through Whatmman no.42 filter paper and filtrate were analyzed for Cr(VI) concentration.

Adsorption isotherm model

Langmuir isotherm

Langmuir isotherm model [Langmuir I. (1918)] is based on the assumption that maximum adsorption corresponds to a saturatedmonolayer of solute molecules on the adsorbent surface. The linear form of the Langmuir isotherm equation canbedescribedbyequation (1).

$$C_e/qe = \frac{1}{q_m\, b} + \frac{C_e}{q_m} \quad \ldots\ldots\ldots\ldots\ldots..(1)$$

Where C_e (mg/L) is the equilibrium concentration of the adsorbate, q_e (mg/g) is the amount of adsorbateadsorbedper unit mass of adsorbent; q_m and b are Langmuir constants related to adsorption capacity and rate of adsorptionrespectively. q_m is the amount of adsorbate at complete monolayer coverage (mg/g) which gives the maximumadsorption capacity of the adsorbent and b (L/mg) is the Langmuir isotherm constant that relates to the energy ofadsorption (or rate of adsorption). The linear plot of specific adsorption capacity against the equilibriumconcentration (Ce) shows that the adsorption obeys the Langmuir model. In order to find out thefeasibility of the isotherm, the essential characteristics of the Langmuir isotherm can be expressed in terms ofdimensionless constant separation factor R_LFerreroF. (2007)and McKay G. et al.(1982) by the equation (2).

$$R_L = \frac{1}{1+bC_0} \quad \ldots\ldots\ldots\ldots(2)$$

The value of R_L lies between 0 to 1for the favorable adsorption, while R_L>1 represent an unfavorable adsorption, and R_L=1represent the adsorption, whilelinearthe adsorption is irreversible if R_L=0

Results and Discussion:

Effect of pH on adsorption

Effect of pH on Cr(VI) adsorptionusing ANFSAC as an adsorbent has been studied in the pH range 1to10 and presented in Figure.3. It is seen that solutionpH plays a very important role in the adsorption of Cr(VI).The percentage removal of Cr(VI) decreases steadily from 87 to 64% when pH is increased from 5 to 10. The maximum removal of Cr(VI) is noticed at pH-4.

Effect of contact time on adsorption

Adsorption experiments were conducted asa function of contact time and results are shown in Figure.4. The rate of Cr(VI) binding with adsorbent was greater in the initial stages then gradually increases and remain almost constant, after optimum period of130 min.

Effect of adsorbent doses

The effect of adsorbent doses as ANFSACon percentage of removal of Cr(VI) at range 1 to 10gm is represented in Figure.5. The initial Cr(VI) concentration was taken to be 30ppm. However after certainadsorbent dose it becomes constant and it is treated as an optimum adsorbent dose, which is found to be 6 gm/lit. for the ANFSAC adsorbent.

Effect of the Initial concentration of Cr(VI) solution.

The experimental studies were carried with varying initial concentration of Cr(VI) ranging from 10 to 100 ppm using 6gm/lit. of adsorbent dose at pH 4.The results are shown in Figure. 6. The results demonstrate that at a fixed adsorbent dose the percentage of Cr(VI) removal decreases with increasing concentration.

Adsorption Isotherm.

The isotherm data have been linearized using the Langmuir equation and is plotted between Ce/qe versus Ce. The Langmuir constant q_m, which is measure of the monolayer adsorption capacity of ANFSAC is obtained as 0.3942. The Langmuir constant b which denotes adsorption energy is found to be 0.8766. The high value (0.9646) of regression correlation coefficient (R^2) indicates good agreement between the experimental values and isotherm parameters and also confirms the monolayer adsorption of Cr(VI) onto the ANFSAC. The dimensional parameter, R_L, which is a measure of adsorption favorability is found to be 0.03663 ($0< R_L < 1$) which confirms the favorable adsorption process for Cr(VI) on ANFSAC adsorbent.

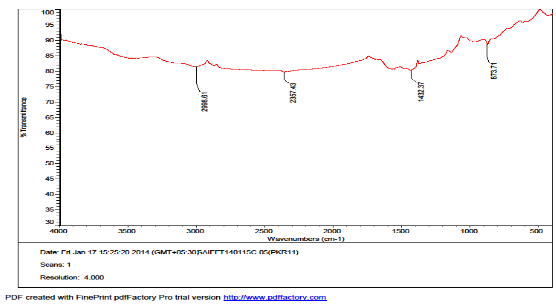


Figure. 1- FTIR of ANFSAC

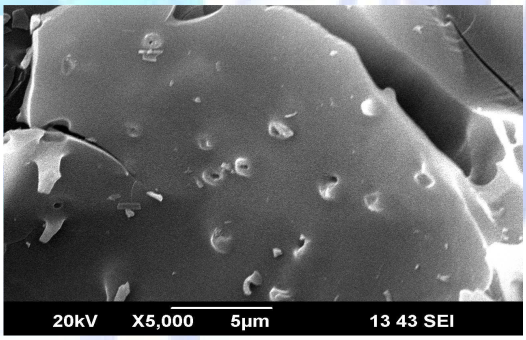


Figure.2-SEM of ANFSAC

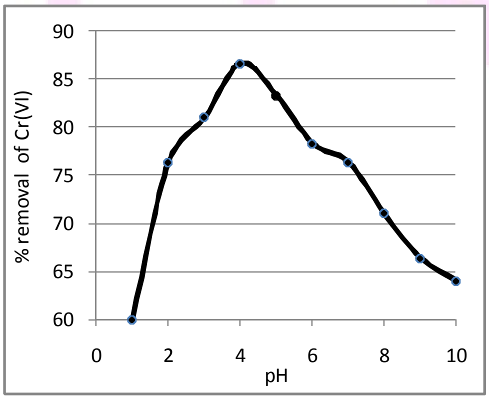


Figure. 3- Effect of pH onCr(VI) adsorption

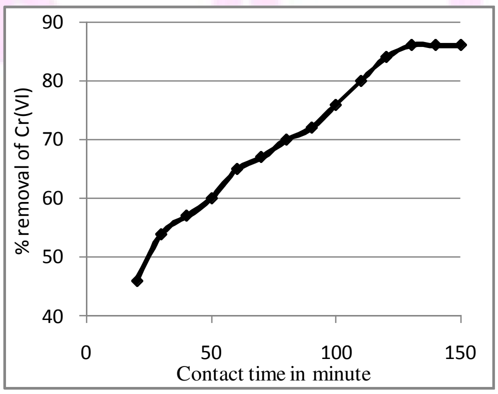
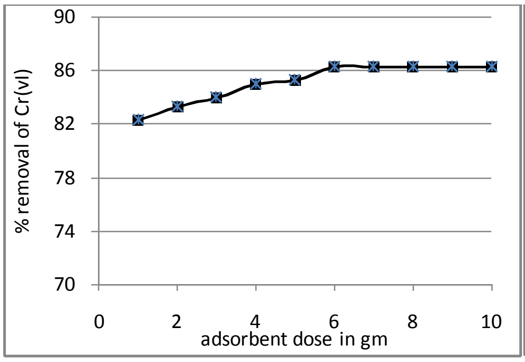


Figure. 4- Effect of contact time on Cr(VI) adsorption



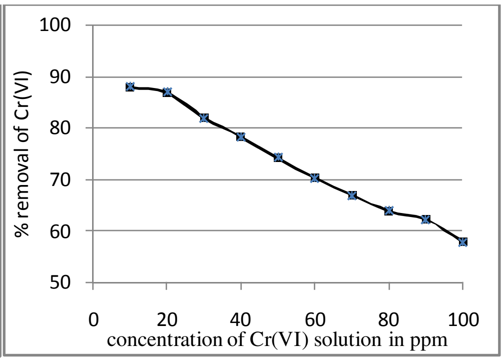


Figure.5- Effect of adsorbent doses onCr(VI) adsorption

Figure. 6- Effect of initial concentration on Cr(VI)adsorption

Conclusion

- The activated carbon derived from the Fruit Shell of *Acacia Nilotica*andcharacterized by employing FTIR and SEM studies.
- The newly developed modified activated carbon has high porous structure and excellent surface area.
- ANFSAC was most effective for Cr(VI) removal. At pH 4, about 87% of Cr(VI) was removed from aqueous solution. Adsorption was found to pH dependent. Above pH 5, decrease in Cr(VI) removal was noticed.
- The increase in percent removal capacity for Cr(VI) was observed with increased in contact time. Maximum removal of Cr(VI) is 86% for 6.0 gm/lit. dose.
- The newly obtained activated carbon under present investigation can be successfully employed for Cr(VI) abatement from contaminated water and thus can be used for water/ wastewater treatment.

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References:

Balarama–Krishna M.V., Chandrasekaran K., Rao S.V., Karunasagar D. and ArunchalamJ.,Speciation of Cr(III) and Cr(VI) in Water Using Immobilized Moss and Determination by ICP-MS and FAAS Talanta,*65 135-143(2005).*

Balasubramanian S. and Pugalenthi V. Determination of Total Chromium in Tannery Waste Water by Inductive Coupled Plasma- Atomic Emission Spectrometry, Flame Atomic Absorption Spectrometry and UV-Visible Spectrophotometric Methods, Talanta, *50, 457-467(1999).*

Chen S.S., Cheng C.Y., Li C.W., Chai P.H and Chang Y.M. Reduction of chromatefrom electroplating wastewater from pH 1to 2 using fluidized zero valent iron process.*J. Hazardous Materials, 142: 362-367 (2007).*

Cvaco S.A. Fernandes S., Quina M.M and Ferreira L. Removal of chromium fromelectroplating industry effluents by ion exchange resin.*J Hazardous Materials,144:634-638 (2007).*

DaifullahA.A.M., Girgis B.S., and Gad H.M.H. Utilization of agro-residue (rice husk)in small waste water treatment plans. *Materials Letters 57, (1723-1731.)*

Ferrero F., *J. Hazard. Mater., 2007, 142-144.*

Heijeman S.G.J. andHopman R. Activated carbon Filtration in drinking water production: Model prediction and new concepts." Colloids and Surfaces *A: Physiochemical and Engineering Aspects 151, 303-310.*

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

Hunge S.S., Rahangdale P.K., and Lanjewar M.R.; Adsorption of Chromium (VI) From AqueousSolution Using Bio-Sorbent, *International Journal of Current Research Vol. 6, Issue,05, 6787-6791, May, 2014.*

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

Langmuir I.,*J. Am. Chem. Soc., 1918, 57, 1361.*

Malkoc E., Nuhoglu Y., Potential of tea factory waste for chromium(VI) removal fromaqueous solutions: Thermodynamic and kinetic studies, *Sep. Purif. Technol.54, 291–298. (2007)*

Martinez-Bravo Y., Roig-Navarro A.F., Lopez F.J. and Hernandez F,Multielemental determination of Arsenic, Selenium and Chromium(VI) Species in Water by High-performance Liquid Chromatography and Inductively Coupled Plasma Mass Spectrometry, *J.Chromatogr., A 926,265-274, 44(2001)*

McKay G., Blair H.S., Gardner J.R,*J. Appl. Polym.Sci., 1982, 27, 3043.*

Namasivayam C. and Yamuna R.T., Adsorption of Chromium (VI) by a Low-Cost Adsorbent: Biogas Residual Slurry, *Chemosphere 30 (1995) 561–578.*

Preetha, B. and Viruthagiri T., Bioaccumulation of Cr(VI), copper(II) and nickel (II) ions by growingRhizopusarrhizus. *Biochem.Engineering J.34: 131-135 (2007).*

Radovic L.R., Chemistry and physics of Carbon, *Marcel Dekker Inc.27 (2000) 227–405.*