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THE CONTROL OF CADMIUM POLLUTION IN WAST WATER USING NEWLY DEVELOPED ADSORBENT

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Abstract:
Prevention is better than cure. Instead of becoming, a victim of certain diseases due to consumption of polluted water. It is always advisable to drink purified water. Pollution of water due to the presence of certain heavy metal ions is a severe socio-environmental problems caused by the discharge of industrial wastewater. In this research paper, the adsorption ability of activated carbon derived from the bark of Ziziphus mauritiana for removal of cadmium from polluted water has been studied with respect to various parameters such as effect of pH, adsorbent dosage, contact time and initial cadmium concentration. The cadmium uptake was dependent on equilibrium pH=7.5, being the optimum pH values. The removal of cadmium from aqueous solution increases with increase in contact time and equilibrium was attained at 160 min. Further, on increasing adsorbent dose, there was increase of cadmium removal. The optimum adsorption (90%) was noticed at 6.0 g/l of adsorbent dose. The increase in initial concentration of cadmium led to decrease in the percent removal of Cd. This investigation verifies that the newly prepared activated carbon from the bark of Ziziphus mauritiana, can be used as a cost effective, valuable adsorbent for removal of Cadmium from aqueous solution and thus can be successfully applied for wastewater treatment.
Keywords: Adsorption,, Ziziphus mauritiana (ZM), batch experiment, Activated carbon

Introduction

Water is one of the most important factors of living and non-living organisms. The pollution of water emerged as one of the most significant environmental problems of recent times[1]. Pollution of water has its origin mainly in urbanization, industrialization and increase in human population observed during the past one and half century. It is well known that some metals can have toxic or harmful effects on many forms of the life[2]. Metals which are significantly toxic to human beings and ecological environments, includes chromium, copper, lead, mercury cadmium, nickel iron[3]. However, its main sources come from industrial process such as electroplating, smelting, alloy manufacturing, pigment, nickel-cadmium and solar battery production. The removal of heavy metal contaminants from aqueous solutions is one of the most important environmental concerns because metals are biorefractory and are toxic to many life forms. Cadmium contamination in drinking water can naturally occur in zinc, lead and copper ores through diffusion. According to the World Health Organization guidelines, the permittable concentration of cadmium in drinking water is less than 0.005 mg^{-1}.Cadmium ion have little tendency to hydrolyze at pH< 8 but at pH> 11,all cadmium ion exists as the hydroxyl-complex[4].

Various treatment technologies have been developed for the purification of water and waste water contaminated by heavy metals. The most commonly used methods for the removal of metals ions from waste water are chemical precipitation, solvents extraction, oxidation, reduction, electrolytic extraction, reverse osmosis, ion-exchange, adsorption etc. Amongst all these methods adsorption is highly effective and economical. It is a growing need to derive activated carbons from cheaper and locally available waste materials[5]. Among all the methods, adsorption is highly effective and economical. Though the use of commercial activated carbon is well known as adsorbent for the removal of heavy metals from wastewater, the high cost of activated carbon limits its use as an adsorbent in developing countries. Hence, it is a growing need to derive the activated carbon from cheaper and locally available waste materials. Several research workers used different low cost adsorbents from agriculture wastes such as coconut coir pith, sawdust, rice husk, banana pith, cottonseed hulls, apples wastes, sugarcane bagasse, peanut hull etc. for the removal of cadmium from water and waste water. The present investigation, studies were carried out for the removal of cadmium from aqueous solution using activated carbon derived from bark of *Ziziphus mauritiana* belong to *Rhamnaceae family* which is an extremely drought hardy and native fruit of India. It is useful as food, fodder, nutrient and medicine. It is extensively used in Ayurveda, Unani and Haemeopathic medicine[6]. The activated carbon derived from the bark of *Ziziphus mauritiana* was characterized by FTIR and scanning electron microscopy (SEM) studies. Batch isothermal equilibrium method was conducted at 303K to evaluate the efficiency of newly developed adsorbent for removal of cadmium from the aqueous solution. Experiments were carried out to evaluate effect of pH, adsorbent dosage, contact time and initial cadmium concentration. Thus, the newly synthesized activated carbon have been proved to be very good adsorbent which can be successfully used for removal of cadmium from aqueous solution.

Materials and Method

Chemicals

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

Preparation of Activated Carbon from the bark of *Ziziphus mauritiana* (ZMAC)

The bark of *Ziziphus mauritiana* tree was collected from the local area. The bark was cut into small pieces, washed with tap water to remove the sand particles and then treated with formaldehyde to avoid release of any colour of bark into aqueous solution. 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 at 360 W for 30 min[7]. 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 ZMAC

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

Adsorption Studies

Working standards were prepared by progressive dilution of stock solution of Cadmium.. Removal of Cadmium using ZMAC was carried out by batch equilibrium method. The influence of various parameters such as effect of pH, contact time, adsorbent dosage and initial Cadmium concentration were studied, taking 30 mg/l of initial Cadmium concentration and 6g/l of adsorbent dose. The effect of adsorbent doses was studied by varying them from 0.5-10g/l. The effect of initial Cadmium concentration was studied by changing concentration from 10-100mg/l with adsorbent dose of 6g/l at room temperature. The residual concentrations were measured using atomic absorption spectrophotometer.

Result and Discussion

Characterization of ZMAC

FTIR spectrum of ZMAC is shown in **Fig1.** A band at 3442.21cm^{-1} is connected with –OH stretching band. The –OH groups are seem to be associated by means of hydrogen bonds, as the band for hydroxyl group not involved in hydrogen bonding usually appears as a sharp band located above 3500cm^{-1}. The band for–OH stretching in the range below 3700cm^{-1} was assigned by Zawadzki[8]. A band at 1633.75cm^{-1} is indicative of C=O stretching in aldehyde or ketone (carbonyl group). The sufficiently lowering in the band position suggest that C=O group may also involved hydrogen bonding. It is because of the reason that the intramolecular hydrogen bonded structure is stabilized by the phenomenon of resonance. The peak at 1084.14cm^{-1} is suggestive of ortho- substitution. Low band at 565.20cm^{-1} is evidence of C-I stretching vibration[9,10]. **Fig.2** represents SEM micrographs of ZMAC. SEM image has been obtained using an accelerating voltage of 20kV at X1500, magnification. High magnification SEM micrographs clearly reveal that the wide varieties of pores are present on the surface of *Ziziphus mauritiana* activated carbon (ZMAC) accompanied with fibrous structure. It can also be noticed that there are holes and cave type openings on the surface of the adsorbent, which would have created more surface area available for adsorption. The size of holes and caves was found to be in the range 1- 10μm.

Effect of pH

The effect of pH on the adsorption of Cadmium by ZMAC was studied at pH 1 to 9. From **fig.3** it is clear that the removal of Cadmium increases with an increase in pH from 1.0 to 7.5 and it is optimum at 7.5. The percent of adsorption increases from 60 to 92 as pH was increased from 1 to 7.5. The percentage of adsorption decreases steadily when pH increased above 7.5 and it was further decreased to 70% as pH was raised to 8.

Effect of Contact Time

Adsorption experiments were conducted as a function of contact time and results have shown in **Fig.4**. It can be observed that Cadmium removal ability of ZMAC increased with increase in contact time before equilibrium was reached. Other parameters such as dose of ZMAC, pH of solution and initial concentration were kept optimum. It can be seen from fig.4 that Cadmium removal efficiency increased from 25 to 90% when contact time was increased from 10 to 160 min. Optimum contact time for ZMAC was found to be 160 min. Cadmium removal efficiency remained nearly constant after 160 min i.e. equilibrium time.

Effect of Adsorbent Dosage

Fig.5 shows the effect of dosage on the removal of Cd which was studied by varying the amount of ZMAC from 0.5 to 10g/1 while keeping other parameters (pH, contact time and initial concentration) constant. It is clear from the figure that percentage removal of Cd increased with the increase in ZMAC doses and it was found to be maximum i.e. 90% at the dose of 6g/l. This is due to availability of more surface area. It indicates that by increasing the ZMAC dosages, the adsorption efficiency for Cd removal increases. After 6g/l dose of ZMAC, the adsorption efficiency remain constant because the maximum adsorption set in and amount of Cd present in the solution bounded to adsorbent remains nearly constant after this dose.

Effect of initial metal ion concentration

The effect of initial metal ion concentration on the percentage removal of cadmium by ZMAC has shown in fig.6. It can be seen that the percent removal of Cd decreases with the increase in initial Cd concentration. In this study, the experiment was performed to study the initial concentration effect in the range 10-100mg/l. The adsorbent dose was maintained 6g/l. The result shows the decrease in removal from 90 to 49%. This can be justified by the fact that adsorbent have limited number of active sites which are saturated beyond certain concentration of adsorbate.

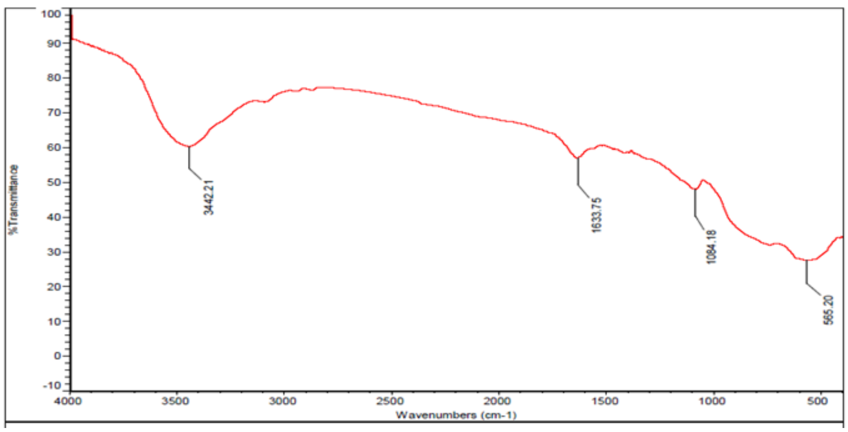

Figure 1 FTIR Spectrum of *Ziziphus mauritiana* Activated Carbon (ZMAC)

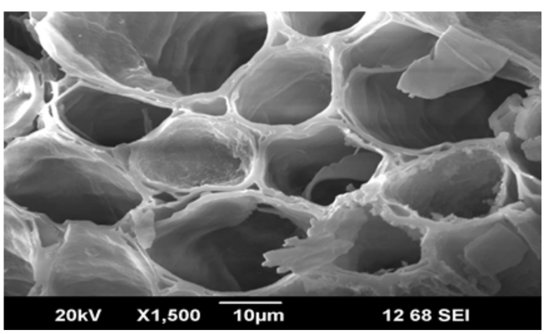

Figure 2 SEM image of *Ziziphus mauritiana* Activated Carbon (ZMAC)

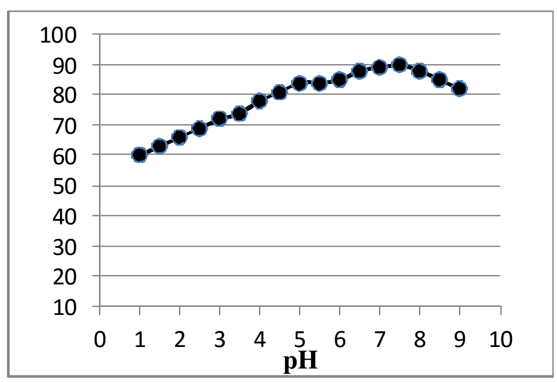

Figure 3 Effect of pH on Cadmium removal by ZMAC

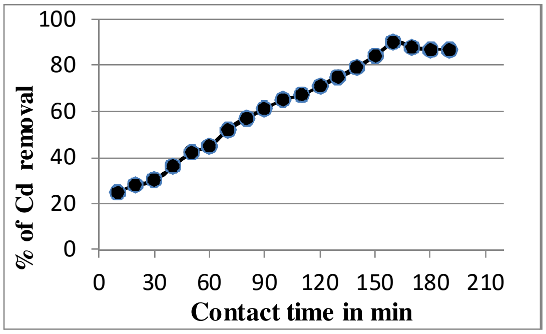

Figure 4 Effect of Contact time on Cadmium removal by ZMAC

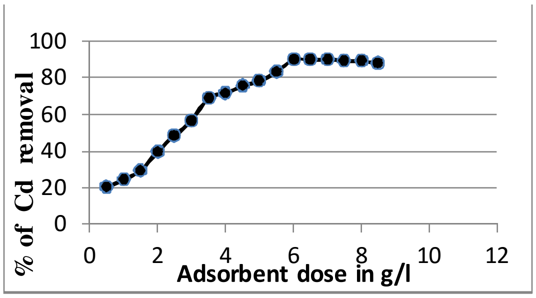

Figure 5. Effect of adsorbent dose on Cadmium removal by ZMAC

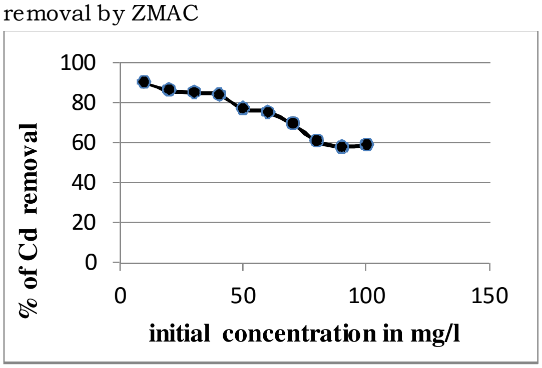

Figure 6 Effect of initial concentration of Cadmium removal by ZMAC

Conclusion

- The activated carbon derived from the bark of *Ziziphus mauritiana* tree was successfully prepared and characterized employing FTIR and SEM studies.
- The newly prepared activated carbon has high porous structure and excellent surface area.
- ZMAC was most effective for cadmium removal. At pH 7.5, 90% of Cd was removed from aqueous solution. Adsorption was found to pH dependent. Above pH 7.5, decline in Cd removal was noticed.
- The increase in percent removal capacity for Cd was observed with increase of adsorbent dose and contact time. Maximum removal is 90% for .0 g/l dose and 160 min. of contact time.
- The activated carbon under present investigation can be successfully employed for cadmium removal from contaminated water and thus can be used for water/ wastewater treatment.

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References

1] KaYrabulut S.,Karabakanv A., Denizli A, Yurum Y., *Sep.purif.Technol.*18*(2000)177*

2] H.J.M.Bowen ,The Environmental Chemistry of the Elements, *Acdemic Press, London,1979*

3] Hunge SS, Rahangdale PK and Lanjewar MR., Role of Newly Developed Adsorbent in the Control Of Cr(Vi) Pollution, *Internation Journal of Research in Biosciences, Agriculture & Technology,spec.issues (1),pp.41-47(2015)*

4] Corapcioglu MO, Huang CP, The adsorption of heavy metal onto hydrous activated carbon, *Water Res.1987;21(9):1031-44*

5] Hunge SS, Rahangdale PK and Lanjewar MR., Adsorption of Chromium(VI) From Aqueous Solution Using Bio-Sorbent, *International Journal of Current Research Vol. 6, Issue, 05, pp. 6787-6791, May,2014*

6] *The Ayurveda Pharmacopeia of India*, part-I, vol.2, The Controller publication, New Delhi, 76-87, (1999)

7] Hunge SS, Rahangdale PK and Lanjewar MR., Removal of hexavalent chromium from aqueous solution using pre-treated bio-sorbent, *International Archive of Applied Sciences and Technology* vol.5(1),pp.6-10(2014)

8] Zawazki J., IR Spectroscopy of Oxygen Surface Compounds on Carbon, *Carbon*, 16, 491-497, (1978)

9] Bouchelta C, Salah Medjram M., Bertrand O. and Bellat J.P., Preparation and Characterization of Activation Carbon from Data Stones by Physical Activation With Steam, *J. Anal Appl Pyrol*, vol 82(1),pp.70-77, (2008).

10] Coates, Interpretation of IR a practical Approach, in Meyers R.A. (Ed.) Encyclopedia of Analytical chemistry, Chichester: *John Wileys of Sons Ltd.* pp.10815-10887 (2000).