APPLICATION OF ACTIVATED CARBON DERIVED FROM CASTER FRUIT SHELL AS GREEN ENVIRONMENTAL MATERIAL

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Abstract

 The presence of heavy metals in the environment is matter of major concerns because of their toxicity, bio-accumulating tendency and threat to human life. Many advanced researches are devoted to developed technique for removal of heavy metals form environment, especially waste-water. The use of low cost locally available and eco-friendly adsorbent has been ideal alternative to current expensive methods for removing toxic metals. The present research article reports the potential use of activated carbon derived from caster fruit shell as an green environmental material for abatement of toxic heavy metals, like lead from waste-water. Adsorption of Pb(II) followed second order kinetics. The adsorption equilibrium was well represented by Langmuir isotherm. The newly developed activated carbon derived from caster fruit shell has been proved to be an attractive option for toxic heavy metal removal from industrial effluents.

Keywords: activated carbon, adsorption, heavy metal toxicity, waste water treatment

Introduction

The increasing contamination of urban and industrial wastewaters by toxic metals ion is worrying environmental problem. These inorganic micro pollutants are of considerable concern because they are non- biodegradable. Lead is ubiquitous in the environment and is hazardous at high levels. It comes into water streams through the combustion of fossil fuels, smelting of sulphide ore and mine drainage. Process industries, such as battery manufacturing and metal plating and finishing are also prime source of lead pollution. Lead accumulates mainly in bones, brain, kidney & muscles and may cause many serious disorders likeanaemia, kidney disease, nervous disorders, sickness & even death. There are several established treatment methods for metal ion removal from aqueous solutions like chemical precipitation, oxidation, reduction, ion exchange, filtration, electrochemical

treatment, reverse osmosis, evaporative recovery and solvent extraction [1 – 3]. Bio sorption processes still retain quite a few advantages over all of the other techniques mentioned since it is selective, effective, cheap and works well at very low concentrations [4]. In addition, it is eco-friendly, since the biosorption processes do not generate toxic sludge, which offers further possibilities for metal recovery and potential biosorbent regeneration[5 – 8]. Biosorption is an alternative technology for the removal of metal ions and organic pollutants from dilute aqueous solutions by employing biomass as the adsorbent. Activated carbon has a great capacity for adsorption. It can be produced by pyrolysis followed by exposing selected carbonaceous material (9-10). The adsorption process is being widely used by various researchers for the removal of heavy metals inclusive of toxic metals from water streams and activated carbon has been frequently used as an adsorbent. Despite its extensive use in the water and waste-water treatment industries, activated carbon remains and expensive material. In recent years the need for safe and economical methods for the elimination of heavy metals from contaminated water has necessitated research interest towards the production of low cost alternative to commercially available activated carbon. In the present work generation, activation practical applicability of environmental/green material i.e activated carbon derived from caster fruit shell for removal toxic heavy metal i.e. lead from polluted water has been reported.

Materials and Method

Biomass: Caster fruits were collected as an agricultural waste and washed several times with tap water followed by washing with distilled water.The clean biomass so obtained was oven dried at 110^0c for 24 hour, and the dried biomass was milled and sieved to get fine particles.

Preparation of activated carbon from caster fruit shell (CCFS): The dried caster fruit biomass was subjected to pyrolysis process. Muffle Furness was used for carbonization. During slow carbonization of the raw material in the absence of air at a temperature range of 600-700K, volatile products were removed and the residue was converted to a char. The char was then

subjected to chemical activation process using 25% zinc chloride solution. The char was treated for 24 hour, filtered, wash with distilled water and dried. The resulting activated carbon particles were ground in a mill, and sieved in a 120-200 mesh size and stored in desiccator. The material is characterized by FTIR and scanning electron microscopy (SEM) studies.

Adsoption studies: Working standards were prepared by progressive dilution of stock solution of lead salt. AR grade HCl, NaOH and buffer solution was used to adjust pH of the solutions.

Removal of Pb(II) using caster fruit shell activated carbon(CCFS) was carried out by batch equilibration method. The influence of various parameters such as effect of pH, contact (agitation) time, adsorbent dose and initial metal ion concentration etc. were studied. For each experimental run, 100ml of waste water of known concentration of metal ion was taken in 250 ml stoppered polyethylene reagent bottles. pH was adjusted to the desired value and a known amount of the activated carbon was introduced into the solutions. The bottles were agitated at temp. (308+ 1K) using a mechanical shaker for a prescribed time to attain equilibrium. At the end of the predetermined time intervals, the samples were taken out, solutions were separated from the activated carbon by filtration using Whatman filter paper No. 41 and the final concentration of metal ions were determined in the filtrate by atomic absorption spectrophotometer. Blank solution was treated similarly (without adding CCFS) and the concentration was taken as initial concentration. The batch adsorption study was replicated twice to confirm the reproducible results. The experimental conditions are tabulated in Table 1.

Table 1:Experimental condition for batch adsorption studies for CCFS.

S.N.	Optimization study	Constants	Variables
1	Agitation time	i) Metal ion conc.=60 mg dm-3 ii) Adsorbent weight=500mg per 0.1 mg dm-3 iii) pH=7.5 + 0.2	Time (min) 10,20,30,40 50 & 60 min
2	pH	i) Metal ion conc.=60 mg dm-3 ii) Adsorbent weight=500mg per 0.1 mg dm-3 iii) Agitation t time =60 min.	pH ranges from 3-10+ 0.2
3	Initial metal ion concentration	i) Adsorbent weight=500mg per 0.1 mg dm-3 ii) pH=7.5+ 0.2 iii) Agitation time =60 min.	Concentration of metal ions 60,50,40,30,20 mg dm-3
4	Adsorbent weight	i) Metal ion conc.=60 mg dm-3 ii) pH=7.5+ 0.2 iii) Agitation t time =60 min.	Adsorbent weight 0.1,0.25,0.5,0.75,1.0,1.25 & 1.50 g per 0.1 dm-3

Sorption isotherm models

The sorption equilibrium data of lead on activated carbon was analyzed in terms of Langmuir isotherm model .Freundlich isotherm equation X/m = KF Ce1/n can be written in the liner form as given below.

$$\text{Log } X/m = \text{Log}K_F + 1/n \text{ Log}C_e$$

Where X/m and Ce are the equilibrium concentration of lead in the adsorbed and liquid phases in mg/g and mg/l respectively. KF and n are the Freundlich constants that are related to the sorption capacity and intensity respectively. Freundlich constant KF and n can be calculated from the slop and intercept of the linear plot with log(X/m) versus log Ce.

The Langmuir sorption isotherm equation $X/m = Q_m K_L C_e/(1 + K_L C_e)$ on linearization becomes

$$\frac{C_e}{X/m} = \frac{C_e}{Q_m} + \frac{1}{Q_m \ K_L}$$

Where Qm & K_L are Langmuir constants which are related to sorption capacity and energy of sorption respectively and can be calculated from the intercept and slope of the linear plot with Ce /(X/m) Versus Ce

Kinetics

The kinetics of the interactions was studied by determining the amount of metal ions adsorbed at different agitation times for various concentrations of the metal tons (20, 15, 10 and 5 mg dm-3) and the optimum pH. Pseudo second order kinetics have been applied for the experimental data to predict the adsorption, which can be expressed as

$$t/q_t = 1/K_2q^2e + 1/q_{e\ t.}$$

Where K_2 is the rate const. K_2 and qe can be obtained from the intercept and slope by plotting t/qt versus t. The experimental results are tabulated in table 2.

Table 2: Adsorption kinetics for removal of Lead on to CCFS for pseudo second order kinetics

	Concentration (mg/g)	qe (Exp) mg/g	Kinetic parameters		
			K2	R2 x 10-4	qe(Theo.)(mg/g)
Metal ion	60	18.95	0.133	9938	18.10
	50	17.39	0.175	9812	13.60
	40	8.82	0.284	9649	8.57
	30	3.71	0.393	9510	3.54

Results & Discussion

Characterization of the Adsorbent Material:

The FTIR spectra (Fig 1) shows absorption band at 2822 cm-1 which can be assigned for C-H stretching in alkyl group. A band at nearly 2376 cm-1 is indicative of N-H bond stretching of amino groups. Strong absorption band at 1594 cm-1 may be due to carboxylic functional group at the surface of CCFS. Band between 1500-1450 cm-1 is attributed to the –CH2 stretching in aromatic skeleton. A characteristic absorption band at 2990 cm-1 is pointing the presence of phenolic –OH group which may be involved in H- bonding.

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Fig. 1:   FT-IR Spectrum of   Caster Fruit Shell Activated Carbon (CCFS)
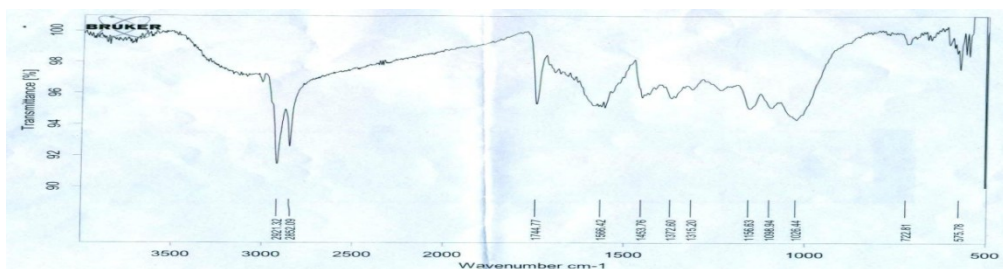
The scanning electron microscopy (SEM) of CCFS show that the surface of the material was rough, uneven and with numerous gaps.   The highly porous surface is indicative of high surface area (Fig. 2).

Fig. 2 : Scanning electron micrographs of the CCFS at 1000 x
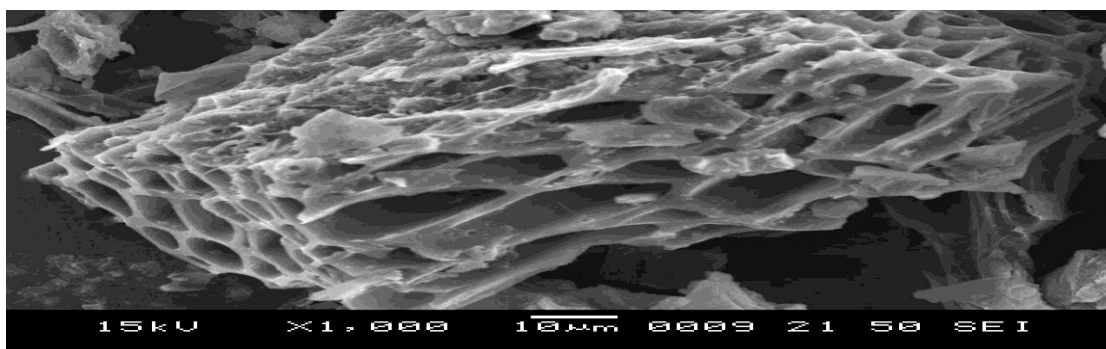
Effect of pH:

The effect of pH on removal of Pb (II) by adsorbent was carried out in the pH range 3.0-10.0 + 0.2 and the results are given in table 3. It can be noted that the removal of Pb (II) ions increased with increasing pH of aqueous solution and reached maximum value at pH 9. It is evident that the CCFS is effective for maximum removal of Pb over the pH range 6.5- 9. Studies were carried out up to pH 9. At the pH beyond 9 the tendency of metal ions to precipitate as metal hydroxide was predominant and hence further studies beyond pH 9 were not conducted.

Table 3: Effect of pH on removal of Lead by CCFS

% removal	57	60	62	64	82	88	89
pH	3	4	5	6	7	8	9

Effect of contact time on the removal lead byCCFS:

Equilibrium time is considered as one of the important parameters for economical waste water treatment plant applications. The experimental results for removal of Pb(II) by the CCFSas a function of contact time at initial concentration of Pb^{+2} is 80 mg dm^{-3}. Equilibrium adsorption was established within 30 min for Pb (II). It could be seen that the removal was found to 90 % for Pb(II) at optimum pH conditions. According to these results the agitation time was fixed at 60 minute for rest of batch experiments to make sure that the equilibrium was reached in every experiment.

Table 4: Effect of contact time on the removal of iron by CCFC

Contact time (min)	10	20	30	40	50	60
% removal	50	61	65	78	89	93

Effect of Anions:

The effect of ions like sulphate, nitrate, chloride, perchlorate, etc. on the adsorption of lead is tabulated in Table 5. The inhibition on adsorption by monovalent Cl^- is less than that of divalent SO_4^{-2}. As can be expected, similar conclusion can be drawn for the effect of perchlorate & nitrate anions. The ionic or electrostatic attraction between sorbent and sorbet is the ordinate mechanism, but other mechanism at low and high pH would be responsible for adsorption.

Table 5: Evaluation of the effect of different electrolytes on the uptake of Pb(II) ion at 308 K .

| concentration of Electrolyte mg./dm^3	Amount of Pb(II) adsorbed per g ofCCFS(mg per g)			
	NaClO4	NaCl	NaNO$_3$	Na2SO$_4$
20	3.6	3.4	3.9	2.8
40	6.5	6.6	6.2	4.7
60	10.1	7.5	8.9	6.1
80	12.2	11.0	11.7	9.3

Adsorption Isotherms:

The analysis of the isotherms data is important to develop an equation which accurately represent the results and could be used for designing purpose. The sorption data was analyzed in terms of Langmuir isotherms models. The fitted constants for Langmuir model along with regression coefficient are summarized in table 6. The Langmuir isotherms are shown in Fig. 5. As can be seen from isotherms and regression coefficients, the fit is better with Freundlich model than with Langmuir model. The essential characteristics of the Langmuir isotherms can be expressed in terms of dimensionless constant separation factor or equilibrium parameter R_L which is defined as

$$R_L = \frac{1}{(1 + K_L C_e)}$$

Table No. 6: Langmuir constant for leadadsorbate.

Langmuir	Lead
Qm	16.45
kL	0.55
R2	0.9432

Fig.3: Adsorption isotherm of Lead
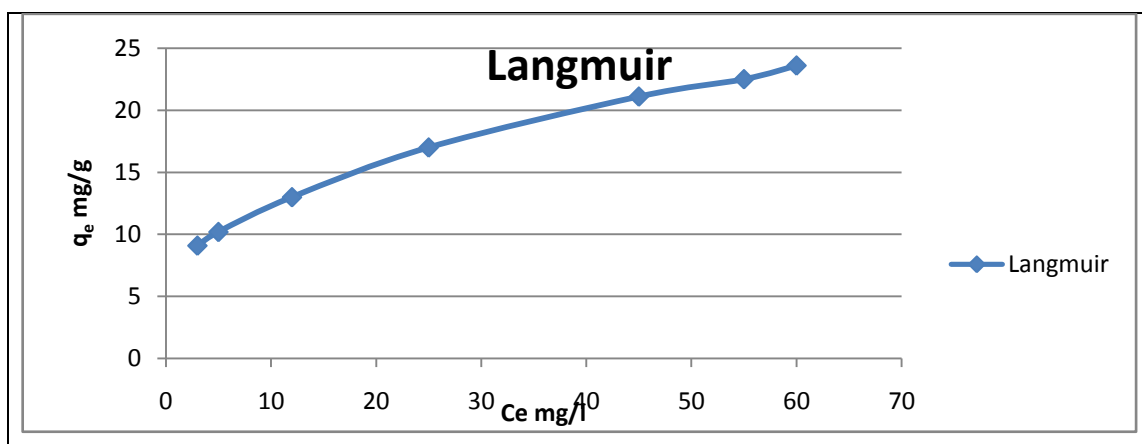
Conclusions

Removal of poisonous lead from aqueous solution is possible using activated carbon obtained from Caster fruit shell (CCFS) which effectively removes more than 90 % of Pb(II) at 308 K. Adsorption of Pb (II) was highly pH-dependent and shown the optimum at pH 9 for the removal of Lead at which Pb(II) exists in the most easily adsorbable form. Increase in the dose of adsorbent, initial concentration of Pb (II) and contact time up to 1h, results in the increased percentage of removal of Pb(II). The adsorption data satisfactorily explained by Langmuir isotherms .Sorption of Pb(II) follows pseudo second order kinetics. The values of R_L factor ranging from 0 to 1 indicate the favourable adsorption situation. Thus the newly generated activated carbon derived from Caster fruit shell has been proved to be an excellent adsorbent which can employed for removal of Pb (II) from polluted water.   Thus it proves the practical applicability of the sorbent under investigation for control of Lead pollution in contaminated water.

References

M. Isik, (2008).Biosorption of Ni(II) from aqueous solutions by living andnon-living ureolytic mixed culture*, Colloids Surf.*, B, 62, 97 – 104.

Z. Salem, and K. Allia, (2008). Cadmium biosorption on vegetal biomass, *Int. J.Chem. Reactor Eng.*, 6, A10.

M. Dundar, C. Nuhoglu, and Y. Nuhoglu, (2008). Biosorption of Cu(II) ions ontothe litter of natural trembling poplar forest, *J. Hazard. Mater.*,151, 86 – 95.

A. Hammaini et al., (2002). Effect of the presence of lead on the biosorptionof copper, cadmium and zinc by activated sludge, *Hydrometallurgy*, 67, 109 – 116.

R. Gupta et al., (2000). Microbial biosorbents: Meeting challenges of heavy metal pollution in aqueous solutions, *Curr. Sci.*, 78, 967 – 973.

B. Benguella, and H. Benaissa, (2002). Cadmium removal from aqueous solutions by chitin: Kinetic and equilibrium studies, *Water Res*. 36, 2463 – 2474.

A. Baran, E. Bicak, S. H. Baysal, and S. Onal, (2007). Comparative studies on the adsorption of Cr(VI) ions on to various sorbents, *Bioresour. Technol.* 98, 661 – 665.

B. Y. M. Bueno, M. L. Torem, F. Molina, and L. M. S. de Mesquita, (2008). Biosorption of lead(II), chromium(III) and copper(II) by R. opacus: *Equilibrium and kinetic studies, Miner. Eng. 21, 65 – 75.*

Banerjee S, et.al. (1976). Activated carbon from coconut shell. *Indian J. Tech.,* 14, 45 – 49.

Ramteke D. S., Moghe C. A. and Thakare R. A. (1983). Activated pyrochar from solid wastes from paper mills.*J. Pule Paper*, 37, 6 – 30.