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Research Article

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Comparison of activated and inactivated coconut husk as an adsorbent for removal of hexavalent chromium from wastewater

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ABSTRACT

The present study has been undertaken to evaluate the potential of utilizing activated and inactivated adsorbent, to remove Cr (VI) from aqueous solutions through adsorption process. The adsorption of hexavalent chromium from aqueous medium by activated and inactivated coconut husk prepared by activation method was studied. The adsorbent which showed highest chromium (VI) removal was inactivated coconut husk. The influence of pH, contact time, adsorbent dosage and initial metal concentration on adsorption was investigated. The adsorptive capacities of the adsorbents were dependent on the pH of the chromium solution, with pH 2 being optimal. The adsorption data fitted well with the Langmuir isotherm model. The adsorption capacities were found to be 0.86mg/g for activated coconut husk and 1.781mg/g for inactivated coconut husk respectively. Hence it is proved that inactivated coconut husk has slightly more adsorption capacity when compared to activated coconut husk.

Keywords: Hexavalent chromium, activated and inactivated coconut husk, adsorption**.**

INTRODUCTION

Chromium, in its hexavalent form, is one of the undesirable heavy metals because it affects human physiology accumulates in the food chain and cause several ailments. Although Cr (III) is an essential element for humans, water soluble Cr (VI) is highly irritating and toxic to humans and animals. The process of adsorption implies the presence of an 'adsorbent' solid that efficiently binds molecules by means of physical attractive forces, ion exchange or chemical binding .Due to the disposal of heavy metals, the pollution of water resources has been an increasing worldwide concern for the last few decades [1]. The quality of water supply is affected due to discharge of toxic metals into water sources is a serious pollution problem. In the industrialized world, the use of chromium in industries like electroplating, textile, leather tanning, metallurgical metal finishing, photography, dye manufacturing, ink and pigments, power generation, and chemical manufacturing etc., is extensive and hence it is not uncommon for the aqueous effluents from such industrial plants to have high amounts of chromium[2,3].Advance technologies such as ion exchange, chemical precipitation, ultra filtration, or electrochemical deposition have been used for removal of heavy metals in wastewater which do not seem to be economically feasible for such industries because of their relatively high costs[4]. Therefore, there is a need to look into alternatives to investigate a low-cost method, which is effective and economic, and can be used by such industries. Many methods have been used namely, membrane filtration, coagulation, adsorption, oxidation, ion exchange, precipitation, etc. have been reported in the literature, but few of them were accepted due to cost, low efficiency, and inapplicability to a wide variety of pollutants. Hence there exists a scope to try locally available, low cost adsorbents for treatment of effluents containing Cr (VI).Adsorbents from local origin: coconut husk was selected as adsorbent[5,6]. The feasibility of these adsorbents for the removal of Cr (VI) was investigated. Effects of contact time, initial Cr (VI) concentration, pH and adsorbent dosage on Cr (VI) removal efficiency are reported. The behavior of adsorbents is also investigated by studying the adsorption kinetics and isotherms [7, 8].

EXPERIMENTAL SECTION

2.1. Preparation of activated coconut husk

Coconut husk was prepared by treating of coconut husk concentrated sulphuric acid and keeping it in an oven at 150 C for 24 h. The carbonized material was washed with distilled water to remove free acid and dried in oven [9, 10].

2.2. Preparation of inactivated coconut husk

Here coconut husk was washed only with distilled water. No chemicals have been used here.

2.3. Preparation of adsorbate solution

Primary chemicals such as potassium dichromate, sodium hydroxide, hydrochloric acid etc. used for the present study were of analytical grade. The stock solution of 1000 ppm Cr (VI) was prepared by dissolving 1.4143 g quantity of potassium dichromate (K2Cr2O7) in 500 mL of de-ionized, distilled water. Working solutions of Cr (VI) standards were prepared by diluting the appropriate quantity of the above stock solution [12].

2.4. Method

A series of batch experiments were conducted to determine the equilibrium conditions (agitation time, initial Cr (VI) concentration, initial pH, and adsorbent dosage) for removal of Cr (VI) using activated and inactivated coconut husk as an adsorbent. All experiments were carried out at room temperature i.e. 28 ± 2°C. The batch adsorption experiments were conducted using, a 100 mL test solution of known initial drawn at regular intervals of time, filtered with Whatman No. 42 filter paper and concentration of Cr (VI) in the filtrate was analyzed by spectro-photometric analysis method using UV-Vis Spectrophotometer (Elico- BL 198) using di-phenyl carbazide method.Cr (VI) concentration in a 250 mL conical flask with stopper. Solution pH was adjusted using either 0.1 M NaOH or 0.1 M HCl and a measured quantity of adsorbent was added. The contents in the flasks were immediately shaken using rotary shaker at 200 rpm. The flasks were kept sealed throughout the duration of the experimentation. Samples were drawn at regular intervals of time, filtered with Whatman No. 42 filter paper and concentration of Cr (VI) in the filtrate was analyzed by spectro-photometric analysis method using UV-Vis Spectrophotometer (Elico- BL 198) using di-phenyl carbazide method [13].

RESULTS AND DISCUSSION

3.1. Effect of agitation time by activated and inactivated coconut husk

Activated coconut husk gave the highest percentage removal of Cr (VI) of 99.7% for 180mins where as inactivated coconut husk gave highest percentage removal of Cr (VI) of 88% for 30mins. This observation clearly indicates that activated coconut husk is efficient when compared to inactivated coconut husk. This is due to the fact that activated coconut husk possess more active sites because of process of activation.

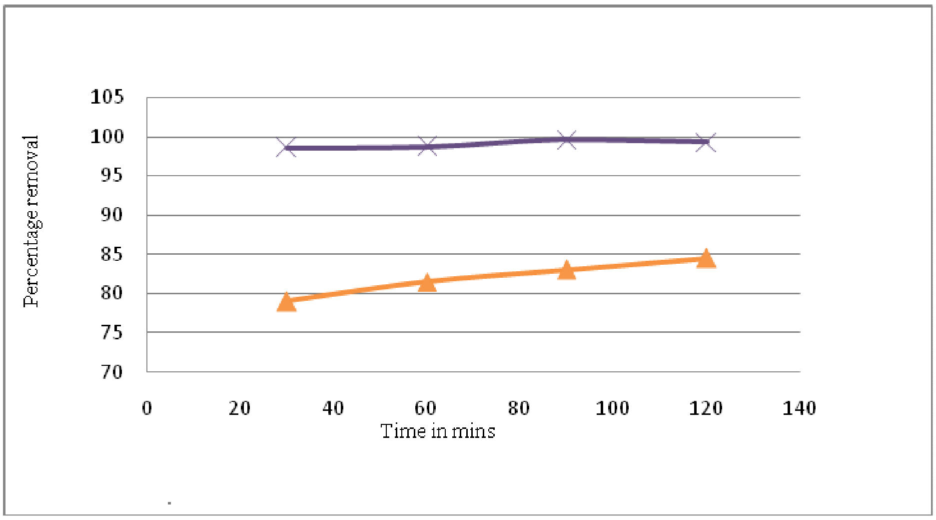

Fig.1 Effect of agitation time by activated and inactivated coconut husk

3.2. Effect of initial metal ion concentration by activated and inactivated coconut husk

Activated coconut husk gave the highest percentage removal of Cr (VI) of 99.5% at 30ppm where as inactivated coconut husk gave highest percentage removal of Cr (VI) of 87.75% at 40ppm. An increase in initial concentration of metal ions resulted in the lowering of metal ion uptake due to reduction in ratio of sorptive surface to ion concentration in case of inactivated coconut husk.

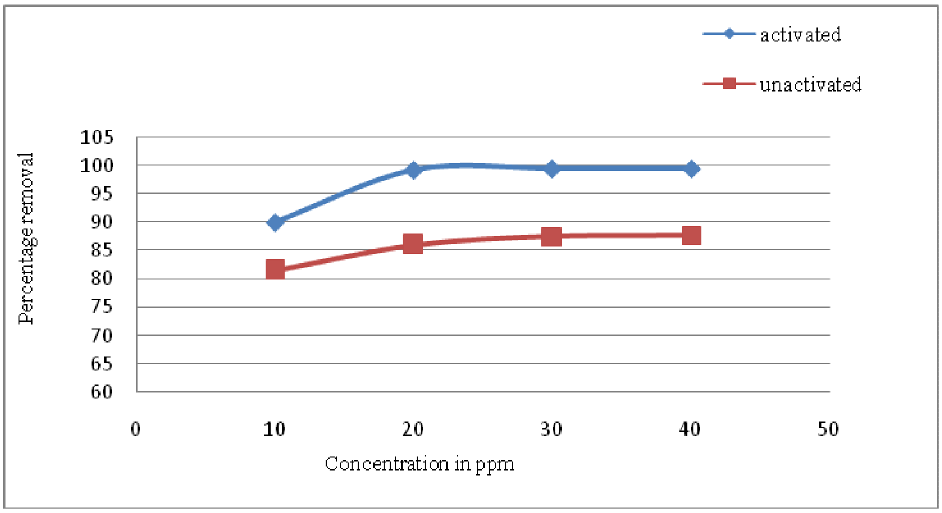

Fig.2 Effect of initial metal ion concentration by activated and inactivated coconut husk

3.3. Effect of pH by activated and inactivated coconut husk

Activated coconut husk gave the highest percentage removal of Cr (VI) of 99.3% at pH 4 where as inactivated coconut husk gave highest percentage removal of Cr (VI) of 92.6% at pH 2. The reduction in adsorption at higher pH may be possible due to the abundance of OH^- ions causing increased hindrance to the diffusion of metal ions in case of inactivated coconut husk

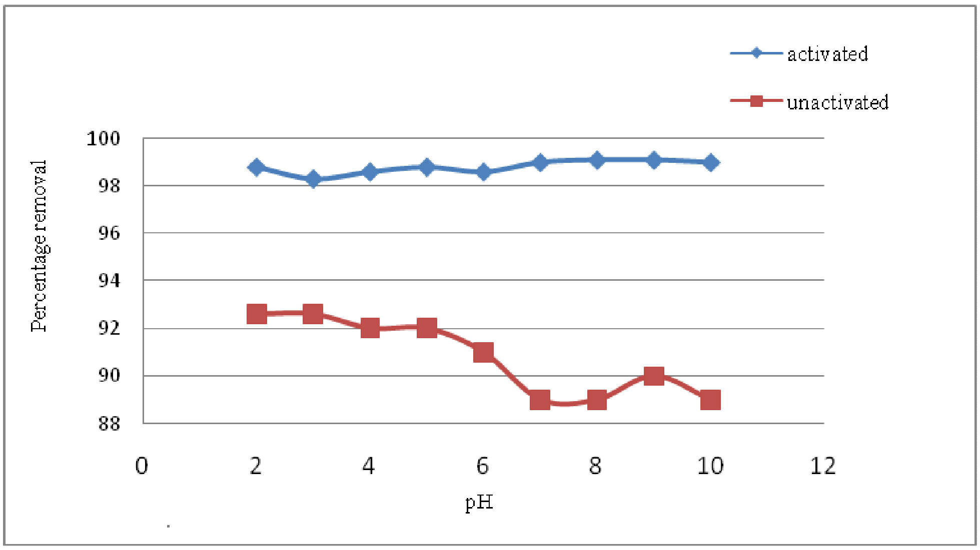

Fig.3 Effect of ph by activated and inactivated coconut husk

3.4. Effect of adsorbent dosage by activated and inactivated coconut husk

Activated coconut husk gave the highest percentage removal of Cr (VI) of 93.3% for 1250mg where as inactivated coconut husk gave highest percentage removal of Cr (VI) of 80.6% for 1250mg.In case of inactivated coconut husk the high concentration of biosorbent resulted in screen effect of dense outer layer of cells and blocking the binding site from metal ions, resulting in lower metal removal per unit biosorbent

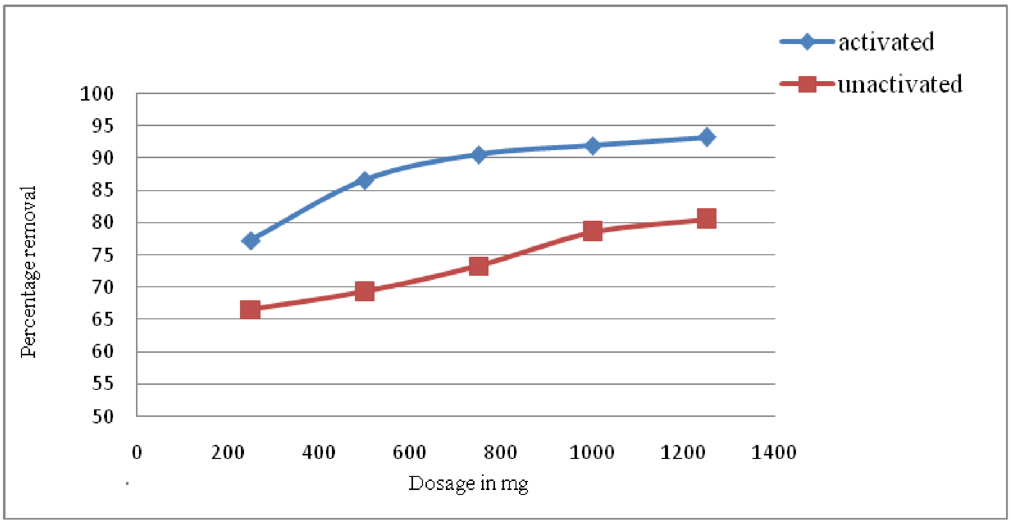

Fig.4 Effect of adsorbent dosage by activated and inactivated coconut husk

ISOTHERMS

Equilibrium occurring during adsorption at a definite concentration range could be represented by Langmuir and freundlich isotherms, the adsorption data obtained for chromium (VI) adsorption onto the biowaste materials used as adsorbents in the present investigation were modeled. The values of the Langmuir constants (q_m b) and Freundlich constants (K, n) are presented for the adsorption of Chromium (VI) by activated and inactivated coconut husk (Table-1).

		Langmuir parameters			Freundlich parameters		
S No.	Adsorbent	q_{max} (mg/g)	**B** (L/mg)	R^2	N	K_f	R^2
1.	Activated coconut husk	0.86	2.32	0.987	4.03	0.40	0.936
2.	Inactivated coconut husk	1.781	4.39	0.991	1.631	0.173	0.952

4.1Langmiur isotherm for activated and inactivated coconut husk

The favorable adsorption process for Cr(VI) removal using activated and inactivated adsorbents, with value of q_{max}=0.86mg/g , b=2.32 l/mg, R^2=0.9937 for activated coconut husk and with value of q_{max}=1.781mg/g , b=4.39 l/mg, R^2=0.991 is represented in fig 5 and fig 6. The plots of Ce/Qe vs Ce are linear which shows that the adsorption of Cr (VI) follows Langmuir isotherm model. The Langmuir correlation coefficient(R) was found to be 0.987, with activated coconut husk and 0.991, with inactivated coconut husk. Hence inactivated coconut husk had the maximum metal uptake capacity of 1.781 mg/g when compared to activated coconut husks.

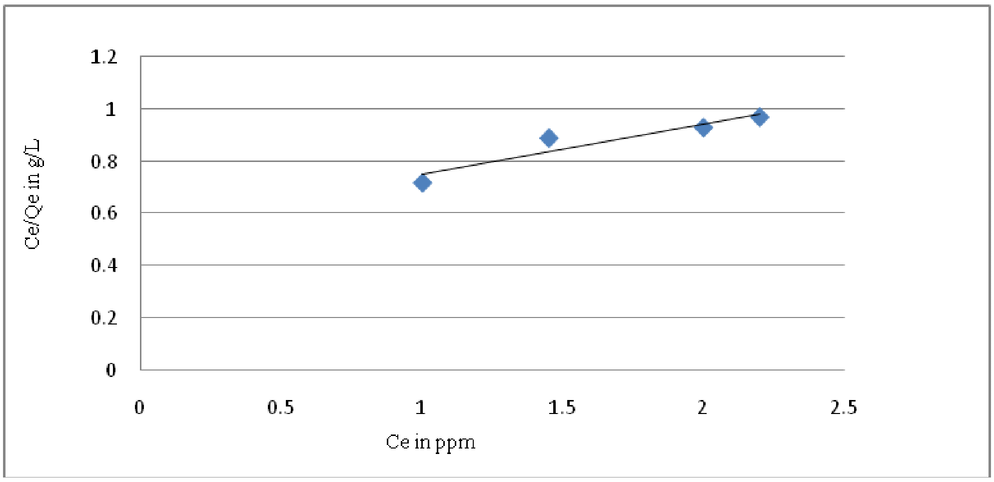

Fig.5 Langmiur isotherm for activated coconut husk

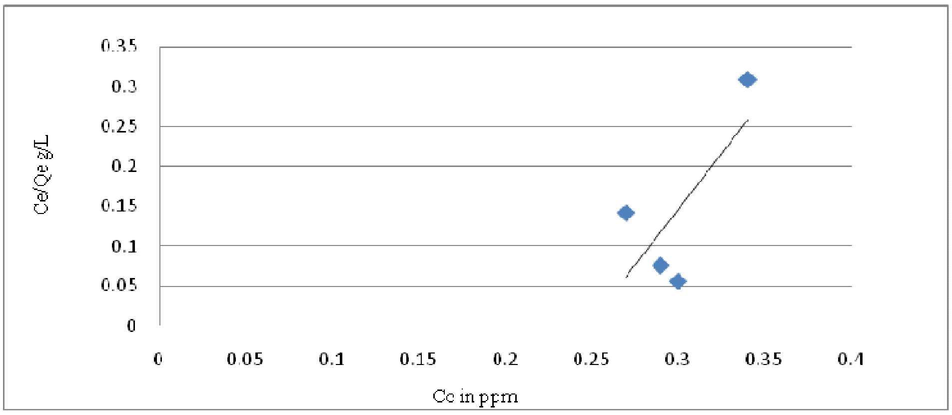

Fig.6 Langmiur isotherm for inactivated coconut husk

4.2 Freundlich isotherm for activated and inactivated coconut husk

The applicability of the Freundlich isotherm is analyzed based on adsorption on heterogeneous surface using the same equilibrium data of Cr(VI) adsorption on adsorbents .Freundlich constants obtained are kf=0.40mg/g, n=4.03, R^2=0.936 is represented in fig 7 for activated adsorbent and kf=0.173mg/g, n=1.631, R^2=0. 952 for inactivated adsorbent represented in fig 8.The obtained result indicate that the equilibrium data is not fitted well with the Freundlich isotherm model.

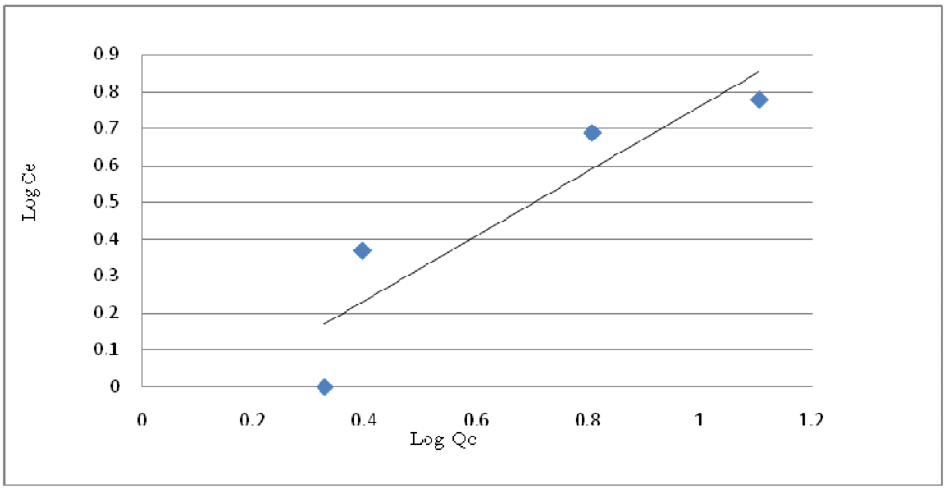

Fig.7 Freundlich isotherm for activated coconut husk

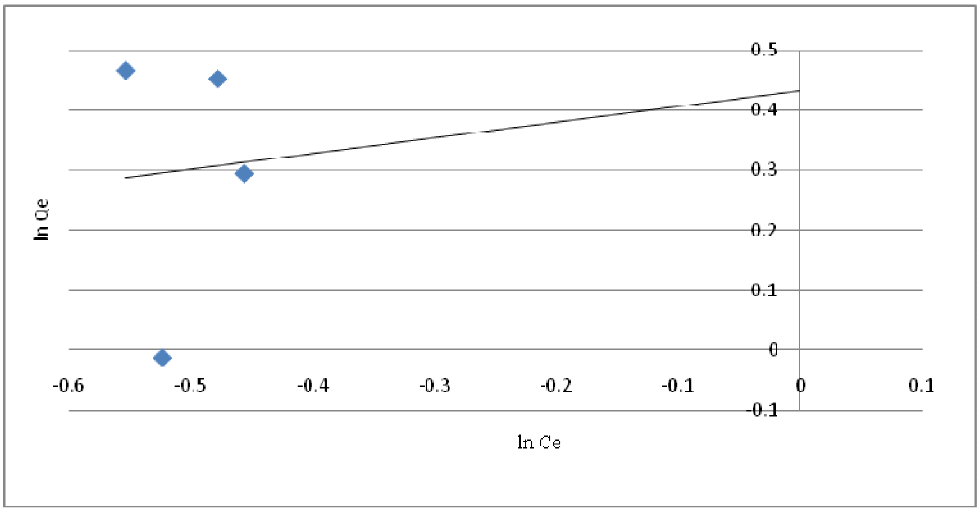

Fig.8 Freundlich isotherm for inactivated coconut husk

CONCLUSION

The aim of this work was to find out the adsorption characteristics of biowaste materials for the removal of Cr (VI) ions. The maximum adsorption capacity was obtained at pH 2.0. The Freundlich and Langmuir biosorption models were used for the mathematical description of the adsorption equilibrium of Cr (VI) ions to adsorbents. The adsorption equilibrium data fitted well to the Langmuir isotherm. The sorption capacities were 0.86,1.781mg/g for activated and inactivated coconut husk. Inactivated coconut husk presented the highest adsorption capacities for the Cr (VI) ion. Inactivated coconut husk is easily available material which can be used without activation with chemicals and can, therefore, be used in batched reactors by small scale industries having Cr (VI) in wastewater.

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