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LOW COST ADSORBENT FOR REDUCING ORGANIC COMPONENTS

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ABSTRACT

The use of low cost activated carbon derived from coconut shell (Cocus Nuciferia), an agricultural waste, has been investigated as a replacement for the current expensive methods of reduction of COD from distillery spent wash. The present study was undertaken to compare the adsorption efficiency of activated carbon prepared from coconut shell (CSC), which is waste and commercial activated carbon (CAC) with respect to uptake of the organic components responsible for the chemical oxygen demand (COD) of industrial wastewater. The adsorption process was examined in terms of its equilibria and kinetics. The effects of pH, contact time and adsorbent dose were investigated. The most effective pH was found to be 5 for CSC and 6 for CAC. The equilibrium data for COD removal fitted the Linear, Langmuir and Freundlich models.

INTRODUCTION

Wastewater discharged by industrial activities is often contaminated by a variety of toxic or otherwise harmful substances which have negative effects on the water environment. Pollution of water by organic and inorganic chemicals is of serious environmental concern. One of the accepted methodologies for waste reduction is to find some use for the waste products so that these may become resource materials for some useful products (Patil, 2007)

The distillery waste water, also called spent wash, is dark brown in color. It carries high organic load and causes severe fouling of the atmosphere in several regions of the country. Waste water discharged by distillery from sugarcane molasses poses problems of discharge to acceptable standards due to their high BOD, COD and color. Lowering of pH value of the stream, increase in organic load, depletion of oxygen content, adverse effects on ground water and land quality, destruction of aquatic life and bad smell are some of the major pollution problems due to distillery wastewater.

In recent years, increasing awareness of the environmental impact of COD has prompted a demand for the purification of industrial wastewaters prior to discharge into natural waters. This has led to the introduction of more strict legislation to control water pollution. A number of conventional treatment technologies have been considered for treatment of wastewater contaminated with organic substances. Among them, adsorption process is found to be the

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most effective method. Adsorption process is gaining interest as one of the effective processes of advanced wastewater treatment for treatment of industrial effluent (Mukherjee *et al*., 2007). If the adsorption system is designed correctly it will produce a high-quality treated effluent. Most commercial systems currently use activated carbon as sorbent to remove dyes in wastewater because of its excellent adsorption ability (Liew *et al*., 2005). Commercial activated carbon is regarded as the most effective material for controlling the organic load. However, due to its high cost and about 10 - 15% loss during regeneration, unconventional adsorbents like fly ash, peat, lignite, bagasse pith, wood, saw dust, periwinkle shells, etc. have attracted the attention of several investigations and adsorption characteristics have been widely investigated for the removal of refractory materials. (Pandey *et al*., 1985; Badmus *et al*., 2007) This study was aimed at analyzing the adsorption capacity of activated carbon prepared from coconut shell on industrial wastewater effluent using a distillery spent wash as a case study, and also to demonstrate the use of activated carbon prepared from coconut shell as an alternative media over conventional activated carbon. This paper deals with the results of the batch adsorption tests to establish adsorption isotherms and adsorption capacity of the activated carbon prepared from coconut shell (CSC) for the removal of COD in wastewater.

MATERIALS AND METHODS

Adsorbent

The low cost adsorbent of coconut shell activated carbon was prepared. The coconut shells derived from various waste sources were cleanly shaved to remove all the fibers on its surface. They were cut into small pieces, washed with distilled water to remove the dirt. The samples were pyrolyzed at 400°C for 3hrs. It results in black carbonized matter. It is again washed with distilled water and dried at 100°C and sieved to the required size.

Spent wash

Distillery waste water, also called spent wash, dark brown in color carrying high organic load was used for studying the efficiency COD removal by using coconut shell powder and commercially available activated carbon. The COD and BOD were 42320 mg/L and 24000 mg/L. pH was neutral, TDS was also high. It also had oil and grease, chlorides, iron and total nitrogen.

Experimentation

The distillery spent wash was collected from a sugar industry. At the collection point, containers were rinsed with samples thrice and then filled with sample, corked tightly and taken to the laboratory for treatment and analysis. The method of analysis was consistent with the standard methods (APHA, 1985). The pH of the sample was measured on the site and other parameters were measured in the laboratory. Samples were stored at a temperature below 4°C to avoid any change in physic-chemical characteristics. The COD of the samples were estimated before and after adsorption giving different treatment. All the experiments were carried out at ambient temperature in batch mode. Batch mode was selected because of its relative simplicity. The batch experiments were run in different glass flask of 250 mL capacity using average speed shaker. Prior to each experiment, a predetermined amount of adsorbent was added to each flask. The stirring was kept constant for each run throughout the experiment ensuring equal mixing. The desired pH was maintained using dilute NaOH/HCl solutions. Each flask was filled with a known volume of sample having desired pH commenced the stirring. The flask containing the sample was withdrawn from the shaker at the predetermined time interval, filtered through whatmann No. 44 filter paper. The experiments were carried out under different experimental conditions.

RESULTS AND DISCUSSION

Effect of adsorbent dosage

The effect of adsorbent on COD removal in Fig. 1 shows that optimum dosage of adsorbents for COD was 8 g/L and 12 g/L of wastewater for activated carbon prepared from coconut shell (CSC) and commercial activated carbon (CAC), respectively. About 91.5 and 94.45% removal were achieved for CSC and CAC, respectively. The rate of adsorption increased with increase in dosage because of increase in surface area of adsorbent.

Effect of pH

Figure 2 depicts the effect of pH on percent removal of COD. For CSC, at pH 4, the COD removal was 91%, which then decreased as the pH was increased. The same trend was observed for CAC. About 96% COD removal was achieved for CAC at pH 4. The reason for the better adsorption capacity observed at pH 4 may be attributed to the larger number of H+ ions present, which in turn neutralize the negatively charged adsorbent surface, thereby reducing hindrance to the diffusion of organics at higher pH. At higher pH, the capacity of the adsorbent recessed. The reduction in adsorption may be possible due to the abundance of OH-ions, causing increased hindrance to diffusion of organics contributing to COD. Similar observations have also been reported by the works (Mohan *et al.,* 1997)

Effect of Contact time

The mixing time had greater impact on COD removal, as shown in Figure 3. At an optimum time of 40 min, about 96% COD removal was achieved for CSC, while about 97% COD removal was achieved for CAC at 40 min. The smooth and independent nature of curve indicated formation of monolayer cover of the adsorbate on the outer surface of the adsorbents. Generally, the rate of adsorption increases with time and remains constant after some time due to equilibrium conditions.

Isotherm studies

Two important physiochemical aspects for the evaluation of the adsorption process as a unit operation are equilibria of the adsorption and the kinetics. Equilibrium studies give the capacity of the adsorbent. The equilibrium relationships between adsorbent and adsorbate are described by adsorption isotherms, usually the ratio between the quantity adsorbed and that remaining in solution at a fixed temperature at equilibrium.

The effect of initial COD concentration on the adsorption capacity is as shown in Figure 4 and 5. The results obtained were analysed using both Freundlich (Freundlich 1906) and Langmuir (Langmuir 1916) isotherms. The Freundlich isotherm in linearised form is,

$$\log \Gamma = \left(\frac{1}{n}\right) \log C_e + \log K$$

where n and K are Freundlich constants:
The linearised form of the Langmuir

$$\frac{1}{\Gamma} = \left(\frac{1}{b_m}\right)\frac{1}{C_e} + \frac{1}{\Gamma_m}$$

isotherm where b is a coefficient related to the affinity m between the sorbent and sorbate, and Γm is the maximum sorbate uptake under the given condition. The data fitted well into both isotherms. The isothermal adsorption parameters for these isotherms are shown in Table 1. These Freundlich and Langmuir isothermal parameters compare well with those of other adsorbents that have been reported. The Freundlich and Langmuir equations obtained are as shown in Figure 4 and 5 and values are tabulated below in Table1. The values of the parameters show that CSC and CAC are good adsorbent for the uptake of COD from wastewaters.

CONCLUSION

The Cocus Nucifera shell carbon showed good adsorption capacity for COD reduction from distillery spent. Among two activated carbons, coal based commercial activated carbon was better than activated carbon synthesized from coconut shell. However, inexpensive activated carbon also showed good results but heavier doses were required for similar adsorption. Thus, agro waste from coconut shell carbon has a good potential for the treatment of distillery waste water. It is physically and economically viable approach. The results obtained showed that CSC can be used in the removal of COD from industrial wastewaters. Trend of COD removal by CSC 95.67%, was comparable to that of CAC with 96.34% efficiency. These results showed that granular activated carbons made from agricultural waste could

Table 2. Adsorption isotherm constants and coefficient of determination for different adsorbents.

Adsorbent	Langmuir Adsorption Constant			Freundlich adsorption constant		
	b_m	G_m	R_2	K	n	R_2
CSC	17.85	0.372	0.991	90.36	1.53	0.948
CAC	12.19	0.300	0.984	80.3	1.8	0.990

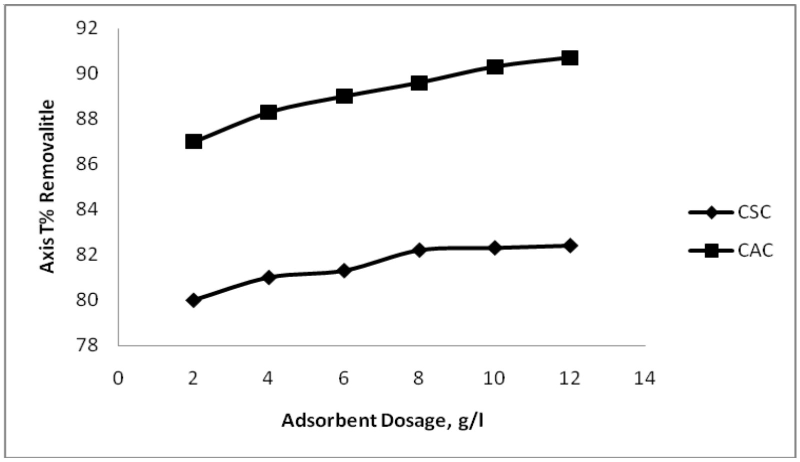

Fig. 1 Effect of adsorbent dose on COD removal activated carbon prepared from coconut shell. ◆ (CSC) and commercial activated carbon ■ (CAC).

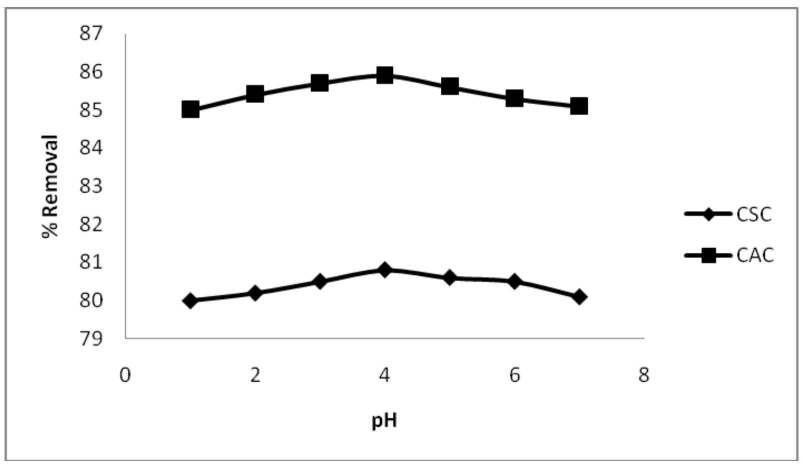

Fig. 2 Effect of pH on COD removal activated carbon prepared from coconut shell. ◆ (CSC) and commercial activated carbon ■ (CAC).

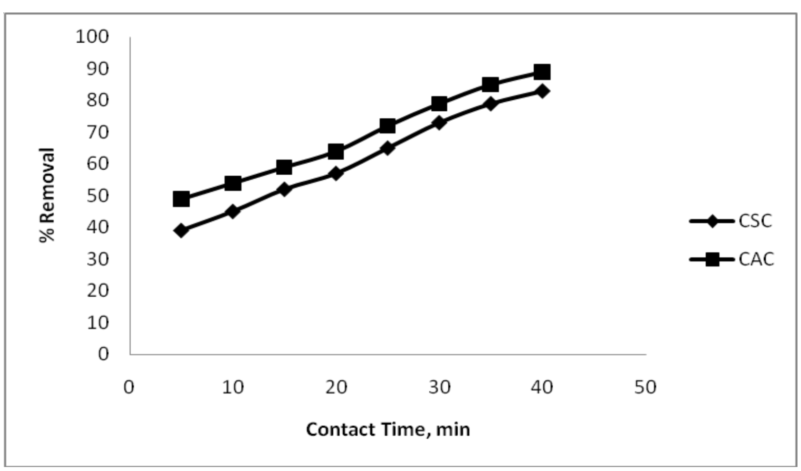

Fig. 3 Effect of contact on COD removal activated carbon prepared from coconut shell. ◆ (CSC) and commercial activated carbon ■ (CAC).

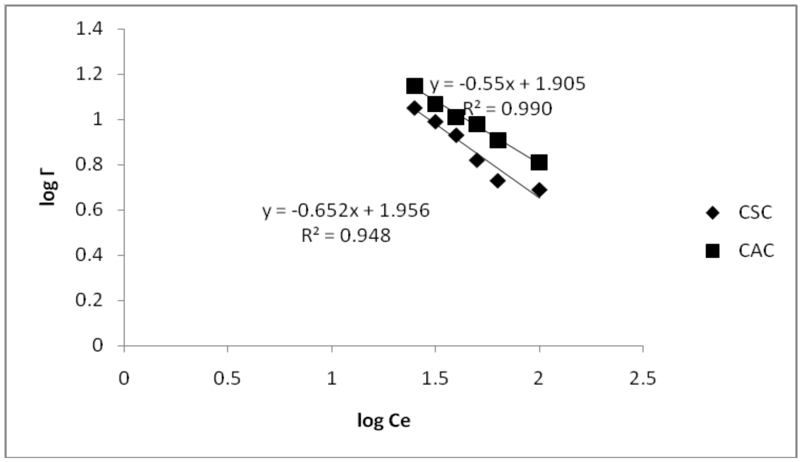

Fig. 4 Comparison of Freundlich isotherms of activated carbon prepared from coconut shell ◆ (CSC) and commercial activated carbon ■ (CAC).

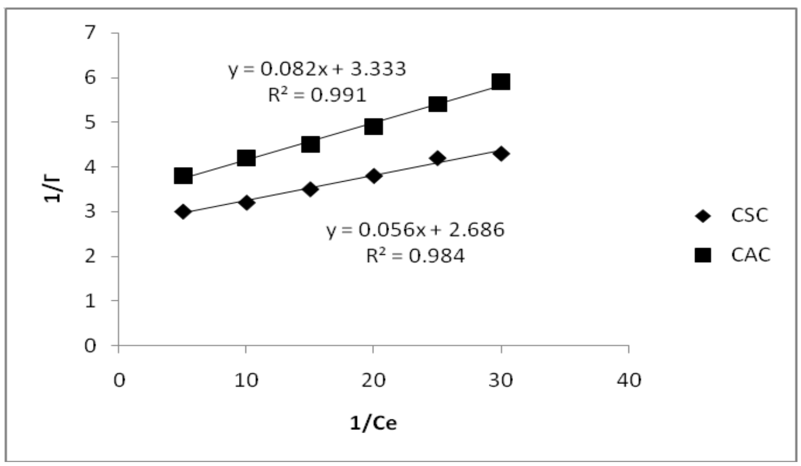

Fig. 5 Comparison of Langmuir isotherms of activated carbon prepared from coconut shell. ◆ (CSC) and commercial activated carbon ■ (CAC).

be used with greater effectiveness for organic matter removal from industrial wastewater. This would be of benefit not only to the manufacturing industry in terms of minimising cost of COD treatment, but also to minimize the impact on the environment. Furthermore, the equilibrium data of adsorption are in good agreement with the models of Freundlich and Langmuir.

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