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Original Research Paper

Study on Removal of Chromium (VI) From Aqueous Solution Using Sulphonated Black Rice Husk Ash and Sulphonated White Rice Husk Ash

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Adsorption
Rice husk ash
DPC method

ABSTRACT

The removal of Cr(VI) from aqueous solution using sulphonated black rice husk ash (SBRHA) and sulphonated white rice husk ash (SWRHA) at various pH and adsorbent doses has been studied. The uptake percentage of Cr(VI) from the solution was determined spectrophotometrically by DPC method. It was found that the amount of Cr(VI) adsorbed increases significantly with decrease in pH from 5.0 to 1.0 for SWRHA and 5.0 to 2.0 for SBRHA. The Cr(VI) adsorption increased significantly with increasing dose of the adsorbent.

INTRODUCTION

Industrial wastewaters are important sources of pollution of heavy metals, which carry severe environmental and public health problems. With advancement in industrial activities, usage of chromium has increased significantly. Frequently toxic pollutants such as Cr, Ni, Cd, etc. are introduced as wastes from various processes. Among these hexavalent chromium is highly toxic and found to be carcinogenic (Gupta et al. 2000).

There are two natural forms of ionic chromium, the trivalent ion Cr(III) and the hexavalent ion Cr(VI). The trivalent chromium is relatively nontoxic and is an essential nutrient in the human diet to maintain effective glucose, lipid and protein metabolism (Ketz & Salem 1994). However, Cr(VI) is toxic to humans and causes damage to the skin and upper respiratory system and causes lung cancer (IARC 1990). There are many industries which use chromic acid and other forms of Cr(VI), and are possible sources of Cr(VI) pollution in water.

A number of treatment methods for the removal of metal ions from aqueous solutions are in use, viz., reduction, ion exchange, electrodialysis, electrochemical, precipitation, evaporation, reverse osmosis, etc. (Feng et al. 2004). Most of these methods, however, suffer from some drawbacks such as capital and operational costs. The low cost activated carbon from sheep hair, wool, tamarind nut, etc. have been already reported (Rengaraj et al. 2000, Kadirvelu et al. 2001). In the present work sulphonated black rice husk ash (SBRHA) and sulphonated white rice husk ash (SWRHA) have been used as adsorbents to remove Cr(VI).

MATERIALS AND METHODS

Preparation of the absorbent: The rice husk ash was collected from VMD Rice Mill, Vellore. Sulphonation was carried out by treating the powdered carbon with 0.75N sulphuric acid overnight, and then washing it repeatedly till there was no traces of acid. This was then air dried. This carbon was termed as sulphonated carbon.

Batch adsorption study: The batch adsorption studies were performed in an orbiteck electrical shaker using 250 mL stoppered conical flask containing 100 mL of stock solution (0.01 mg/L) with 2.0 g of adsorbent at a shaking speed of 300 rpm at 28°C. After equilibrium period the contents were filtered using Whatmann No. 4 filter paper and the amount of Cr(VI) in the filtrate was determined spectrophotometrically (Perkin Elmer Model 550) by DPC method (APHA 1998).

RESULTS AND DISCUSSION

Equilibrium time: The equilibrium time for SBRHA and SWRBA was computed by the equation:

$$q_e = \frac{(C_o - C_e)\,V}{M_s}$$

Where q_e – Equilibrium time
C_o – Initial concentration of chromium
C_e – Equilibrium concentration of chromium
V – Volume of Cr(VI) solution taken
M_s – Weight of adsorbent in g

The equilibrium time for both SBRHA and SWRHA was 4 hours (Table 1 and Fig. 1).

Effect of pH on Cr(VI) uptake: The effect of pH on the removal of Cr(VI) from the solution is shown in Table 2 and Fig. 2. The pH of the test solution was adjusted from 5.0 to 1.0 using 0.1 N HCl or 0.1 N NaOH, taking the equilibrium time and adsorbent dosage constant. Maximum adsorption was observed at pH 1.0 for SWRHA and pH 2.0 for SBRHA.

The effect of pH on heavy metal adsorption from aqueous solutions has been reported (Okiemen et al. 1991, Namasivayam & Senthilkumar 1998). It was found that the removal of heavy metal ions

Table 1: Evaluation of equilibrium time for the removal of chromium (VI) using SWRHA and SBRHA.

Time (Hours)	% of Cr(VI) removed	
	SWRHA	SBRHA
1	10	15
2	20	25
3	35	36
4	40	45
5	40	45
6	40	45
7	40	45

Table 2: Effect of pH on the removal of chromium (VI) using SWRHA and SBRHA.

pH	% of Cr(VI) removed	
	SWRHA	SBRHA
1.0	40	39
2.0	36	45
3.0	29	31
4.0	19	21
5.0	4	6

was pH dependent. Each result presents a characteristic variation of pH with amount adsorbed depending on the adsorbent type, metal ion and/or initial concentration of metal ions.

Effect of adsorbent dosage on Cr(VI) uptake: The effect of adsorbent dosage was performed by using different amounts of adsorbents with the constant pH at which maximum adsorption of the metal ion was observed. As the adsorbents dosage were increased there was regular increase in the rate of removal of Cr(VI) (Table 3 and Fig. 3).

The study investigated the sorption of Cr(VI) from aqueous solution using indigenously prepared and chemically modified adsorbents (SBRHA and SWRHA). The adsorption was found to be strongly dependent on pH, adsorbent dose and contact time. Adsorption capacity of the activated carbon can be further increased by chemical modification. Surfactant modified adsorbents can be more efficient for the removal of toxic metals and hazardous materials from industrial effluents.

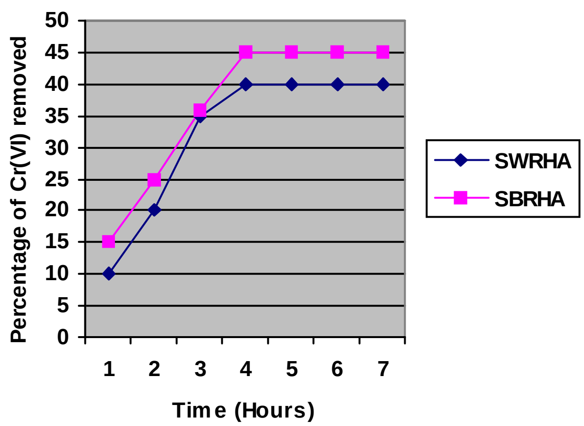

Fig.1: Evaluation of equilibrium time for the removal of chromium (VI) using SWRHA and SBRHA.

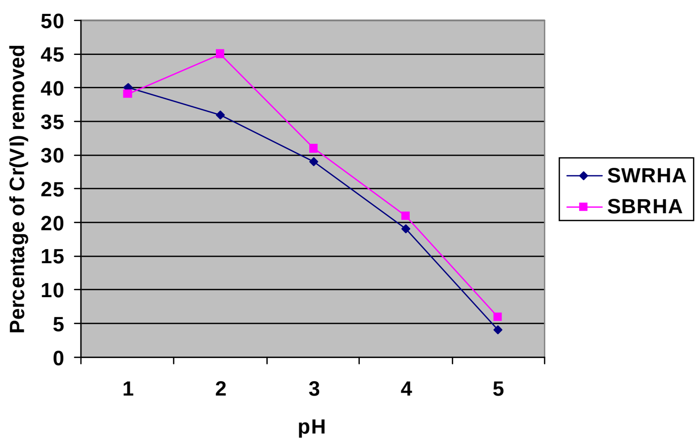

Fig 2: Effect of pH on the removal of chromium (VI) using SWRHA and SBRHA.

Table 3: Effect of adsorbent dosage on the removal of chromium (VI) using SWRHA and SBRHA.

Adsorbent dosage (g)	% of Cr(VI) removed SWRHA	SBRHA
2	20	18
4	24	27
6	30	34
8	35	40
10	40	45

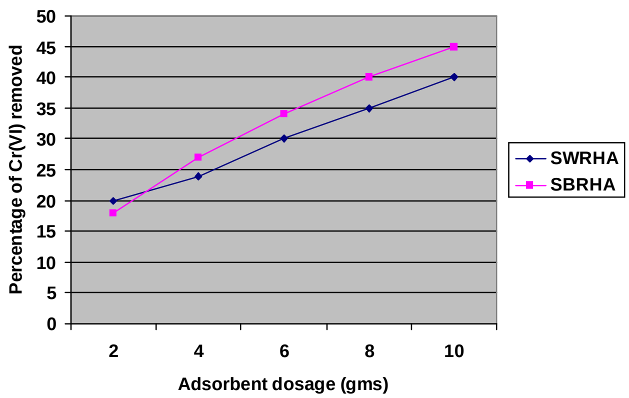

Fig. 3: Effect of adsorbent dosage on the removal of chromium (VI) using SWRHA and SBRHA.

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