COMPARATIVE STUDY OF REMOVAL OF CR(VI) WITH PAC, GAC AND ADSORBENT PREPARED FROM TOBACCO STEMS

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ABSTRACT

There are numerous sources of industrial effluents leading to chromium enrichment of the aquatic environment. It is reported that industries, like electroplating and other metal finishing and inks, paints, pigments, leather tanning, textile etc., are the major contributors of chromium to wastewater. Various methods are available for removal of hexavalent chromium from the effluents. Most of these methods need high capital cost and recurring expenses. Adsorption is suitable method for the treatment of chromium bearing wastewatyer. An attempt has been made to work out for a natural and cheaper alternative based on surface adsorption for treatment of industrial effluent containing Cr (VI). The extent of removal was found to be dependent on adsorbent dosage, contact time and initial concentration of the solution.

INTRODUCTION

Water pollution due to release of industrial wastewater has already become a serious problem. Usually no consideration is taken with regard to the deleterious environmental impact upon the receiving water body. There are numerous sources of industrial effluent leading to chromium enrichment of the aquatic environment. The predominant forms of chromium namely Cr(III) and Cr (VI) are found in many industrial wastewaters such as textile, leather tanning, electroplating, finishing industries. The toxicity of chromium varies greatly according to its oxidation state, for example Cr(VI) is more toxic than

Cr(III) and it is more hazardous to biological activities. A number of health hazards due to chromium pollution have been reported in the literature. Cr(VI) causes skin irritation, resulting in ulcer formation, chromatitis, over exposure to Cr(VI) leads to liver damage, pulmonary congestion and edema. It also causes perforations in nasal septum and malignant growth in respiratory tract. The maximum tolerance limit for total chromium has been fixed at 0.05 mg/L and 0.1 mg/L in the drinking and inland surface water respectively.

There are several methods available for the treatment of the chromium bearing effluents, such as reduction-precipitation, electrochemical reduction, ion exchange, reverse osmosis and direct precipitation. Main drawbacks of these methods include high capital and operating costs in the form of cost of chemicals and other expensive reagents. Due to these reasons, they are very uneconomical for small scale industries. Amongst the physico-chemical treatment methods available, adsorption of heavy metals onto activated carbon is an important and highly effective method. It is established that adsorption method is a suitable and viable mode to remove chromium from the industrial effluent.
A number of adsorbents like activated carbon, silica gel, chitin and such other substances have been used. Among all these adsorbents, the activated carbon is more effective and it is used extensively. But it is expensive and necessitates regeneration. Therefore, efforts are being directed towards the use of low cost natural resources as the adsorbents for removal of chromium.

The use of low cost adsorbents based on agricultural waste for the removal of chromium is constantly encouraging the researchers in preference to the other conventional methods. The application of rice husk carbon (Srinivasan et. al., 1988). Activated carbon prepared from ground nut husk carbon (Periasamy et. al., 1991), Waste tea leaves carbon (D.K. Singh and J. Lala, 1992), coconut fiber pith based pseudo activated carbon (D.K. Singh and J. Lal, 1992), coconut fiber pith based pseudo activated carbon (G.N. Manju et. al., 1997) and activated carbon prepared from rice straw (A.K. Samanta et. al., 2000) as the adsorbent for removal of chromium (VI) from the wastewater have been reported.

In the present studies, an attempt has been made to prepare adsorbent from agricultural waste, such as tobacco stems, and use them for the removal of chromium (VI) from the wastewater. Also, the results are compared with commercially available PAC and GAC for removal of chromium. The effect of different process variables, such as concentration of the chromium solution, adsorbent dosage, and contact time of the solution on the adsorption process have also been studied.

MATERIALS AND METHODS

In order to assess the performance of each adsorbent and to avoid interference by other elements in the wastewater, the experiments were conducted with aqueous solution of chromium in distilled water. Solutions of hexavalent chromium were prepared by dissolving potassium dichromate in distilled

water. The concentration of Cr(VI) in the aqueous solution was analyzed by colourimeter using 1,5- diphenyl carbahydrazide as a reagent.

TABLE - 1
Characteristics of the Adsorbents

Adsorbents	PAC	TSAC
Bulk density, g/ml	0.7	0.55
Matter soluble in water, (%)	1.5	2.55
Matter soluble in acid (%)	2.5	3.15
Moisture content (%)	5.6	9.2
Ash content (%)	6.8	10.65

Preparation of Adsorbents

Tobacco stems were collected from a nearby village and allowed for sun drying for about 12-15 days. Firstly, it was washed with distilled water to remove the soluble impurities and surface adhered particles and then dried a 110^0C in oven to get rid of the moisture and other volatile impurities. Thereafter an impregnation was done with the solution of $ZnCl_2$ in a mixing cylinder for about 12 hours and then kept in a muffle furnace for activation. The sample was washed with concentrated HCL to remove practically all the traces of $ZnCl_2$ followed by washing with distilled water until the pH of the filtrate liquor is neutral. The washed product was dried in the hot air oven at 100 ± 5^0C for 2 hours. The product was cooled upto room temperature by putting into desiccators and finally ground to pass through a standard sieve of 20-20 mesh ASTM. The physiochemical properties of the adsorbents are listed in Table- 1.

Experimental Studies

The studies were carried out in the Environmental Engineering Laboratory of BVM Engineering College, V.V. Nagar. To determine optimum dose of TSAC, 50 mL of Cr(VI) solution was taken in 6 conical flasks and then known amounts of TSAC were added into each flasks. The solutions were equilibrium for 30 min. in a mechanical shaker. After equilibration period, the carbons were filtered and analyzed for Cr(VI) following the standard colourimetric procedure. Using this optimum dose, optimum time was determined for TSAC.

Similar experiments were carried out for PAC and GAC, to determine their optimum dose and time.

RESULTS AND DISCUSSION

Effect of Adsorbent Dosage

The plot of %R- percent removal of the chromium versus m- adsorbent dosage for TSAC, PAC, and GAC, as in Figure- 1, postulate that the removal of chromium is increased with the increase in the adsorbent dosage. The results also

suggests that TSAC can become comparable adsorbent with the commercially available PAC ad GAC. The increase in adsorbent dosage was due to the availability of more surface area for contact between the adsorbent and the adsorbate, which will naturally increase the rate of adsorption. Also, the rate of increase in the percent removal of chromium has been found to be rapid in the beginning, which becomes almost stable as the dose increases further.

The plots of the q- amount of chromium adsorbed per unit weight of the adsorbent versus m- adsorbent dosage as shown in Figure- 2, for TSAC, PAC and GAC, also indicate that the amount of chromium adsorbed was increased with increase in dosage.

Effect of Contact Time

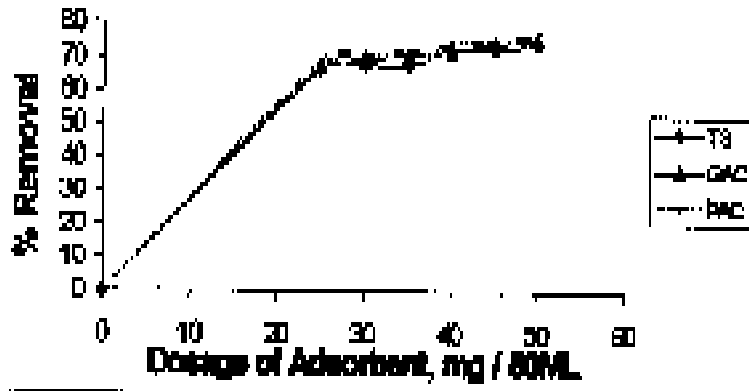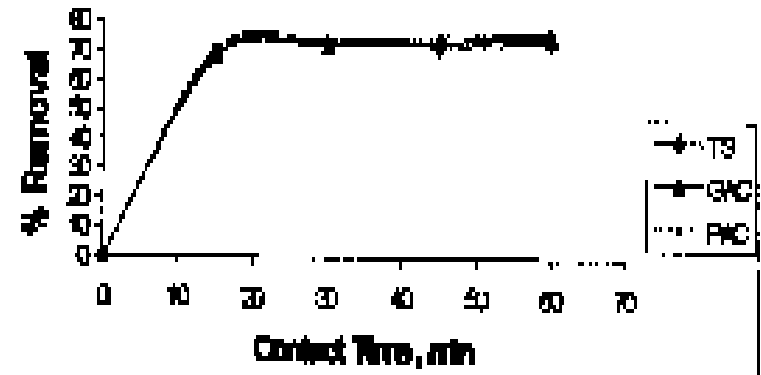Fig.-1 Comparison Of Different Adsorbent On Adsorption Of Cr^{+6} (C0 = 1 mg/L)

Fig.-2 Comparison Of Different Adsorbent On Adsorption Of Cr^{+6} (C0 =1 mg/L)

Fig.-3 Comparison Of Different Adsorbent On Adsorption Of Cr^{+6} (C0 = 1 mg/L)

The effect of contact time on TSAC, PAC and GAC can be observed from the plots of %R versus contact time as in Figure-3.
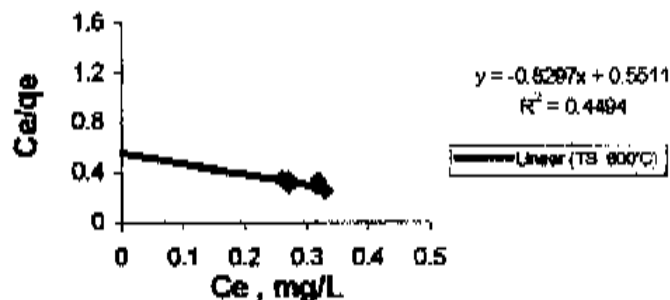
For all the three adsorbents, percent of chromium removal was found to be increased as the time increased. The optimum time was found to be 30 minutes for TSAC, PAC and GAC in case of the initial concentration of 1.0 mg/L. It is clear from the plots that major removal of chromium was achieved during the initial stage of contact. In this, instant adsorption is achieved within first 30 minutes, followed by adsorption- desorption phenomenon with time. The plots are splitted into two regions. First one is the adsorption zone of the mass transfer zone while the second zone is the saturation zone or exhausted zone. In the first zone, the rate of adsorption almost linearly increases with time. The effect of contact time on PAC and GAC was found to be same as that for TSAC. In the saturation zone, there is no or little, further increase in the rate of adsorption since the pores present in the adsorbents gets already occupied by the chromium molecules.

The effect of contact time on the adsorption of chromium on TSAC, PAC and GAC was observed by plotting the amount of chromium adsorbed per unit weight of adsorbent- q versus contact time- t. the rapid uptake of chromium was observed during the initial stage of contact. It is also seen that the adsorption of chromium was increased with lapse of time and gradually attained equilibrium in almost 45 minutes for the adsorbents under identical conditions of concentration and temperature of the solution.
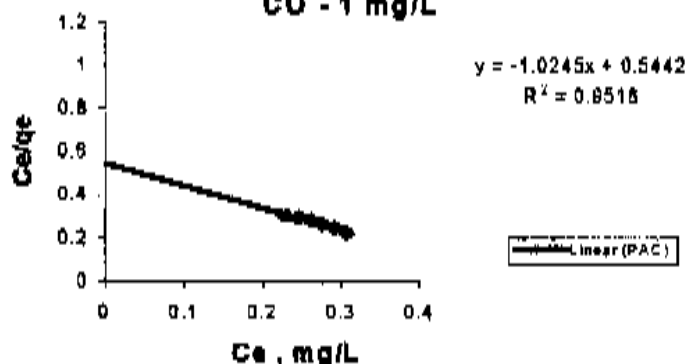
Adsorption Isotherms

The best isotherm equation to be used in a particular instance can be determined by comparing the goodness of fitting of the data, when plotted in the form, for each isotherm, which should yield a straight line. The equilibrium data for removal of chromium in the present investigations were analyzed using Langmuir model for adsorption. The linearized characteristics of the
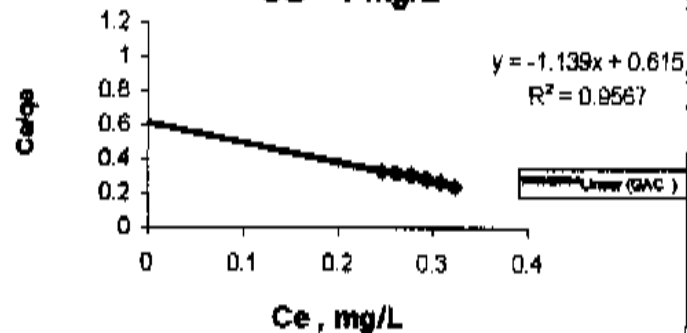
Fig.-4 Langmuir Isotherm For Adsorption Of Cr^{+6} On TS AC 600°C (CO - 1 mg/L)

$y = -0.5297x + 0.5511$
$R^2 = 0.4494$

Linear (TS 600°C)

Ce/qe vs Ce, mg/L

Fig.-5 Langmuir Isotherm For Adsorption Of Cr^{+6} On PAC CO - 1 mg/L

$y = -1.0245x + 0.5442$
$R^2 = 0.8515$

Linear (PAC)

Ce/qe vs Ce, mg/L

Fig.-6 Langmuir Isotherm For Adsorption Of Cr^{+6} On GAC CO - 1 mg/L

$y = -1.139x + 0.615$
$R^2 = 0.9567$

Linear (GAC)

Ce/qe vs Ce, mg/L

plot of Ce/qe versus Ce- equilibrium concentration of chromium in aqueous solution as shown in Figure- 4 to 6 for TSAC, PAC and GAC, gives conformation of the validity of this model for adsorption of chromium under study conditions. This clearly indicates monolayer coverage of adsorbate at the outer surface of the adsorbent. The Langmuir isotherm constant q0 defines the total capacity of the adsorbent in mg/g. the value of b implies the bonding of adsorbate with the adsorbent. Thus, in present investigation, the Langmuir isotherm model was found to be applicable for TSAC, PAC and GAC.

CONCLUSION

The result of the experimental study shows that PAC has the highest adsorption capcity in all the three adsorbents. But the results of TSAC are also comparable with the results obtained for PAC and GAC and so it may become an economical alternative for the removal of Cr (VI) from the industrial effluent. Also, because of its low cost, the regeneration of TSAC is not necessary.

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Conferences in 2004 ....

➤ I[st] Regional European Conference of the International Association for Engineering Geology and the Environmnet 4th May 2004, Liege, Belgium.

➤ International Conference and the Environmnetal studies/ Intenrational Conference on Science and Technology 14th October 2004, Singapore.

➤ Sustainability: Steel and Environmnet 1st Nov. 2004. Birmingham, UK.

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