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REMOVAL OF HEXAVALENT CHROMIUM Cr (VI) BY USING SUGARCANE BAGASSE AS AN LOW COST ADSORBENT

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ABSTRACT

Chromium is commonly found in large quantities in tannery wastewater and also in small and medium scale industries. Which are posing a serious threat to the environment by virtue of discharging effluents of a polluting nature? The problems become severe due the presence of heavy metals in the effluents. Chromium is widely used in a number of industries such as electroplating, metal finishing, cooling towers, dyes, paints, anodizing and leather tanning industries. The toxicity of Chromium (VI) is well known and is considered a hazard to the health of humans and animals. The presence of Cr (VI) in aquatic environments at high concentration is also lethal to marine species. The treatment of chromium bearing effluents have been reported through several methods, such as chemical reduction, precipitation, ion exchange, electro chemical reduction, evaporation, reverse osmosis and adsorption. However, among these, adsorption is found to be highly effective in expensive and an easy method to operate (M.A. Mohamed, 2012). India is an agricultural country and generates a considerable amount of agricultural wastes, such as, sugarcane bagasse, coconut jute, nut shell, rice husk ash, rice straw, wheat straw, waste tea leaves, ground nut husk peanut nulls and fertilizer wastes. Successful studies on these materials could be beneficial to developing countries and could be easily applied as adsorbents for the removal of chromium from wastewater. Most of the previous work highlights the use of commercial activated carbon but these adsorbents are relatively expensive and less feasible to be used in developing countries. Keeping these in view batch experiments have been designed to study the feasibility of sugar cane bagasse to remove chromium (VI) from the aqueous solutions. While evaluation the impact of various parameters such as adsorbent does contact time, initial concentration and pH on Cr (VI) efficiency, the result indicate a prominent of pH on the Cr (VI) reduction by the adsorbent used in the present study.

KEYWORDS: Toxicity, Adsorption, Chromium, Sugarcane Bagasse.

The industrial estates contains trace elements of heavy metals such as nickel, Mn, Pb, Cr, Cd, Zn, Cu, Fe and Hg. Some of these metals are essential to the growth of biological life and absence of sufficient quantities of them could limit their growth larger concentrations, however could cause adverse effects on humans, animals, and plants. The rapid industrialization has resulted in accelerating the flux of heavy metals into surgical environment. Pollution, due to these heavy metals, has been a major source of concern to scientists and environmental engineers. The presence of any of the above mentioned heavy metals in excessive quantity will interfere with many usages of water because of their toxicity. Therefore, it is desirable to measure and control the concentrations of the substances. Several mishaps related to heavy metals concentrations in the aquatic environment have increased the awareness about heavy metal toxicity. Among these minamata tragedy in Japan due to metallic mercury escaping from the laboratories and industries, mainly from chlorine manufacturing. It was acquired by aquatic life and passed along through natural food chains to humans, largely by fish. Another disease 'Itai-Itai' that occurred among the farmers who drank water containing Cd supplied from the Jentsu River in Japan (Benefield, Jadleins and Weand *et al*. 1982). Chromium is toxic, exists in aqueous system in trivalent [Cr (III)] as well hexavalent [Cr (VI)] forms. The effluents of process industries, dyes and pigments, inks, metal finishing, cement, mining, glass, ceramics, rubber, fertilizers and electroplating exhibit traces of chromium (Umesh K. Garg, Diraj Sud, 2005 and Asha Gupta *et al*. 2011).

Chromium (VI) causes many adverse effects on humans, aquatic life and soil. Some effects as human nausea, epiesgestric pain, severs diarrhea, hemorrhage, dermatitis by skin content, nasal mucous membrane, ulcer (Satyanaryan *et al*. 1995) lung cancer and tissue necrosis. Aquatic life as reduction in fish production at high concentrations, chromium accumulates in fish tissues and reaches to consumers. Gold fish and trout are killed at a concentration of 180 gm/l. In soil fertility is also reduced if chromium bearing effluents are discharged on land (Park *et al*., 2005 and Agarwal *et al*., 2006).

The treatment of chromium bearing effluents has been reported through several methods, such as, chemical reduction and precipitation, ion exchange, electrochemical reduction, evaporation and reverse osmosis. Most of these methods need high capital costs and recurring expenses such as chemicals. Less attention has been paid towards the treatment of effluent containing chromium by means of the adsorption technique using agricultural wastes. Hence there exists a scope to try locally available, low cost adsorbents for treatment of effluents containing Cr (VI). Adsorbents

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from local origin sugarcane bagasse were selected as adsorbents. The various low cost adsorbent used for chromium removal reported by many investigaters as Sarin and Pant (2006), Saha *et al*., (2016), Khan *et al*., (2016), Dehghani *et al*., (2016) Babu and Gupta (2008) and Sucharita and Nandini (2009) etc.

MATERIALS AND METHODS

The sugarcane bagasse was collected from local market and the pith was separated manually. The bagasse was boiled with water for 30 minutes in order to remove soluble sugars present. Primarily the wastewater to be used in the investigation was prepared by dissolving a known amount of potassium dichromate ($K_2Cr_2O_7$) in a known volume of distilled water in order to have waste of uniform characteristics and to avoid the interference with other elements. To evaluate the potential of bagasse to remove hexavalent chromium, batch experiments were carried out. Wastewater containing known concentrations of Cr (VI) were prepared from the stock solution and taken separately in glass stoppered conical flasks. Then known quantities of the adsorbent were added to the wastewater. The system was equilibrated by shaking the contents of the flask at room temperature so that adequate contact time between adsorbent and the metal ion was maintained. The suspension was filtered through Whatman No.1 filter paper and the filtrate was analyzed to evaluate the concentration of Cr (VI) metal in the treated wastewater. All the analyses were performed according to Standard Methods (Standard Methods, 1989). Metal analysis was carried out by using Atomic Absorption Spectrometry (model: GBC- 902).

RESULTS AND DISCUSSION

Effects of Contact Time at Different Adsorbent Doses on Cr (VI) Removal

To study the effect of contact time on the removal of Cr (VI) is presented in Fig.-1. The observations reveal that the percentage of removal of Cr (VI) increases with an increase in contact time. The removal efficiency is further increased as the dose of bagasse (adsorbent) increases from 0.1 to 0.85 g and the contact time varies from 0.4 to 2.4 hr. It is also observed that at 0.4 hr the removal efficiency increased from 29-80% as the adsorbent dose increased from 0.2 to 0.8 g. If the contact time is raised to 1.2 hr, the removal efficiency varies from 39 to 94% for the same variation of dose (0.2 to 0.8 g). A removal efficiency of 95.6% of Cr (VI) is observed at a contact time of 1.6 hr with a dose of 0.70 g/50 ml. Chand *et al*. (Shrichand, 1994).

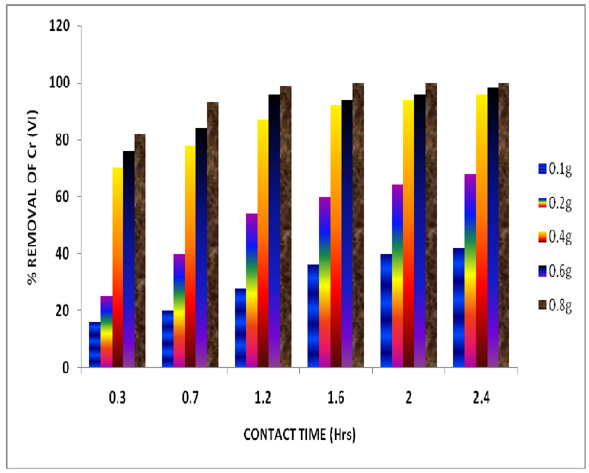

Figure 1: Effect of contact time at different adsorbent (bagasse) doses on Cr(VI) removal

Effects of Adsorbent Dose at Different Contact Time on Cr (VI) removal

To study the effect of adsorbent dosage the bagasse on the removal of Cr (VI) from the wastewater are shown in Figure-2 .The results indicate an increase in the removal efficiency of Cr (VI) with increase in the dose of raw bagasse up to a certain level, beyond which the removal efficiency remains constant. It is evident that a dose of 0.6 g/50 ml is sufficient to remove 75-100% Cr (VI) in 0.5-3.5 hr. The increase in the removal efficiency with a simultaneous increase in adsorbent dose is due to the increase in surface area and hence more active sites are available for the adsorption of chromium Cr (VI).

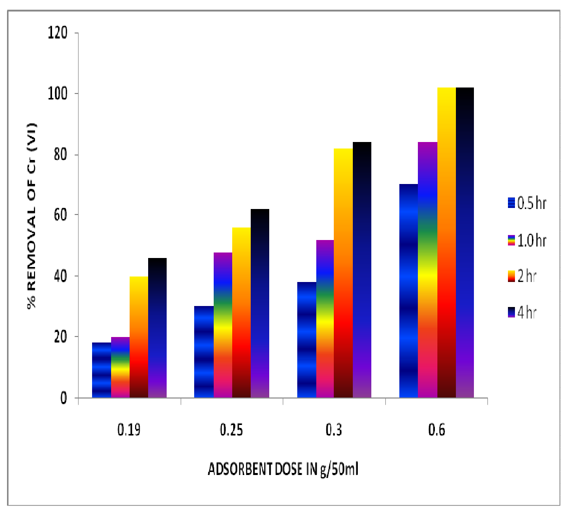

Figure 2: Effect of adsorbent doses at different contact time on Cr (VI) removal

Effect of pH on Chromium Cr (VI) Removal

It is well known that adsorption of heavy metal ion depends upon the pH of aqueous solution. The effect of pH on Cr (VI) removal shows that at lower pH, the Cr (VI) removal efficiency is higher and at higher pH the removal efficiency is reduced considerably (Figure-3). So at pH 1.5 the removal efficiency is 100%, whereas on increasing the pH to 3.0 the removal efficiency is reduced to 17%. One of the reasons for the better adsorption capacity observed at low pH values may be attributed to the large number of H^+ ions present at these pH values, which in turn neutralizes the negatively charged hydroxyl groups (^-OH) on the adsorbed surface thereby reducing hindrance to the diffusion of dichromate ions. At higher pH, the reduction in adsorption may be due to an abundance of OH^- ions causing increased hindrance to diffusion of positively charged dichromate ions.

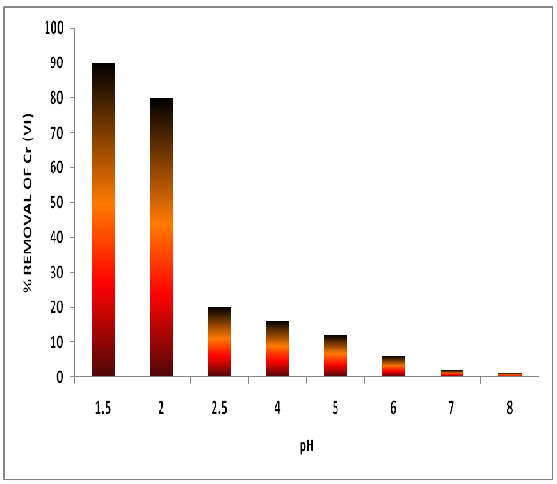

Figure 3: Effect of pH on Cr(VI) removal

Effects of Initial Metal Ion Concentrations

Adsorption efficiency of sugarcane bagasse has been studied. Result show that at low initial concentrations of chromium (VI) (5.0 to 10 mg/l) the removal efficiency is higher (70-100%). The removal efficiency is 60% at a concentration of 20 mg/l and it decreases to 48% when chromium concentration was increased to 50 mg/l. In a similar study Chand *et al.* (Shrichand, 1994) obtained 90% removal efficiency at a Cr (VI) concentration of 10 mg/l in a dose of 1.0 g/100 ml at a contact time of 1.5 hr when the pH of the solution was 2.0.

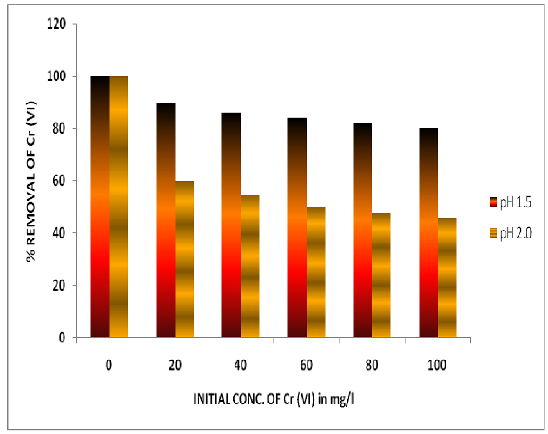

Figure 4: Effect of Initial Cr (VI) concentration on Cr(VI) removal

CONCLUSIONS

The following conclusions can be drawn from the present study.

An adsorbent dose of 0.8 g/50 ml is sufficient to remove 80-100 % Cr (VI) from a solution having an initial concentration of 50 mg/l. The data obtained during the present study may be quite helpful in designing a full-scale adsorbed for the treatment. Before applying raw bagasse for the treatment of wastewater there is a need for further investigations as the acid hydrolysis of cellulose in acidic medium produces alcohol that may increase the expand of the wastewater. Raw bagasse exhibits a high degree of Cr (VI) removal and it can be utilized for the treatment of industrial wastes containing chromium (VI) concentrations between 10-100 mg/l. The raw bagasse after adsorption can be burnt for heat recovery and the bagasse ash containing small quantities of Cr (VI) can be disposed off on low-lying areas.

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