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Acid activated tea bag waste as an adsorbent for the removal of chromium ions from tannery waste water

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ABSTRACT

This research work focuses on the utilization of tea bag waste of some commercial teas as a precursor for the production of an adsorbent for the removal of chromium ions from tannery waste effluent. The tea bag waste was chemically activated with 1.0 M sulfuric acid to produce the adsorbent. Nearly 100% removal of chromiumfrom real tannery waste water is achieved with the activated tea bag waste adsorbents.

Keywords: Chromium, Effluent, Tea bag waste, Adsorption

INTRODUCTION

Chromium compounds are among the most dangerous inorganic water pollutants [1]. Generally, all forms of chromium can be toxic at high levels. People who are allergic to chromium may have asthma attacks after breathing high levels of chromium in air [2,3]. Repeated or prolonged skin contact with chromium compounds may cause irritation. In severe cases, skin allergy can occur with itching, redness and/or an eczema-like rash. Chromium compounds mainly occur in either trivalent, Cr (III), or hexavalent, Cr (VI), forms in aqueous solutions. There are two major sources of chromium contamination: metal finishing industries (hexavalent chromium) and tanneries (trivalent chromium).

Both chromium (III) and chromium (VI) have high chronic toxicity to aquatic life. The toxicity of chromium compounds depends on the oxidation state of the metal. Trivalent chromium compounds are considerably less toxic than the hexavalent chromium compounds and are neither irritating nor corrosive under normal conditions. Long term exposure to trivalent chromium is known to cause allergic skin reaction and cancer. Long exposure to chromium (VI) has been associated with increased incidence of lung cancer. hexavalent chromium compounds are said to be carcinogenic and mutagenic [4]. However, due to the possible oxidation of the Cr (III) to the more harmful Cr (VI), environmental regulations usually set the limiting values for both the total and the hexavalent chromium concentration in waters [5].

Since the majority of heavy metals do not degrade into harmless end products, their concentrations must be reduced to acceptable levels prior to discharge of industrial effluents. Otherwise they could pose threats to public health. According to the World Health Organization (WHO), the metals of most immediate concern are aluminium (Al), Chromium (Cr), manganese (Mn), iron (Fe), cobalt (Co), (Ni), copper (Cu), zinc (Zn), cadmium (Cd), mercury(Hg) and lead (Pb), [6].

The most common methods for the removal of chromium from industrial effluents are: chemical precipitation, solvent extraction, dialysis, electrolytic extraction, cementation, reverse osmosis, membrane filtration, ion exchange, adsorption and co-precipitation. Conventional physical and chemical treatment of large volume waste water is often very costly. Consumptive processes, such as chemical precipitations, entail large capital and operating costs. Attention has thus focused on non-consumptive methods that include ion-exchange and other sorption processes. However, commercially available resins and activated carbons can be expensive. Adsorption is the most preferred method because the other methods suffer some drawbacks such as high capital and operating cost or the disposal of the residual metal sludge, [7].

The idea of using low cost materials such as agricultural by products for the removal of toxic metals from wastewater has been investigated [2,7,9]. Agricultural byproducts and biological materials have been found to be useful for metal sorption. For example, by products of soybean and cottonseed hulls, rice straw and sugarcane bagasse were evaluated as metal ion adsorbents in aqueous solutions [9]. The utilization of these sources of biomass would solve some disposal problem as well as access to cheaper materials for adsorption of heavy metals in aqueous waste water control systems. This paper presents a report on the application of an acid activated waste tea bag as an adsorbent for the removal of chromium from tannery effluent.

MATERIALS AND METHODS

Waste tea bags were collected from some tea joints in Tudun-Wada, Kaduna state, Nigeria in March, 2009. The contents of the bags were then emptied, soaked in distilled water overnight and then washed several times. It was then dried using a tray dryer. The dried waste tea was then chemically activated with 1.0 M sulphuric acid for three hours. It was then washed several times with distilled water and dried to a constant weight in a tray dryer. The dried waste tea was then sieved to a particle size of 710µm.

Tannery effluent was obtained at Challawa tannery plant in Kano state, Nigeria. The effluent sample is used as obtained without any treatment.

Adsorption experiments were carried out by mixing a given amount of the adsorbent with the tannery effluent in a 50ml flask for two hours. Thereafter, the contents of the flask was then transferred into a test tube and loaded in a centrifuge for separation. The centrifuge was operated at a speed of 2000 rpm for 10 minutes. After centrifugation, the supernatant was carefully decanted and analyzed by atomic absorption spectrophotometry. The amount retained by the adsorbent was calculated as the difference between the amount of chromium in the raw effluent, and that found in the supernatant of the treated effluent.

RESULTS AND DISCUSSION

The concentration of Chromium in the obtained raw tannery effluent as determined by atomic absorption spectrophotometry is 0.7557mg/l. This shows that the concentration of chromium is within the recommended limit of discharge stipulated by the Nigerian Federal Ministry of Environment [6].

The removal efficiency of chromium by the activated tea bag waste based adsorbents is calculated as:

$$\text{Removal efficiency} = [C_0 - C_t / C_0] \times 100$$

Where C_0 and C_t are the concentrations of chromium before and after adsorption. Two different commercial waste tea bags, labeled A and B, respectively, were used for the experiments. The removal efficiency achieved are 99.9% and 99.7% using A and B, respectively. This result shows that 1M H_2SO_4 activated tea bag waste can be successfully deployed as adsorbent for the removal of chromium from waste water.

CONCLUSION

A new adsorbent has been developed by treating tea bag waste with 1M H_2SO_4. Nearly 100% removal of chromium from real tannery waste water is achieved with the acid activated tea bag waste adsorbent.

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