Published by :
http://www.ijert.org

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 10 Issue 02, February-2021

Removal of Cr(VI) from Synthetic Wastewater by Low Cost Adsorbent Developed from Amla Wood Sawdust (Emblica Officinalis)

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***Abstract*— The present study aims to understand the effectiveness of using Amla Wood Sawdust (AWS) for the removal of hexavalent Chromium metal and to obtain an optimum condition for maximum extraction. AWS was prepared using waste barks of Amla tree which was then dried, ground and activated to prepared the low cost adsorbent. Stock solution of chromium was prepared in the laboratory using potassium dichromate and distilled water and the pH of the stock solution was varied using sulphuric acid. The effects of contact time, pH value of stock solution and adsorbent dosage were studied under batch mode of operation. Experimental data revealed that hexavalent chromium concentration in synthetic wastewater was reduced up to 83.2% at suitable conditions of contact time, pH and adsorbent concentration.**

Keywords*— Adsorption, Chromium (VI), Synthetic Wastewater, Amla Wood Sawdust,Heavy metals.

I. INTRODUCTION

The presence of heavy metals in drinking water sources and in edible agricultural crops can be harmful to human. It is well known that heavy metals can be toxic e.g. they damage nerves, liver and bones and also block functional groups of vital enzymes [1]. Heavy metals are found in water, air and soil. The major sources of heavy metals in water and soil are waste water streams from various industrial processes [2]. Heavy metals like chromium, copper, lead, zinc, mercury, cadmium etc. are present in waste water from several industries such as metal cleaning and plating baths, refineries, paper and pulp, tanning, dyes and pigments, wood preserving, glass, ceramic paints, catalysis chemical manufacturing etc. in which chromium (VI) is present from 5 to 220 mg/dm^3 which are discharged into environment [3-5]. Heavy metals have been used by humans for thousands of years. Although several adverse health effects of heavy metals have been known for a long time, exposure to heavy metals continues, and is even increasing in some parts of the world, in particular in less developed countries. Although emissions have declined in most developed countries over the last 100 years, heavy metals are dangerous due to their tendency for bio-accumulation. Bio-accumulation indicates an increase in the concentration of a certain chemical within a biological organism over time, compared to the chemical's concentration in the environment. Compounds accumulate in living things any time they are taken up and are stored faster than they are broken down (metabolized) or excreted. . There are more than 20 heavy metals, of which four are of particular concern to human health: Lead (Pb), Cadmium (Cd), Mercury (Hg), and inorganic Arsenic (As).These four heavy metals are four of the top six hazards present in toxic waste sites. They are highly toxic and can cause damaging effects even at very low concentrations. They tend to accumulate in the food chain and in the body and can be stored in soft (e.g., kidney) and hard tissues (e.g., bone). Being metals, they often exist in a positively-charged form and can bind on to negatively-charged organic molecules to form complexes. In the present study an attempt has been made to study the removal of hexavalent Chromium (Cr-VI) using Amla Waste Sawdust from dried barks of Amla trees.

II. EXPERIMENTAL

A. *Adsorbent Preparation*

Amla Wood was collected locally and was grounded to small particles of size 120-500 µm. It was washed with deionized water for removal of dirt, color and other particular matter and then dried again. AWS was then treated with sulfuric acid (H_2SO_4) by adding 5 ml of H_2SO_4 to 100 ml of deionized water and 10 grams of AWS. The final mixture was stirred and treated at 305 K for 24 hours till the mixture became thick slurry. The slurry was washed with deionized water and the pH of filtrate was fixed at 5. The final adsorbent was dried and then stored in plastic bags in a dessicator at room temperature to prevent moisture to come in contact with the adsorbent.

Figure 1: Adsorbent prepared from Amla Saw Dust

B. *Stock solution of Chromium*

The stock solutions chromium ions were prepared using 1.4145 gram of Potassium Dichromate ($K_2Cr_2O_7$) in 500 ml of distilled water in a 1000 ml volumetric flask. It was dissolved by shaking and the volume was made up to the mark. Chromium solution concentration of this solution was 500 mg/l.

C. Batch mode adsorption studies

The adsorption of Chromium (VI) on adsorbent was studied by batch process. In this study, the analytical grade chemicals were used for testing various parameters in wastewaters. The absorbance and chromium ions of synthetic wastewater were found using UV spectrophotometer. A known weight of adsorbent (e.g. 0.5 to 4 g adsorbent) was equilibrated with 100 ml of the each chromium ions solution of known concentration 500 mg/l in 12 stoppered glass flasks at a fixed temperature (303 K) in a orbital shaker for a known period (30–150 minute) of time. After equilibration, 100 ml sample collected from each flask, in time interval of 30, 60, 90, 120, and 150 minutes. The adsorbent was separated from solution by filtration using Whatman No. 42 filter paper. The concentration of chromium ions retained in the solution was measured by UV visible spectrophotometer. The effect of several parameters, such as pH, contact time and adsorbent dose on the adsorption were studied. The pH of the absorptive solutions was adjusted using sulfuric acid, sodium hydroxide and buffer solutions when required.

The results of these studies were used to obtain the conditions for maximum Cr (VI) removal from aqueous solution. The percent Cr (VI) removal was calculated using the following equation:

$$\text{Metal ion removal (\%)} = \left(\frac{C_0 - C_e}{C_0}\right) \times 100$$

where, C_0: initial concentration of test solution, mg/l;
C_e: final equilibrium concentration of test solution mg/l.

The effect of adsorbent dosage, pH, contact time, initial concentration of Cr (VI) and temperature were studied by varying any one of the parameters and keeping the other parameters constant.

III. RESULTS AND DISCUSSIONS

A. Effect of adsorbent dosage

The adsorbent dosage was varied from 0.5 to 4 grams per 100 ml of stock solution. From figure 2 we can observe that there is a linear increase in the removal of Cr-VI with increase in adsrobent concentration. The linear rise however reaches a maxima at 82% removal at 2.5 gm per 100 ml of adsorbent dosage. Beyond the optimum dosage, there is no noticable increase in Cr-VI removal which indicates that 2.5 gm per 100 ml as the optimum adsorbent dosage for the removal of Cr-VI. This optimum dosage of adsorbent was used for further studies to observe the effect of pH and contact time.

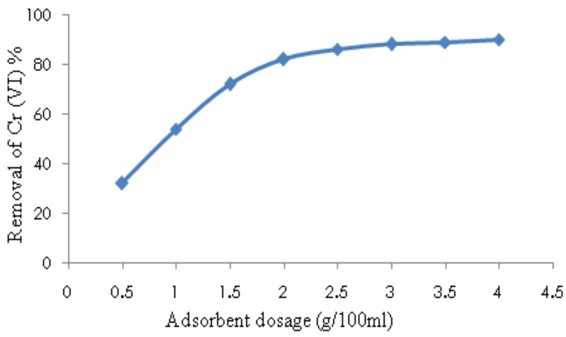

Figure 2: Effect of adsorbent dosage on % removal of Cr-VI

B. Effect of pH

Optimum adsorbent dosage of 2.5 gm per 100 ml of solution was used and pH of the solution was varied to study the effect of pH of the adsorption of Cr-VI. Different pH conditions were maintained by adding H_2SO_4 and acetic acid-sodium acetate buffer solution.From figure 3, we can see that the maximum adsorption occured at a predominantly acidic solution with a pH range pH2 and 3. However any further increase in pH lowers the potential of adsorption significantly.

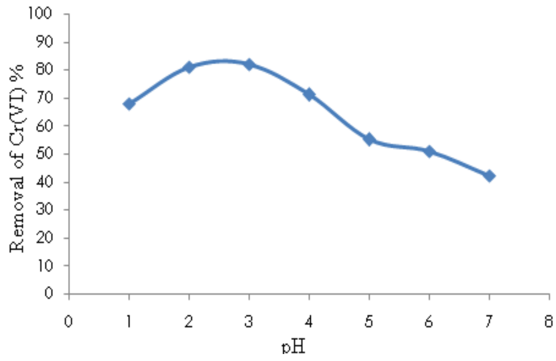

Figure 3: Effect of pH on % removal of Cr-VI

C. Effect of contact time

The time required to reach equilibrium for adsorption by AWSis shown in Figure 4. The adsorption of chromium was dependent on pH of aqueous solution and increased with decrease in pH of Cr (VI). The contact time was varied between 30 minutes to 150 minutes. The rate of adsorption increased at lower contact time and then it reached equilibrium at 100 minutes of contact time. At this condition the maximum removal of Cr-VI was observed at 83% for a dosage of 2.5 gm per 100 ml stock solution at pH2.

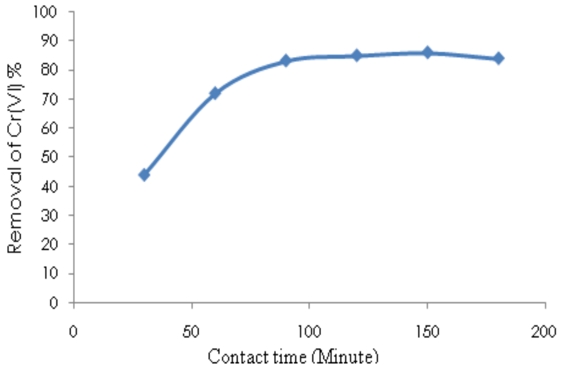

Figure 4: Effect of contact time on % removal of Cr-VI

IV. CONCLUSION

The effect of adsorbent concentration, pH and contact time on the removal of Cr-VI from wastewater shows the conditions at which maximum adsorption occurs and also gives some insight into the underlying mechanism of the adsorption that occurs. Beyond the optimum dosage of adsorbent in the system there is no significant increase in the adsorption rate. This indicates that at higher concentration there is no increase in active sites but the excess adsorbents are carried out of the system without being used. The study also shows that the adsorption rate is dependent on the surface charges that are present in the system. At lower pH, there is an increase of H^+ in the adsorbent surface which tends to attract the Cr-VI particles thus leading to an increase in the rate of adsorption. The optimum contact time was at 100 minutes for the optimum dosage and pH beyond which the adsorption curves flattens. The nature of adsorption can be further studied using the various isotherms to have a better understanding of the underlying phenomena. The present study shows that using AWS we can obtain a maximum removal of 83% of Cr-VI at the optimum conditions of concentration, pH and contact time.

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