APPLICATION OF SUGARCANE BAGASSE FOR THE REMOVAL OF CHROMIUM (VI) AND ZINC (II) FROM AQUEOUS SOLUTION

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Abstract - *Pollution due to Heavy metals has become most serious environmental problems. The treatment of heavy metals is special concern due to their persistence in the environment. Therefore a methodology is developed for the removal of toxic metals from its aqueous solution. In the present work bagasse waste product of sugar mill was used as adsorbent. Batch adsorption study determines that sugarcane bagasse has a significant capacity for adsorption of Cr (VI) and Zn (II). The parameters used in the study include contact time, pH, concentration and adsorbent dosage. Adsorption of these metals was found to be pH dependent.*

Key Words :Adsorption, adsorbent, sugarcane bagasse, adsorbent dosage and batch studies etc

1. INTRODUCTION

Heavy metal pollution is common environmental hazard. Dissolved toxic metal ions can reach the food chain and become a risk factor for public health (1-3). Metal ions are present in the wastewaters of several industries such as metal cleaning and plating baths, refineries, paper mills and tanning industries (3). The excessive intake of metal by human being leads to severe mucosal irritation, capillary damage, hepatic and renal damage, central nervous problems followed by depression, gastrointestinal irritation and necrotic changes in liver and kidney (3-4).

Heavy metals are most important pollutants in water and are becoming a severe public health problem. The heavy metal ions are persistent environmental contaminants because they cannot be degraded and destroyed (4-5). There are many methods for the treatment of wastewater, these methods are precipitation, neutralization, ion exchange and adsorption. Adsorption process is the best method for the removal of heavy metal ions from aqueous solution (6).

A great attention has been directed towards bio adsorbent from renewable resources such as cellulose, starch, lignin, chitosan, agricultural wastes, charcoal and other polysaccharides. In this work bagasse is used as an adsorbent for the removal of Cr (VI) and Zn (II). Sugarcane bagasse is waste that is obtained from crushing of sugarcane and it is chemically composed of cellulose and lignin (2, 6).

There are many binding sites that are available to take up the metallic ions therefore it is potential material used as an adsorbent.

2. MATERIAL AND METHOD

2.1 Adsorbent Preparation

The banana peel was obtained from Dhaka village, west Mukherjee Nagar, New Delhi. Sugarcane bagasse was washed with tap water and dried in sunlight. After sometime sugarcane bagasse was washed with distilled water until dust is removed. After sometime sugarcane bagasse was dried in the oven at 80°C for 4 hours. Then crushed and sieved through 2.2 mm sieve (7). Powder was collected and washed with distilled water until washing are free from colour after this sample was kept for the batch adsorption studies.

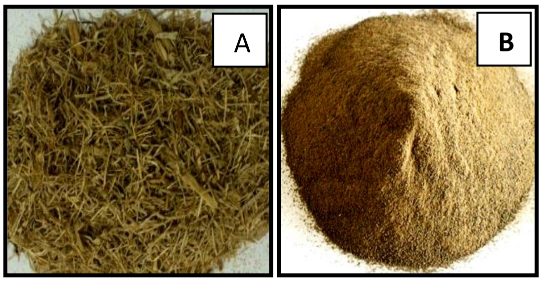

Figure-1: Raw sugar cane basses (A)
Sugar cane basses powder (B)

2.2 Adsorbate solution

The Cr (VI) and Zn (II) ions solutions were prepared from an AR grade chromium trioxide (CrO_3) and zinc sulfate ($ZnSO_4.7H_2O$). Distilled water was used for the preparation of all solutions and adsorption experiments. 1000mg L^{-1} stock solution of chromium (VI) and zinc (II) was prepared. The initial concentration (100 mg L^{-1}) of each metal was prepared from the stock solutions by dilution.

2.3 Batch adsorption experiments

Chromium (VI) and Zn (II) metal ion, 100 ml containing concentration of 100 mg L^{-1} were measured into separate eight 250 ml conical flasks. Adsorbent (1.0 g) were added in these solutions. The flasks were agitated at 250 rpm. The suspensions were then filtered using Whatman filter paper No. 42, centrifuged for 15 minutes and analyzed by atomic absorption spectrometer (4, 8).

2.3.1 Effect of pH:

The effect of pH on the amount of Cr (VI) and Zn (II) metal ions was analyzed on pH range from 1-7. In this experiment, 100 ml metal ions concentration of 100 mg L^{-1} was measured into 250 ml conical flask and 1.0 g of the adsorbent was added and agitated at 250 rpm. The solution was filtered using Whatman filter paper No. 42 and the residual metal ions concentration analyzed by atomic absorption spectrometer (4,9).

2.3.2 Effect of contact time:

The effect of contact time on the removal of Cr (VI) and Zn (II) ions were carried out for a period of 2 h at a time interval of 10 minutes. Adsorbent was weighed from 0.5-3.0 g and transferred into the 250 ml conical flasks. Metal ion solutions (100 mg L^{-1}) of Cr (VI) and Zn (II) were added in each conical flask. The flasks were covered and shaken for 1 hr, the suspensions were filtered through Whatman filter paper No. 42, centrifuged for 15 minutes and analyzed by atomic absorption spectrometer.

2.3.3 Effect of metal ions concentrations:

In order to determine the effect of metal ions concentrations, 100 mL of various solutions ranging from 40-100 mgL-1 were kept in conical flasks for Cr (VI) and Zn (II) ions separately. One gram of the adsorbent was added in each flask, agitated for 1 h, filtered, centrifuged for 15 minutes and analyzed by atomic absorption spectrometer. The initial pH of each solution was adjusted by drop-wise addition of 0.1 M NaOH and 0.1 M HCl.

Adsorption capacity and % removal efficiency were calculated using the following equations respectively.

$$qe = \frac{(Co - Ce) \times V}{m} \quad \ldots (1)$$

$$\textbf{Removal efficiency (\%)} = \frac{(C0 - Ce) \times 100}{C0} \quad \ldots (2)$$

Where:

qe (mg g−1) is the amount of Cr (VI) and Zn (II) ions adsorbed, Ci (mg L−1) is the initial concentration of Cr (VI) and Zn (II) ions, Ce (mg L−1) is the concentration of Cr (VI) and Zn (II) ions in solution at equilibrium, V (L) is the volume of of Cr (VI) and Zn (II) ions and m (g) is the mass of the adsorbent.

3. RESULTS AND DISCUSSION:

3.1 Effect of pH:

The effect of pH on the adsorption of Cr (VI) and Zn (II) ions is shown in Figure 2. It shows that adsorption of Cr(VI) and Zn(II) metal ions by sugarcane bagasse is found to increase from pH 1-4. Maximum sorption occurred at pH 4 for both Cr (VI) and Zn (II) metal ions. Zinc (II) and chromium (VI) was removed 84.57 % and 92.65 % (4, 11-12).. The adsorption capacities of Cr (VI) and Zn (II) ion increased as pH increased.

The decrease in the % adsorption with increase of pH may be due to the decrease in electrostatic force of attraction between the adsorbent and the adsorbate ions. At lower pH ranges, electrostatic force of attraction is high and the percentage of Cr (VI) and Zn (II) ion removal is high. At very low pH value, the surface of adsorbent could also be surrounded by the hydronium ions which enhance the Cr (VI) and Zn (II) ion interaction with binding sites of the adsorbent. A sharp decrease in adsorbents above pH 4 may be due to the occupation of the adsorption sites.

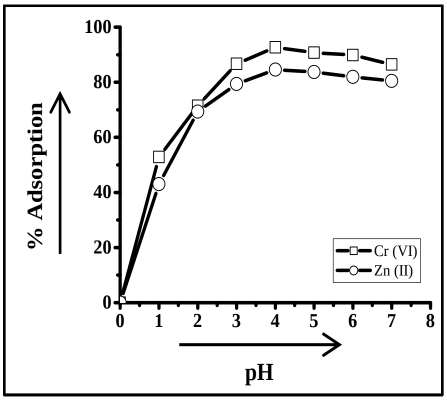

Figure-2: Effect of pH on sorption of Cr (VI) *and Zn (II) ions from aqueous solution (initial concentration= 100 mgL^{-1}, pH=4, equilibrium time =1 h)*

3.2 Effect of contact time

The effect of contact time on adsorption of Cr (VI) and Zn (II) ion was presented in Figure 3. The percentage removal increases with increasing contact time and the equilibrium was obtained after 50 minutes.

Therefore, the adsorption for 50 minutes could be considered for whole batch experiments. The agitation speed was 250 r.p.m.

Time interval was 10 min and an initial metal ion concentration was 100 mg L^{-1}, adsorption increased very fast and decreased with increase in time, therefore the best contact time for adsorption using sugarcane bagasse with Cr (VI) and Zn (II) was 50 minutes. It proves that the individual metal ions bound to the sugarcane bagasse in less than 50 minutes and remained stable. The percentage Cr (VI) and Zn (II) removal was 92.65% and 84.57%.

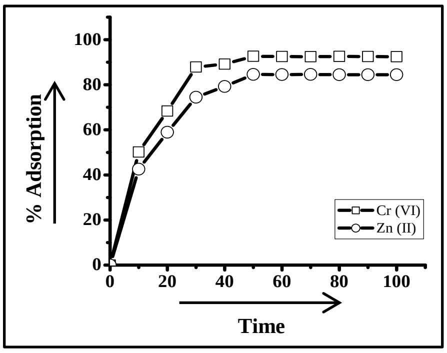

Figure – 3: Effect of contact time on the % removal of Cr (VI) and Zn (II) ions from aqueous solution. (Initial concentration= 100 mgL^{-1}, pH=4.

3.3 Amount of adsorbent:

The effect of adsorbent dosage is shown in Figure 4. The percentage of chromium and zinc ions removable is increased with increasing adsorbent dosage until the surface became saturated and further increased adsorbent amount had no effect on % adsorption. The increase was highest with 1.5 g adsorbent. It removes 98.84% chromium and 94.67% of zinc. This can be explained by a greater availability of exchangeable sites or surface area at higher amount of the adsorbent.

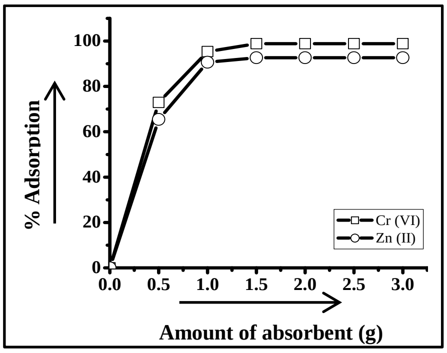

Figure 4: Effect of adsorbent dosage on adsorption of Cr (VI) and Zn (II) ions from aqueous solution (initial concentration= 100 mgL^{-1}, pH=4, equilibrium time =1 h)

3.4 Effect of metal ions concentrations

The removable efficiency decreases with increasing initial concentrations from 30-110 mg L^{-1}, shown in Figure 5. Maximum adsorption occurred at minimum concentration of metal ions. It may be because of the greater number of ions in aqueous solution and thus leading to desorption of the metal ions from the binding sites of adsorbent (4, 13). Numbers of ions are limited, therefore limited number of collisions takes place between metal ions that is why low concentration of metal ions showed higher adsorption rate.

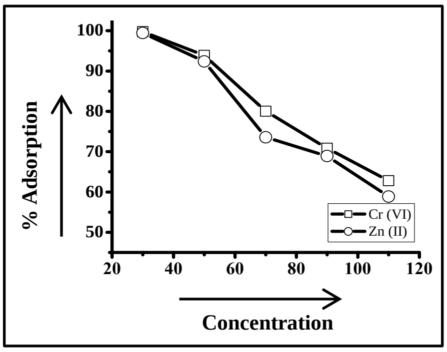

Figure 5: Effect of initial concentrations on adsorption of Cr (VI) and Zn (II) ions from aqueous solution (initial concentration 30-110 mgL-1, pH=4, equilibrium time =1 h)

4. CONCLUSIONS

Conclusions are drawn from the above results and discussion:

1. Sugarcane bagasse could be used as adsorbent for the removal of Cr (VI) and Zn (VI) prepared from aqueous solution.
2. The maximum adsorption of Zn (II) and Cr (VI) was obserbed at pH 4.
3. Removal of Cr (VI) and Zn (II) increases with increasing the amount of adsorbent dosage.

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