

Biosorption Studies for Chromium (VI) Removal Using Sweetlime Fruit Skin & Bagasse

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ABSTRACT: Heavy metals are released into the environment from a wide range of natural and anthropogenic sources. As a result, there has been a great deal of attention given to effective and low cost technologies for removal of heavy metal ions from polluted water. Biosorption is one such emerging technology which utilized naturally occurring waste materials to remove heavy metals from different sources. The aim of the present study was to utilize the locally available agricultural waste as biosorbent for heavy metal removal from wastewater. The potential to remove Cr (VI) from aqueous solutions through biosorption using low-cost adsorbent such as sweetlime fruit skin (SLFS) & bagasse (BG) was investigated in batch experiments. The concentration and pH were the parameters used. Change in pH had appreciable effect on the adsorption of Cr (VI). The adsorption process for the removal of Cr (VI) is more efficient in acidic medium for both adsorbents. SLFS gives better adsorption capacity at 2.5 pH and bagasse (BG) gives at 5 pH. The experiments were conducted for various concentration of Cr(VI) and it was found the percentage removal efficiency was high with 40 µg/l Cr(VI) solution.

Keywords: Biosorption, Low-cost biosorbent, Sweetlime fruit skins (SLFS), Bagasse (BG)

1. INTRODUCTION

The research on the utilization of agricultural waste as adsorbent for the removal of heavy metals from the aqueous solution has become an interesting field for researchers. The agricultural wastes are available at low-cost. They are capable of binding to heavy metals by adsorption.

The discharge of heavy metals in to the environment has become a matter of concern over the last two decades. There are many metals present in the wastewater such as lead, chromium, mercury, zinc, arsenic, cadmium, copper, nickel etc. Chromium is a toxic metal of widespread use and exists in several oxidation states. Cr (VI) is one of those valuable heavy metals, which comes out as pollutant, discharged into natural water from various industries including textile industries, electroplating, leather tanning and metal finishing industries. Once chromium is introduced into the environment it exists in two stable oxidation states, Cr (III) and Cr (VI). The trivalent form is relatively innocuous, but hexavalent chromium is toxic, carcinogenic and mutagenic in nature, highly mobile in soil and aquatic system and also is a strong oxidant capable of being adsorbed by the skin.¹

Chromium (VI) considered being the most toxic of chromium is usually associated with oxygen as chromate (CrO_4^{2-}) or dichromate ($\text{Cr}_2\text{O}_7^{2-}$) ions. The tolerance limit of Cr (VI) for discharge into inland surface water is 0.1 mg/l and in potable water is 0.05 mg/l. But the concentration of Cr (VI) in the industrial

wastewater ranges from 0.5 to 270.000 mg/l.² Dara (2004) reports the tolerance limit for Cr (VI) into industrial and sewage effluents is 0.1 mg/l and in drinking water 0.01 mg/l. According to WHO guidelines for Cr in drinking water is 50 µg/l.³ For adsorption of Cr (VI), a number of biomass or bio materials can be used such as lignocellulosic agricultural waste, *Sargassum sp.*, activated carbons prepared from agricultural wastes, Chitosan coated oil plum shell charcoal, kendu fruit gum dust, london plane leaves, rice husk, coniferous leaves, coconut husk and palm pressed fibers, bengal gram husk have been reported in the literature.^{4,5,6,7,8,9,10,11,12,13} Many other biomaterials were used for the adsorption of other heavy metals.

In this study, sweet lime fruit skin (SLFS), bagasse (BG) agricultural wastes are used as biosorbents to remove Cr (VI) from aqueous solution. Study was carried out using pH and concentration as parameters.

2. MATERIALS AND METHODS

2.1. Pretreatment of biosorbents

Sweetlime fruit skins (SLFS) and bagasses (BG) were collected from different juice centers at Raipur, Chattishgarh, India. The SLFS and BG were washed in tap water and dried in open. The air dried SLFS and BG has soaked in 0.3 N HNO_3 for 24 hr, followed by washing thoroughly with distilled water until a pH of 6.98 to 7 was attained. After that it dried in air and finally in oven at 60 °C. The activated biomass was grounded using a food processor (Maggi model

medium 3000) and then screened through Tyler screen to obtain the particular size (8/10 mesh size) of biomass.

2.2. Preparation of stock solution

Chromium stock solution was prepared by dissolving $K_2Cr_2O_7$ in distilled water. 1.414 g of $K_2Cr_2O_7$ was dissolved in 1000 ml of distilled water.¹⁴ pH of the solution was adjusted using 0.2 N H_2SO_4 .

2.3. Biosorption Experiments

The batch experiments were conducted in 250 ml borosil beakers containing 100 ml of Cr (VI) solution of desired concentration (i.e. 40, 60 μg Cr (VI) /l). For investigation of effect of pH the experiments are repeated at different pH such as 2.5, 5, 7. The samples were shaken continuously at room temperature with 5 g/l of each adsorbent (SLFS, BG, 8/10 mesh size). The solutions were withdrawn at different time intervals and filtered through a 41 Whatman filter paper. From the filtered solution 10 ml sample was pipette out and diluted up to 100 ml, the initial pH of the sample was adjusted 1.0 ± 0.3 using 0.2 N H_2SO_4 , well mixed then 2.0 ml 1,5-diphenylcarbazide solution was added and kept for 10 min for full color development. After the coloration an appropriate volume has taken in absorption cell and its absorbance was measured at 540 nm (using microprocessor photo colorimeter 1312 ELICO). The remaining concentration of Cr (VI) in the sample was determined. The above procedure was repeated for different sets of experiments.

2.4. Analytical methods

Absorbance was measured at 540 nm using microprocessor photo colorimeter 1312 ELICO. The amount of Cr (VI) adsorbed in $\mu g/g$ at time 't' was calculated using;

$$q_t = [(C_o - C_t)/m] \times V$$

(1)

Where, C_o and C_t are the concentration in μg Cr (VI)/l initially and at time 't' respectively. 'V', 'm' and 'q_t' is the volume of the Cr (VI) solution (ml), weight of biosorbent (g) and the amount of metal uptake at time t (μg Cr (VI)/g) respectively.

The percentage removal (% R) of Cr (VI) ions from aqueous solution was calculated by;

$$\% R = [(C_o - C_t)/C_o] \times 100$$

(2)

3. RESULTS AND DISCUSSION

3.1. Effect of Cr (VI) concentration

To investigate the effect of Cr (VI) concentration, two solution of different concentration of Cr (VI) was prepared i.e. 40 $\mu g/l$ and 60 $\mu g/l$. SLFS and BG were used as biosorbent. The experiments were conducted with optimized pH for each biosorbent. It was found that the Cr (VI) removal was fast in low concentrate

i.e. 40 $\mu g/l$ Cr (VI) solution in comparison of 60 $\mu g/l$ Cr (VI) solution [Figure.1]. The percentage removal of Cr (VI) was 65% with SLFS at 2.5 pH. Similarly with BG biosorbent the percentage removal of Cr (VI) was 75% at 5 pH [Figure.2]. Graph shows that the rate of biosorption is a function of the initial concentration of metal ions. This happens due to the increase in the number of ions competing for the available binding sites in the biosorbent and also due to the lack of binding sites for the complexation of Cr ions at higher concentration levels. At lower concentrations, all metal ions present in the solution would interact with the binding sites and thus facilitated higher biosorption. At higher concentrations, more Cr ions are left unabsorbed in solution due to the saturation of binding sites of biosorbent.¹³ Therefore, the concentration of metal ions is a significant factor to be considered for effective biosorption.

3.2. Effect of pH

To study the effect of pH, three different pH of Cr (VI) solution was adjusted i.e. 2.5, 5 and 7 pH. The effect was investigated for both concentrations i.e. 40 $\mu g/l$ and 60 $\mu g/l$ of Cr (VI) solution. The Cr (VI) removal was observed with different pH of Cr (VI) solution with two biosorbents i.e. 'SLFS' and 'BG' for 60 min biosorption process. It was observed that the 2.5 pH was optimum pH for SLFS and 5 pH for BG. Result shows that the biosorption process for the removal of Cr (VI) is more efficient in acidic medium for both biosorbents (Figure.3 and Figure.4). The reason for this is, the pH of the aqueous phase is lowered, a large number of hydrogen ions can easily coordinate with the amino and carboxyl groups present on the biomaterial surface. Thus, a low pH makes the biomaterial surface more positive.¹⁵

3.3. Effect of adsorbent

The concentration of both the Cr (VI) metal ions and the biosorbent is a significant factor for effective biosorption. The rate of adsorption is a function of the initial concentration of ions.

The effect of biosorbent on the removal of Cr (VI) from aqueous solution was studied. For the observation equal amount of each biosorbent was used i.e. 5 g/l of 8/10 mesh size. It was found that the SLFS and BG both biosorbent gives better Cr (VI) removal efficiency with low concentrate Cr (VI) solution. It was found that BG gives efficient removal of Cr (VI) at 5 pH and it is 75% [Figure.5].

It may be the surface characteristic of BG is more favorable for Cr (VI) removal. This requires further study based on surface analysis such as Fourier Transmission Infra-Red (FTIR), Scanning Electron Microscopy (SEM) etc.

4. CONCLUSION

Based on the present investigation, it is concluded that the SLFS and BG biosorbent have efficient

biosorption capacity for Cr (VI) removal from aqueous solution. The removal is pH dependent. Both biosorbent works efficiently in acidic medium. The efficiency of SLFS was fairly high at 2.5 pH whereas with BG at 5 pH. Biosorption is fast with low concentration of initial Cr (VI) solution. It was found that BG shows efficient capacity to remove Cr (VI) in comparison to SLFS. Bagasse (BG) gives 75 % removal of Cr (VI) instead of 65% with SLFS biosorbent. Further study is required for more clarification such as characterization of biosorbent and kinetics.

5. REFERENCES

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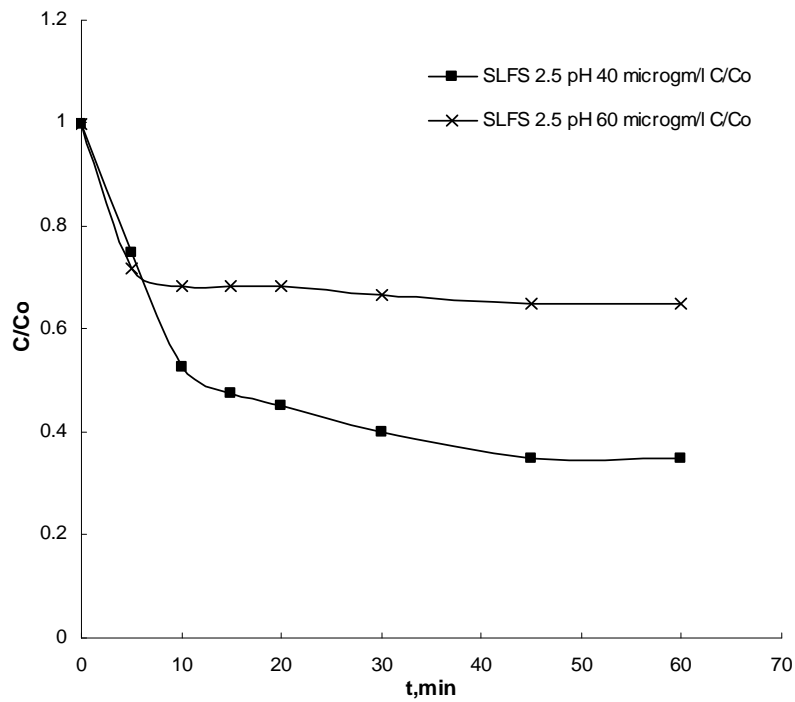


Figure 1. Effect of different concentration at 2.5 pH with SLFS biosorbent

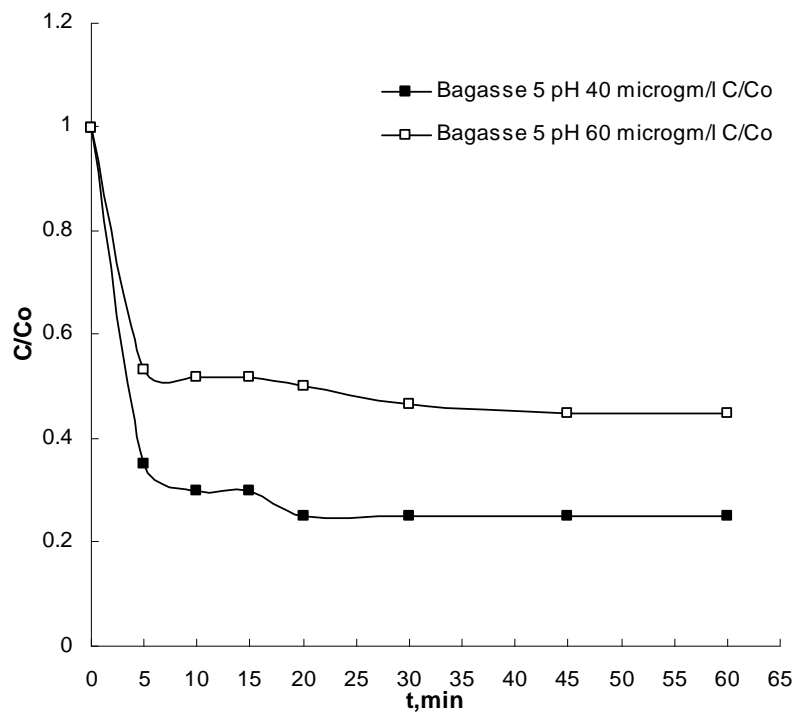


Figure 2. Effect of different concentration at 5 pH with BG biosorbent

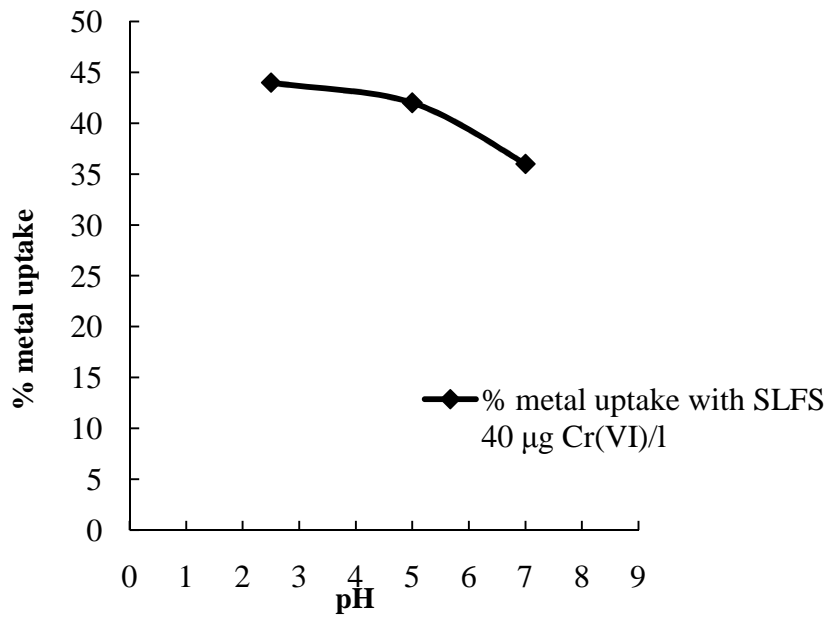


Figure 3. Effect of different pH with SLFS biosorbent

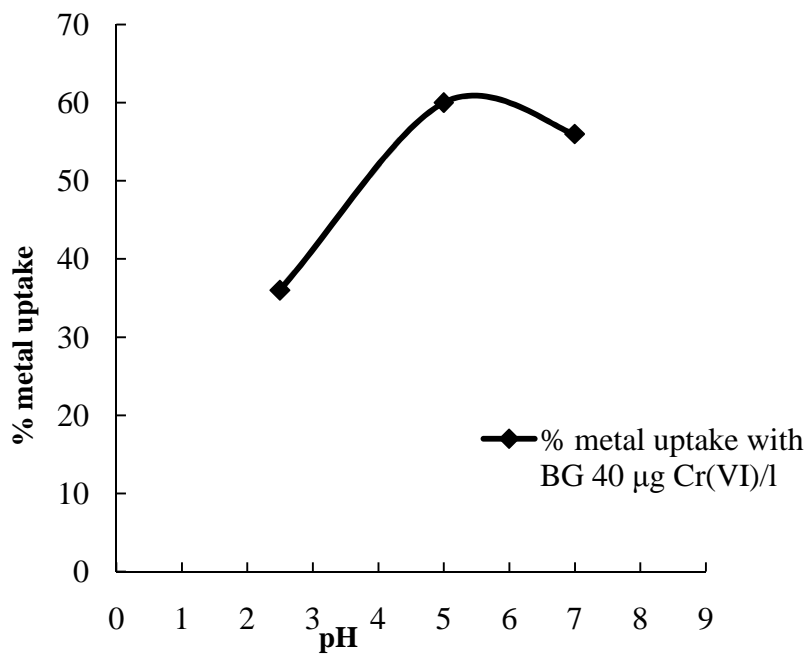


Figure 4. Effect of different pH with BG biosorbent

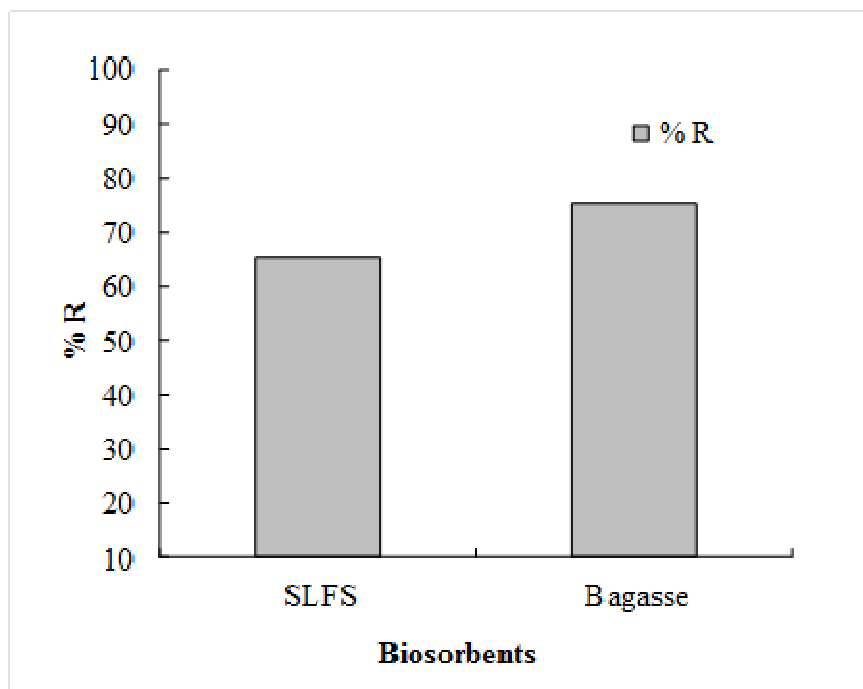


Figure 5. Percentage Cr (VI) Removal efficiency of biosorbent for SLFS and BG