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Original Research Paper

Biosorption of Chromium from Fortified Solution Using Biodross

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ABSTRACT

Biodross obtained from canteens, restaurants, public places and college messes, was used as a biosorbent for the toxic heavy metal chromium (VI) from the fortified solutions. At different physical conditions and parameters biosorption of chromium was studied. The sugarcane waste, carrot peels and banana peels show highest amount of adsorption at different pH, biomass and concentrations respectively.

INTRODUCTION

Heavy metal contamination due to the industrial activities like mining and metal processing can lead to heavy metal contamination in water bodies, where they enter the food chain, causing toxic effects (Sharma et al. 2005). The pollutants of concern include lead, chromium, zinc and copper. Heavy metals such as zinc, lead and chromium have number of applications in basic engineering works, paper and pulp industries, leather tanning, petrochemicals fertilizers, etc. (Dean et al. 1972). The hexavalent and trivalent chromium is often present in electroplating wastewater. Other sources of chromium pollution are leather tanning, textile, metal processing, paint and pigments, dyeing and steel fabrication (Kumar et al. 2013). Strong exposure of hexavalent chromium causes cancer in the digestive tract and lungs and may cause gastric pain, nausea, vomiting, severe diarrhoea, and haemorrhage (Qaiser et al. 2007, Kooner et al. 2014). These heavy metals are difficult to remove from the environment (Chauhan et al. 2014). The orthodox metal removal methods, i.e. precipitation, redox reactions, electrochemical processes, membrane treatments and ion exchange are extremely inefficient and expensive (Hantson et al. 2005) especially for large solution volumes at relatively very low concentrations. The emerging process of 'biosorption' uses nonviable or viable biological materials to bind contaminants via physico-chemical mechanisms, whereby factors like pH, size of biosorbent, ionic strength and temperature, influence the metal biosorption (Das et al. 2007). Effectiveness and the possibility of desorbing metals from the sorbent are the prime attributes of biosorption. Economical, naturally occurring materials like industrial wastes, household waste and canteen wastes can be used as biosorbents. The application of biosorption in environmental treatment has become a significant research area in the past ten years (Demirbas 2008).

In the present research work, the different type of biosorbents collected from canteens, restaurants and hostel's mess, were used for the purpose of biosorption of chromium from the fortified solutions.

MATERIALS AND METHODS

Collection of Biosorbents

The carrot peels, banana peels and orange peels were taken from juice corner; coconut coir, corn husk, corn fibre, ground nut shell and sugar cane wastes were taken from roadside vendors; cabbage wastes, onion wastes, and cucumber peels were taken from a hostel's mess (Fig. 1 to 11). The collected biowastes were washed, autoclaved and then dried in oven at 60°C for overnight, then powdered using a pestle and mortar and preserved in polythene bags for further experiments.

Biosorbents Used for Biosorption of Chromium

Preparation of solution

1. **Dichromate solution:** 0.282g of potassium dichromate was dissolved in 100 mL of distilled water and stored in a reagent bottle.
2. **Diphenyl carbazide solution:** 0.25 g of 1, 5-diphenyl

carbazide was dissolved in 50 mL of acetone, and transferred into a sterilized brown reagent bottle.

Biosorption by Various Biowastes

Biowastes in powdered form were taken for the experiment. This experiment was carried out with three parameters like different pH (2, 4, 7, 9), biomass (0.2g, 0.3g, 0.4, 0.5g) and concentrations (1:7, 2:6, 3:5, 4:4).

***Methodology*:** Test tubes were cleaned by using Cadepol and sterilized with the help of the autoclave. In case of pH, six sterilized test tubes were taken, three for test and three for control, then 4μL of dichromate solution and 4 mL of distilled water, adjusted at pH 2, were poured into the six test tubes and 0.2g of biowaste powder was added only into the three test tubes. All test tubes were covered with a sterilized cotton plug and kept for five days. After five days the test and control solution from all the test tubes was taken into a centrifuge tube and kept in a high speed centrifuge at 5000rpm and 25°C for 14 minutes. After centrifugation, the diphenyl carbazide method was used to measure the OD of solution by UV-visible spectrophotometer at 540nm. This process was repeated for pH 4, 7 and 9 respectively.

Similarly the above process was repeated for 0.3, 0.4, and 0.5g of biowaste powder. This process was also repeated for 1:7 concentration (one part of chromium solution and seven parts of distilled water), 2:6 (two parts of chromium solution and six parts of distilled water solution), 3:5 (three parts of chromium solution and five parts of distilled water), and 4:4 (four parts of chromium solution and four parts of distilled water) ratios respectively.

RESULTS AND DISCUSSION

Study of Biosorption by Various Biowaste Materials

Under different pH: Percentage of chromium removed at different pH values is shown in Fig. 12. In case of pH 2, sugar cane wastes shows good result that is 95.84% of chromium absorption, because it depends upon ion attraction. Here, the number of ions is more, so biomasses adsorb more ions. Orange peels adsorb low amount of ions, so the result shows the less percentage of chromium absorption that is 43.7 (Fig. 12). Due to this reason all the pH 4, 7, and 9 show low and high percentage of adsorption.

In case of pH, if chromium mix with water, then it forms chromate having negative ion. So negative ion combines with positive ion and it forms an acidic condition. Here, pH 2 and pH 4 show acidic condition.

Under varying weight of biowastes: Percentage of chromium removed by using different quantities of of biowastes is shown in Fig. 13. Biosorption of carrot peels shows good

Fig.1: Onion waste.

Fig. 2: Corn fibre.

Fig. 3: Groundnut shell.

Fig. 4: Sugarcane waste.

Fig. 5: Corn husk.

Fig. 6: Cabbage waste.

Fig. 7: Cucumber peel.

Fig. 8: Banana peel.

Fig. 9: Orange peel.

Fig. 10: Carrot peel.

Fig. 11: Coconut coir.

result that is 94.39% of chromium absorption at 0.2g and ground nut shell shows 34.78% of chromium absorption. If biomass increases, the absorption percentage also increases, when the surface area increases then it can absorb more ions. Due to this reason all the 0.3, 0.4 and 0.5g show low and high percentage of adsorption.

Under different concentration: Percentage of chromium removed under different ratios of chromium is shown in Fig. 14. If the solution concentration increases and biomass remain same, then the amount of ion also increases in solution. So biomaterial cannot absorb more amount of ions. In case of 1:7, banana peels absorb more percentage of ion that is 97.88, and orange peels absorb low percentage of ions that is 50. Due to this reason all the concentration 2:6, 3:5 and 4:4 show low and high percentage of absorption.

From earlier studies we found that, many experiments done on biosorption of chromium by using agricultural bio waste like banana skin, rice husk, peanut shell, walnut shell, almond shell, tamarind pod shell, pistachio hull powder, jambol carbon and oak leaf etc. In case of banana, one gram of banana peel could reduce 249.6 (±4.2) mg of Cr (VI) at initial pH 1.5 (Donghee Park et al. in 2008). Waleska et al. (2008), used coffee husks and found that, it adsorbs 79 to 86% of chromium. In earlier studies, orange peels used as an adsorbent for chromium and it showed a 77.60% of adsorp-

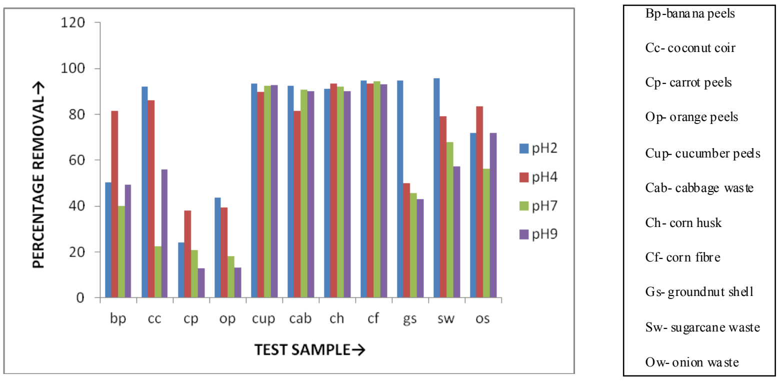

Fig. 12: Percentage of chromium removed at different pH.

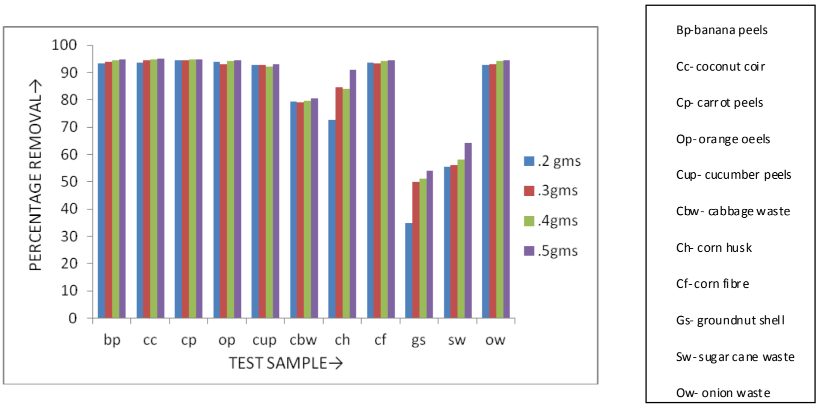

Fig. 13: Percentage of chromium removed under varying weight of the biowaste.

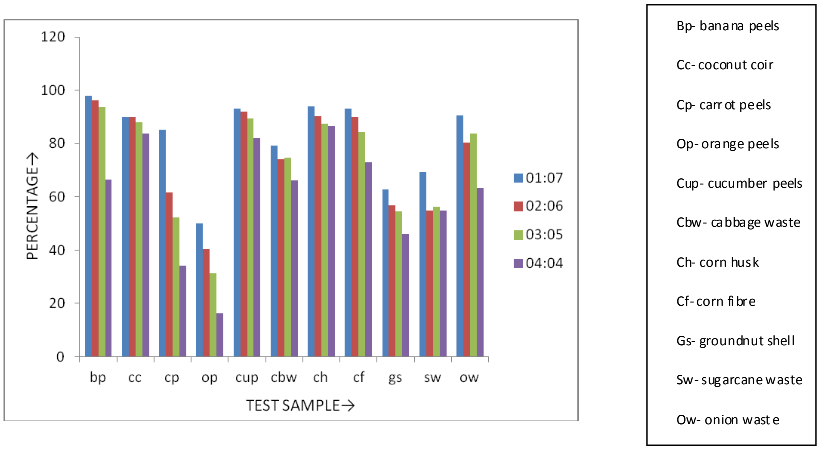

Fig. 14: Percentage of chromium removed at different concentration of Cr.

tion (Pavan et al. in 2006). Also in case of coconut coir, the results shown by the coir was amendable and it showed a 76.3mg/g adsorption of chromium (Namasivayam et al. in 2008). Garg et al. (2009), found that sugarcane adsorb chromium from an aqueous solution of 50 mg/L at an adsorbent dose of 20 g/L at pH 2.0. When peanut shells are used as a biosorbent, it showed adsorption of 27.86 mg Cr^{3+} per 1g biomass (Anna Witek-Krowiak et al. 2011).

In earlier studies, eggshells were also used as an adsorbent and they were able to remove Cr (III) at the initial concentration of metal ions 100 mg/kg, at sorbent concentration of 15 g/L (Chojnacka 2005). In case of agricultural waste like rice husk carbon, it has the capacity to adsorb 91.75% of Cr (VI) at pH 2.0 (Bansal et al. 2009). Bansal et al. (2009) studied that saw dust carbon can adsorb 94.33% of Cr (VI) at pH 2.0. In earlier studies on tamarind wood carbon as a biosorbent, it can adsorb chromium (VI) 28.019 mg/g (Jyotikusum Acharya et al. 2009). Xu et al. (2011), used amine-cross linked wheat straw for biosorption of chromium and they found that it adsorbed 74.8% of Cr (VI). Chand et al. (2009), used grape waste as biosorbent material, and it shows that grape waste has maximum loading capacity of 1.91 mol/kg at pH 4. Wheat stem and *Acacia* bark were used as agro waste carbons to remove nickel from the effluent of the electroplating industry. Electroplating wastewater showed 2%-10% lower removal as compared to the synthetic solutions in similar conditions. Also chicken feathers were used for biosorption of chromium (Ishikawa et al. 2004).

CONCLUSION

From the present study, biowaste material can remove toxic heavy metal like chromium from contaminated water. It shows around 98% removal, while in earlier studies the highest percentage removal was below 95%. Biowastes like vegetable wastes and fruit wastes are economically better source in respect to the presently used methods for the purpose of biosorption. Among eleven biowastes, sugarcane waste, coconut coir, banana peels, and carrot peels show better results for the removal of chromium from the synthetic solutions. These biowaste materials remove high percentage of chromium from the solutions under different physical conditions. On studying different pH conditions, the biosorption efficiency showed better results in the acidic conditions. Under varying biomass of the waste material the biosorption efficiency increases with increase in the weight of the biomass. In the condition of varying concentration of chromium solution, the percentage efficiency of biosorption decreases with increase in the concentration of chromium.

The biowaste materials i.e., banana peels and ten other biowaste materials used in present research can remove toxic heavy metals like chromium from polluted environment and these biowastes are the eco-friendly, cost effective and vital source for the purpose of biosorption of chromium from the water bodies and from the contaminated sites.

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