



Novel approach to use food waste for detoxification of Cr (VI) from aqueous solutions

Shruti B Mhaske, Mrunal S Joshi, Kulkarni RA

Department of Microbiology, Government College of Arts and Science, Aurangabad, Maharashtra, India

Abstract

Pollution has become a major issue due to its impact on environment. One of the major cause for pollution is the rapid industrialization. The effluent discharged from the industry have adverse effect on environment. Due to development there is also increase in various types of industries like paint, tanning, electroplating etc. These industries contains Cr (VI) in its effluent that contaminate water as well as soil. As hexavalent chromium is in dissolved form it is more toxic to living cells. So there is a need to detoxify it from effluent before allowing it to enter in soil and water resources. In this paper household kitchen residues are used for the detoxification of hexavalent chromium from the metal containing solution. The household waste material like Tea powder, Egg shells, Coconut coir, Orange peel and Sugarcane bagasses is used to detoxify Cr (VI) from metal solution. The residual chromium was estimated by an assay performed using 1, 5-Diphenyl Carbazide (DPC) method.

Keywords: hexavalent chromium, household residue, DPC method

Introduction

As the growing pollution has become an important issue for the living beings so it has become very necessary to control it. One of the major cause of pollution is growing industrialization. Most of the effluent of industries are discharged in the river or soil which causes ill effects on living beings. Metal contamination is one of the serious issue caused by industrialization. The metals can inhibit toxicity when they are present above its threshold concentration. Many metals are discharged like Cd, Hg, lead, arsenic, Cr etc. Chromium is one of the important metal in the effluent of the industries like tannery, paint, electroplating etc which is of concern. Chromium pollution leads to severe adverse effect on the human health (nausea, vomiting, lung cancer etc), aquatic life (reduction in fish production) (D.K. Singh, B. Srivastava and R.K. Bharadwaj. 2001) ^[1], and is one of the source of the contamination of soil and water. Chromium concentration that is permissible for health consideration is <0.1 ppm (Environment Protection Agency, 2018) ^[2]. The Cr is present in two form i.e Trivalent and Hexavalent. Hexavalent chromium (Cr⁶⁺) due to its solubility in water is more toxic to living system than the Cr (III). So it has become a keen issue to detoxify the chromium and convert the Cr (VI) to Cr (III) form. The Hexavalent chromium exposure can cause severe problems in human beings like respiratory infections, ulceration of skin, allergic dermatitis, transformation of mammalian cells (Bock, M., Schmidt, A, Bruckner, T., & Diepgen, T.L. 2003) ^[10].

Chromium detoxification can be done by using various chemical and physical methods. The methods such as ion exchange, reverse osmosis, electrochemical reduction and precipitation. The use of chemical and physical methods are cost expensive. There are also other methods like solvent extraction, chemical precipitation etc. All these methods are expensive very sophisticated and require chemicals hence to

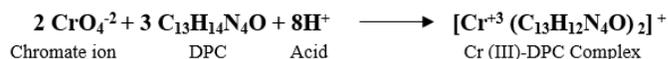
overcome this problem of cost the household residue can serve as a potential detoxifier for the detoxification of the chromium. As the household materials are least toxic to the environment they are waste we can use them effectively. Various residues like tea leaves (Saranya Kuppasamy, Palanisami Thavamani, Mallavarapu Megharaj *et.al.* 2016) ^[3] and mango and neem leaves (BI Shahin, PD Gayatri, VR Aboli, MA Sonali, SC Madhuri, 2007) has been used. In current study we have used different household residues like tea powder, coconut coir, egg shells and sugarcane baggase for the detoxification of hexavalent chromium. Thus the use of household residues for chromium detoxification will serve Reuse, Recycle and Reduce.

Materials and Methods

Principle

Cr (VI) reacts with 1, 5-diphenyl Carbazide dye, in acidic condition which forms the purple color. As a result of a redox reaction, Cr (VI) is reduced to Cr (III), and DPC is oxidized to 1, 5-diphenylcarbazone (DPCA). Cr (III) and DPCA forms a purple color species with lambda max of 540 nm. (Annija Lace, David Ryan, Mark Bowkett and John Cleary, 2019)

Reaction



Materials

Household residues (Tea powder, Egg shells, Coconut coir, Sugarcane bagasses, Orange Peel), Sulphuric acid: Water, Ortho phospheric acid (1:1), 1,5-Diphenyl Carbazide reagent (DPC), Distilled Water, Potassium dichromate stock solution (100 ppm).

Methods

Estimation of Chromium

Standard solution of Potassium dichromate was prepared with different concentration form (10-100 ppm) by the DPC method (In this method 1ml supernatant, 0.5 ml Sulphuric: Water, 0.1 ml Ortho phosphoric acid, 8.5 ml Distilled water, 0.5 ml DPC reagent) and the graph was plotted at 540 nm.

Preparation of Matrix:

1. Tea Powder, Orange Peel and Egg shells

The Above matrixs were crushed and used in powdered form

2. Coconut coir and Sugarcane Bagasses

Above Matrixs were cut in simple shape of equal size and used

Study of various parameters on Cr (VI) sorption and assayed by 1, 5-Diphenyl Carbazide reagent

1. Effect of biomass on percent sorption of Cr (VI)

To study the effect of intial biomass concentration the flasks containing 100 ml of 100 ppm Cr (VI) solution were inoculated with different percent of residues (0.5, 1.0, 1.5, 2.0, 2. 5%). The flasks were then incubated at 37°C on shaker at 100 rpm for 1h. After 1h the sample was removed and centrifuged at 8000 rpm. Then the supernatant was collected and analyzed for percent sorption using DPC method.

2. Effect of Cr (VI) concentration on percent sorption

To study the effect of initial Cr (VI) concentration flasks containing different Cr (VI) solution were prepared (20, 40, 60, 80, 100 ppm). The flask were inoculated with 1% residue. The flasks were incubated at 37°C on shaker for 1h at 100 rpm. After 1h the sample was removed and centrifuged at 8000 rpm and analyzed for percent sorption

using DPC method.

3. Effect of Holding Time of Cr (VI) on percent sorption

To study the holding time on percent sorption flask containing 100 ml of 100 ppm stock of Cr (VI) were inoculated with 1% residues. The flask were incubated on shaker at 37°C at 100 rpm for different time intervals (30, 60, 90, 120, 150 mins). After particular time the sample was centrifuged at 8000 rpm and the supernatant was collected and analyzed for percent sorption using DPC method.

4. Effect of pH on percent sorption of Cr (VI)

To study the effect of pH on percent sorption flask containing different pH of Cr (VI) solution were prepared (pH 3, 5, 7, 9, 11) (which were adjusted by 1N NaOH and 0.1 N HCL). The flask were inoculated with 1% residue. The flask were incubated at 37°C on shaker for 1h at 100 rpm. After 1h the sample was removed and centrifuged at 8000 rpm and supernatant was collected and analyzed for percent sorption by using DPC method.

5. Effect of Holding Temperature on percent sorption of Cr (VI)

To study the effect of holding temperature on percent sorption flask containing 100 ml 100 ppm stock of Cr (VI) were inoculated with 1% residues. The flasks were incubated at different temperature (10, 20, 30, 40, 50°C) for 1 h. Then the sample was centrifuged at 8000 rpm and the supernatant was collected and analyzed for percent sorption by DPC method.

Result and Discussion

Following results were obtained for growth independent percent sorption by using Cr (VI) by using home residues:

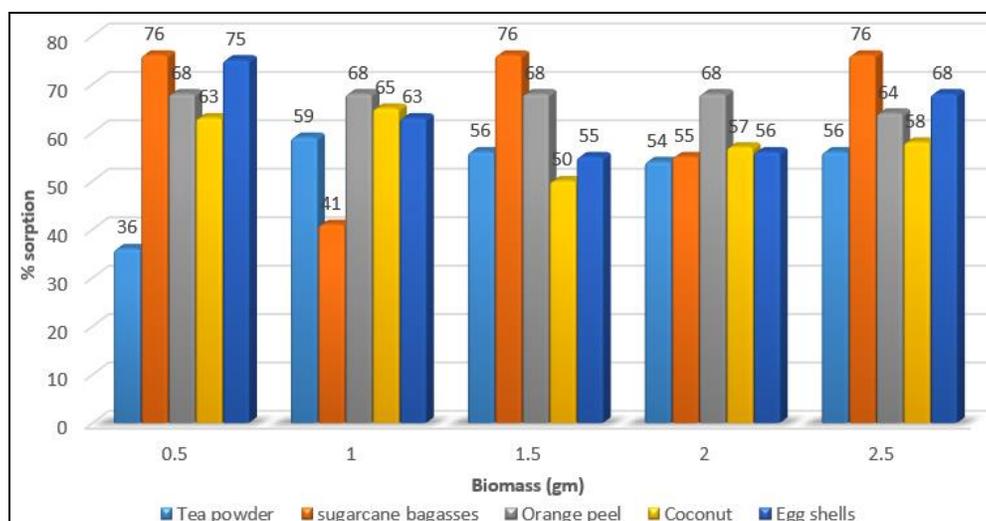


Fig 1: Effect of biomass on percent sorption of Cr (VI)

Results of Initial biomass of matrix on Cr (VI) percent sorption are shown in the graph 1. From the graph it can be concluded that when tea powder matrix was used increase in

biomass showed increase in percent sorption till 1.5 gm after that increase in biomass concentration showed constant sorption. 0.5 gm of sugarcane bagasses and orange peel,

coconut coir and egg shells gave maximum sorption and was constant thereafter.

Fourest and Roux (1992) [6] suggested that increase in the biomass concentration leads to the interface between the binding sites. So, this factor needs to be taken into the

consideration in any application of biomass as a bio sorbent. While comparing above matrix it was observed that sugarcane bagasses, orange peel were found to be good matrix for Cr sorption and tea powder was found to be very poor matrix for sorption.

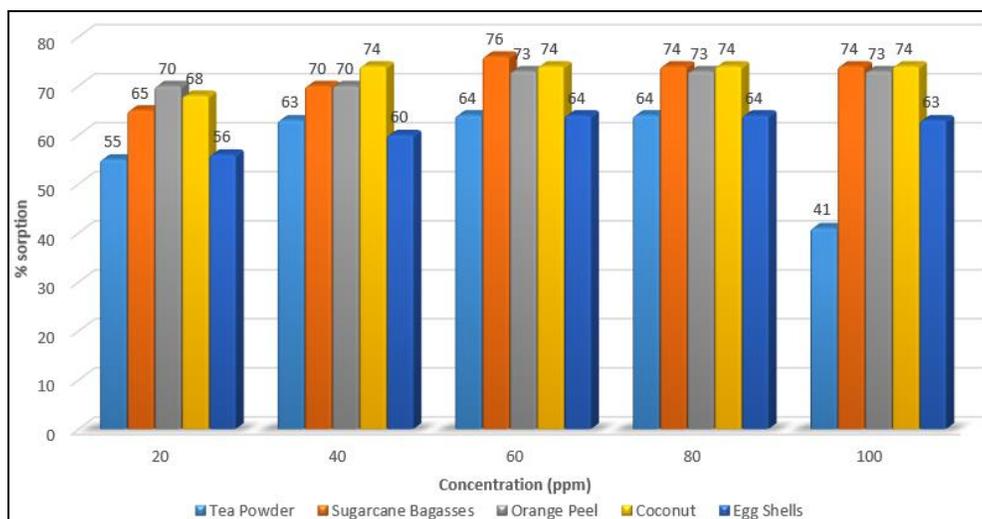


Fig 2: Effect of initial Cr (VI) concentration on percent sorption

Result of initial concentration of matrix on Cr (VI) percent sorption are shown in the graph 2. From the graph it can be concluded that when the tea powder matrix was used increase in concentration showed increased in percent sorption till 80 ppm after that increase in concentration showed decrease in sorption. Matrix like sugarcane bagasses, orange peel, coconut

coir and egg shells showed increase in sorption with increase in concentration till 80 ppm and was constant thereafter. While comparing it was found sugarcane bagasses, orange peel, coconut coir and egg shells were found to be good matrix for Cr sorption then tea powder.

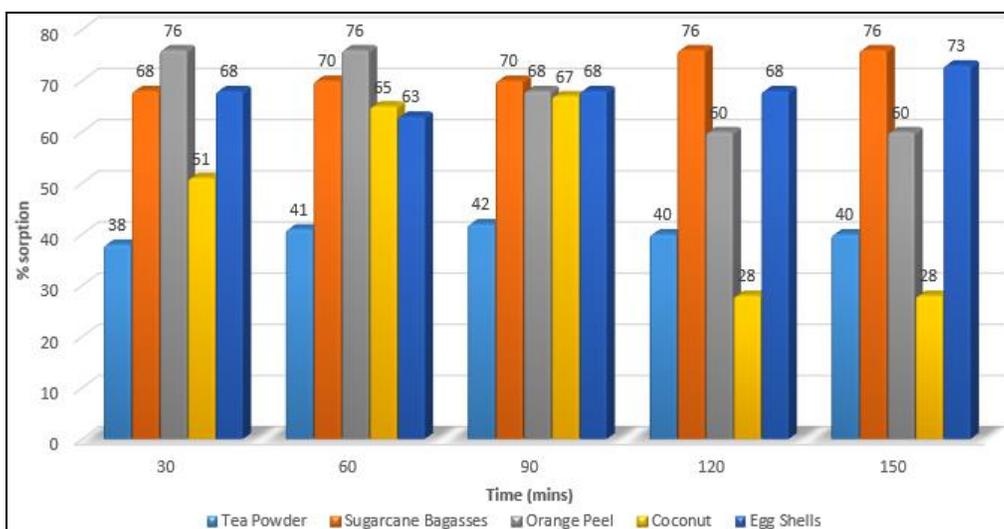


Fig 3: Effect of Holding Time of Cr (VI) on percent sorption

Result of holding time of matrix on Cr (VI) percent sorption are shown in the graph 3. From the graph it can be concluded that when tea powder, orange peel and coconut coir were used it showed increase in sorption with increase in the time till 60-90 mins which was decreased there after though the time was increased. Sugarcane bagasses and egg shells showed increased in sorption with increase in time but after time 90 mins after increase in time showed the constant sorption. It

can be concluded that maximum sorption can be obtained within less time. Greater amount of adsorbate will be retained on the surface of the adsorbent after the time is increased. Since a greater interaction is produced between the adsorbate and the surface, the adsorption will increase. The adsorption of Cr (VI) increases with increasing the time. (R.K. Srivastava, A.K. Ayachi and Mona Mishra, 2001) [1].

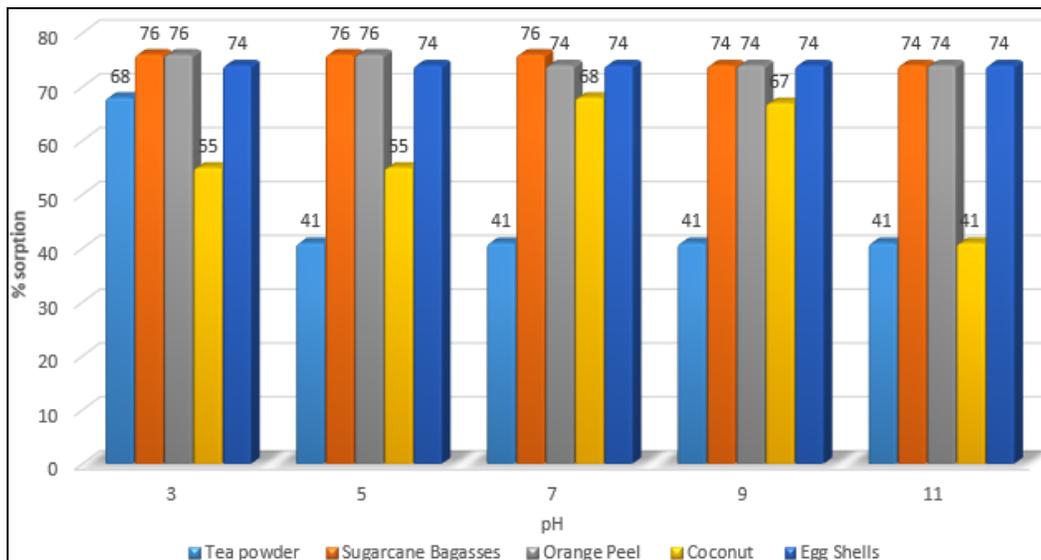


Fig 4: Effect of pH on percent sorption of Cr (VI)

Results of pH of matrix on Cr (VI) percent sorption are shown in graph 4. From the graph it can be concluded that when tea powder matrix was used it showed maximum sorption at acidic pH (3) which was decreased thereafter when the pH was increased. When sugarcane bagasses, orange peel and egg shells matrix was used it showed constant sorption at all the pH level. When Coconut Coir was used it showed its maximum sorption at the alkaline pH. It can be concluded that sugarcane bagasses, orange peel and egg shells can be used to treat any effluent of any pH. Hydrogen ion concentration of solution seems to be the important parameter in the sorption

process. pH affects the solution chemistry of the metal i.e activity of the matrix and the competition of the metallic ions. One of the reason for the better adsorption observed at low pH values may be attributed to the large number of H⁺ ions present at these pH values, which in term neutralize the negatively charged hydroxyl groups (-OH) on the adsorbed surface thereby reducing hindrance to the diffusion of chromate ion. (Sohail Ayub, S.I.Ali and N.A. Khan, 2001) [9] The increase in metal binding with increasing pH could be due to formation of metal hydroxides, reducing the free metal ions available for sequestration.

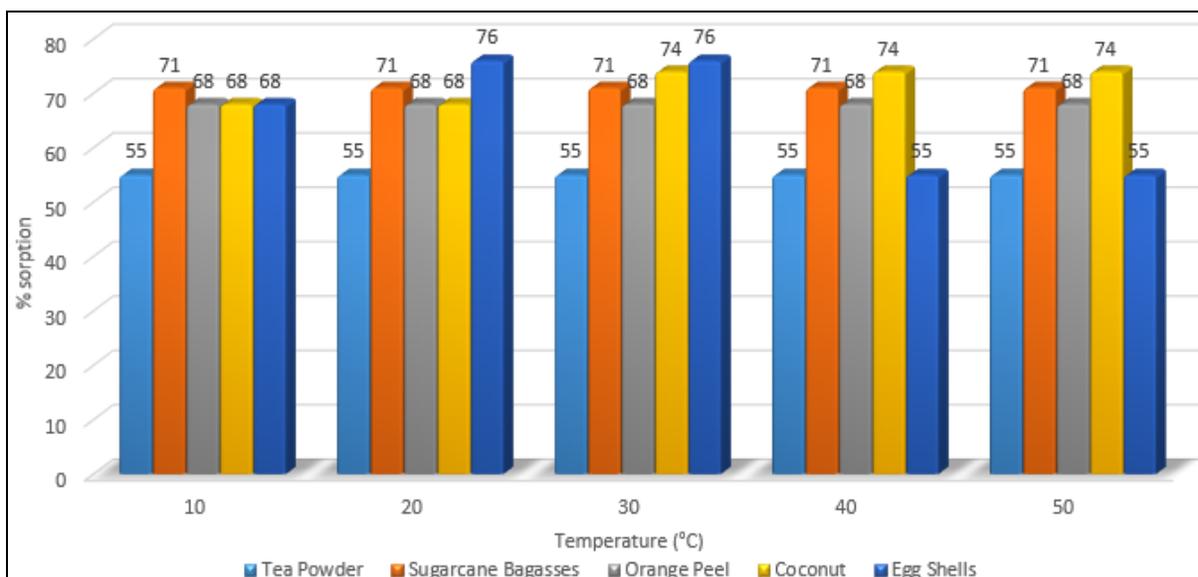


Fig 5: Effect of Holding Temperature on percent sorption of Cr (VI)

Result of holding temperature of matrix on Cr (VI) percent sorption are shown in graph 5. From the graph it can be concluded that when the matrix like tea powder, sugarcane bagasses and orange peel were used it showed constant sorption at all the temperature. When matrix like coconut coir and egg shells were used it showed increase in sorption with

increase in temperature they showed maximum sorption at the optimum temperature which was decreased with further increased in temperature. It was observed that adsorption increases with increasing temperature. The increase may be due to an increase in temperature may bring about an increase in number in active sites on the adsorbent surface also and this

will consequently lead to an increase adsorption. (R.K. Srivastava A.K. Ayachi and Mona Mishra, 2001) ^[1]. High temperature may break the matrix.

Conclusion

Various methods are used to detoxify hexavalent chromium. Among these waste from kitchen or plant residues are prominent one. It includes various matrices like bidi leaves (R.K. Srivastava et.al. 2001) ^[1], tea powder (D.K. Singh et.al., 2001) ^[1], sugarcane bagasses (Sohail Ayub et.al., 2001) ^[9]. In this study Cr (VI) detoxification was studied using various parameters on Cr (VI) sorption. It was observed that sugarcane bagasses, orange peel, egg shells and coconut coir have capacity to absorb chromium in acidic or alkaline pH so they can be employed on different types of effluents from industries with different pH. It was observed that the matrix gave maximum sorption at 30 °C hence can be used at room temperature. Waste from the kitchen is helpful in controlling the pollution.

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