

REMOVAL OF Cr (VI) USING ORANGE PEEL AS AN ADSORBENT

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ABSTRACT

The presence of heavy metals in the environment causes adverse impacts on the earth. One useful solution for the elimination of Cr (VI) from the environment is the treatment of wastewater using an efficient method, adsorption, before being discharged into the aquatic systems. Adsorption is one of the efficient and effective method for the removal of heavy metals with a suitable low cost adsorbent. The development of low cost adsorbent is essential for the benefit of the common people. At present, batch experiments are conducted to determine the amount of Cr (VI) removal from the aqueous solutions. From this, effect of various parameters such as pH, contact time, adsorbent dosage and initial concentration for the adsorption of Cr (VI) on orange peel is investigated. Maximum Cr removal achieved at an agitation time of 150 min, pH of 2, and initial concentration of 10 mg/l.

Keywords: - Chromium VI, orange peel, Adsorbents

1. INTRODUCTION

The discharge of heavy metals into the environment has been increasing continuously due to rapid industrialization and has created a major global concern. Chromium and its compounds are toxic metals introduced into natural water from a variety of industrial wastewater. Cr (VI) refers to chemical compounds that contain the element chromium in the +6 oxidation state. Chromium is a lustrous, brittle, hard metal. Its colour is silver-gray and it can be highly polished. It does not tarnish in air, when heated it burns and forms the green chromic oxide. Chromium is unstable in oxygen, it immediately produces a thin oxide layer that is impermeable to oxygen and protects the metal below. Cr (VI) is used in various fields, mainly in textile dyes, wood preservation, and as anti-corrosion and conversion coatings and a variety of niche uses. Chromium hexavalent compounds exist in several forms. Industrial uses of hexavalent chromium compounds include chromate pigments in dyes, paints, inks, and plastics; chromates added as anticorrosive agents to paints, primers, and other surface coatings; and chromic acid electroplated onto metal parts to provide a decorative or protective coating. Hexavalent chromium can be formed when performing "hot work" such as welding on stainless steel or melting chromium metal. In these situations the chromium is not originally hexavalent, but the high temperatures involved in the process result in oxidation that converts the chromium to a

hexavalent state. Conventional technology for removing Chromium from water and wastewater involves the precipitation, coagulation, filtration and separation of Chromium by settling the coagulants. These conventional methods are ineffective for the removal of Cr (VI) where adsorption is an economically feasible alternate [8].

2. MATERIALS

Orange peel is the material used as an adsorbent for the removal of Chromium (VI). Orange peel is an attractive and economic alternative for the removal of metal ions from waste water. Orange peels are excellent for the skin. Most of people waste orange peels because lack of knowledge about benefits of peels. The main components of orange peel are cellulose, pectin, hemicelluloses and lignin which contain functional groups as possible binding sites for metals. The natural adsorbent is collected from the local market.



Fig 1. Orange peel

3. METHODS

3.1 Adsorbent preparation

Orange peels were cut into pieces and dried under sunlight for 3 weeks. 10g of dried orange peel were taken along with 2 litres of distilled water and wash properly to remove the impurities. After washing and filtration the orange peels were oven-dried at 60°C – 80°C for 24 hours. The dried orange peels were powdered and stored.



Fig 2. Orange peel powder

3.2 Preparation of stock solution and Reagent

Stock solution is prepared by dissolving 141.4 mg of $K_2Cr_2O_7$ in 100 ml distilled water. Diphenylcarbazide Solution is the reagent used for the removal of Chromium. For this dissolve 250 mg of 1, 5-diphenylcarbazide in 50 ml acetone and stored in a dark room.

4. EXPERIMENTAL SETUP

4.1 Jar Test Apparatus

Jar test has been used to determine the optimum pH. The dosage of adsorbent is 1g. The pH values provided are 2, 4, 6, 8, 10, 12, 14. The jar apparatus has six beakers and six steel paddles which help in the agitation process. The stock solution of 800 ml is taken in each beaker. The initial speed of agitation is 100 rpm for 2 min, followed by 40 rpm for 30 min. The settling time applied for this coagulation process is 30 min. The pH is determined by pH meter. Optimum pH obtained is 2.

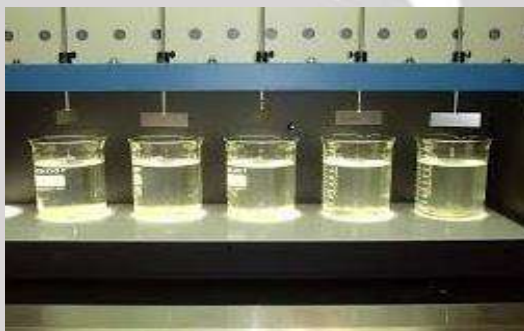


Fig 3. Jar Test Apparatus

4.2 Spectrophotometer

Chromium ions are detected using a spectrophotometer. The basic principle used in a spectrophotometer is that each compound absorbs or transmits light over a certain range of wavelengths. Different concentrations of chromium stock solutions were tested in the spectrophotometer and the optimum concentration is found out.



Fig 4. Spectrophotometer

5. SAMPLE ANALYSIS

10 ppm of chromium standard solution is taken in 100 ml conical flasks and distilled water was added to make up to mark. Then 1 g of the adsorbent was added to each of the conical flasks and agitated for different time intervals of 30, 60, 90, 120 and 150 min, respectively. After 30 min of agitation the solution was filtered with Whitman filter

paper No. 42. From the filtered solution 10 ml of the sample was taken in 50 ml volumetric flask and to make it up to the mark, the distilled water was added. 10 ml of sample was pipette out from the volumetric flask in to a conical flask and 2 ml of concentrated sulphuric acid (H_2SO_4) and 2 ml of 0.5% Diphenyl Carbazide were added to each of the conical flasks. Absorbance of Cr is measured at wavelength of 560 nm. Same procedure is carried out with different time intervals of 60, 90, 120, 150 min, and with different doses of adsorbent of 2 g and 3 g.

Removal efficiency can be calculated from the formula:

$$\text{Efficiency (\%)} = \frac{\text{Initial concentration} - \text{Final concentration}}{\text{Initial concentration}} \times 100$$

5.1 Preparation of Calibration curve

For the preparation of calibration curve different concentrations of stock solutions were analyzed (10ppm, 20ppm, 30ppm, 40ppm, 50ppm) in the spectrophotometer. The absorbance readings were obtained at 560nm and they are noted as shown in the table below. Using these values calibration curve was plotted.

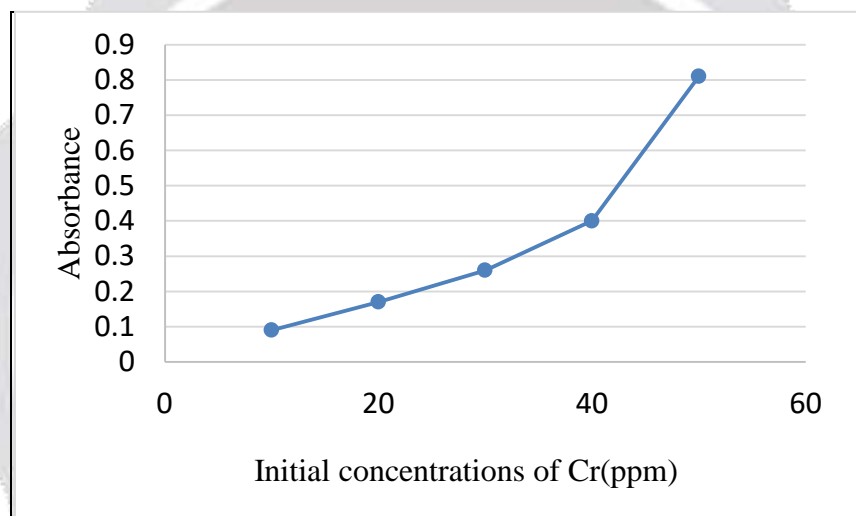


Fig 5. Calibration curve

6. RESULTS AND DISCUSSION

Stock solution was treated with natural adsorbent, orange peel powder. Different characteristics were analyzed.

6.1 Effect of Adsorbent Dosage

One of the parameters that strongly affect the sorption capacity is the dosage of the adsorbent. Effect of adsorbent dosage of 1g, 2g, 3g, 4g, and 5g were analyzed.

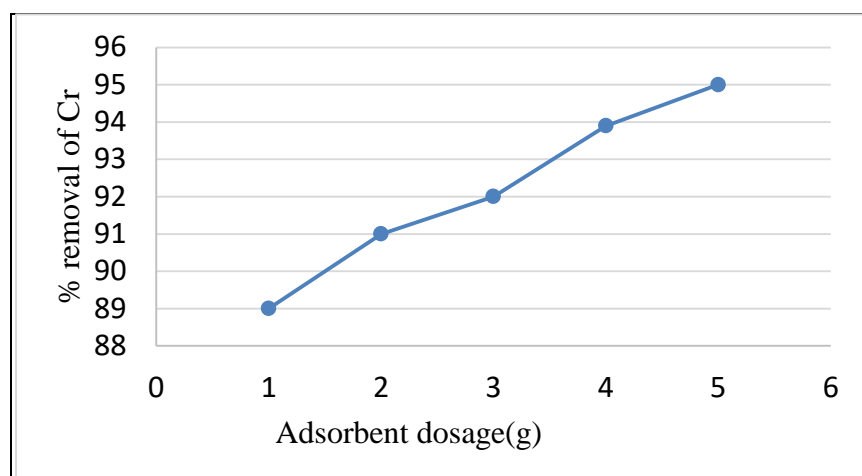


Fig 6. Effect of adsorbent dosage

The percentage removal of metal ions increases with increasing weight of adsorbent. For a fixed initial adsorbate concentration, increasing adsorbent dose provides greater surface area or more adsorption sites. Then it can be attributed to the binding of metal ions onto the surface. After certain adsorbent dosage the maximum removal efficiency of 95% achieved at an adsorbent dosage level of 5g. At an adsorbent dosage of 3g, the graph only shows slight increase due to the competition of Chromium ion for the sites available.

6.2 Effect of Agitation Time

The experiment is carried out at different agitation time of 30min, 60min, 90min, 120min and 150min.

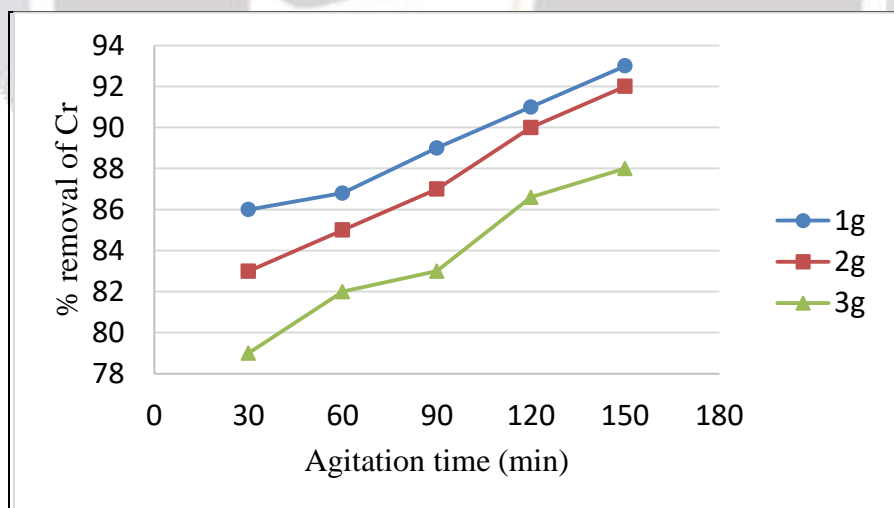


Fig 7. Effect of agitation time

The removal of Cr ions increases with agitation time. Rate of percent metal removal is higher in the beginning due to a larger surface area of the adsorbent being available for the adsorption of metal and a high concentration gradient. After the active sites of the adsorbent gets exhausted, the rate of uptake is controlled by the rate at which the adsorbate is transported from the exterior to the interior sites of the biosorbent particles. Maximum removal efficiency is achieved at an agitation time of 150 minutes.

6.3 Effect of Concentration of Chromium

The efficiency of Cr (VI) removal was affected by the initial metal ion concentration. The experiment is carried out at an increasing Chromium concentration of 10 mg/l, 20 mg/l, 30 mg/l, 40 mg/l, and 50 mg/l.

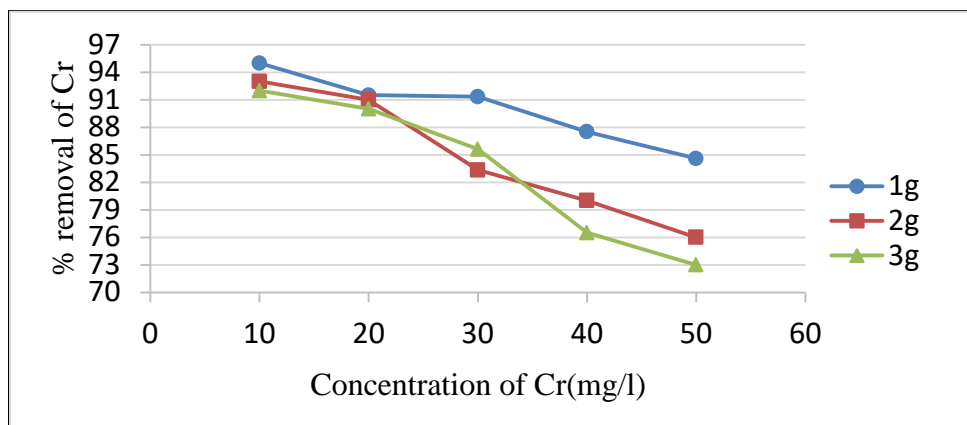


Fig 8. Effect of concentration of Chromium

The efficiency of Cr (VI) removal was affected by the initial metal ion concentration. The experiment is carried out at an increasing Chromium concentration of 10 mg/l, 20 mg/l, 30 mg/l, 40 mg/l, and 50 mg/l. As the concentration of Chromium increases % removal decreases. At low concentrations, metals increasing are absorbed by specific sites, while with increasing metal concentrations the specific sites are saturated and the exchange sites are filled. And also lower initial concentration sufficient adsorption sites are available for adsorption of chromium ions and at higher concentrations the chromium ions will be more than the available adsorption sites. Thus maximum percentage of removal obtained. Maximum % removal efficiency obtained at 10 mg/l.

6.4 Effect of pH

One of the parameters that strongly affect the sorption capacity is the pH. The experiment is carried out in different pH 2,4,6,8,10,12,14.

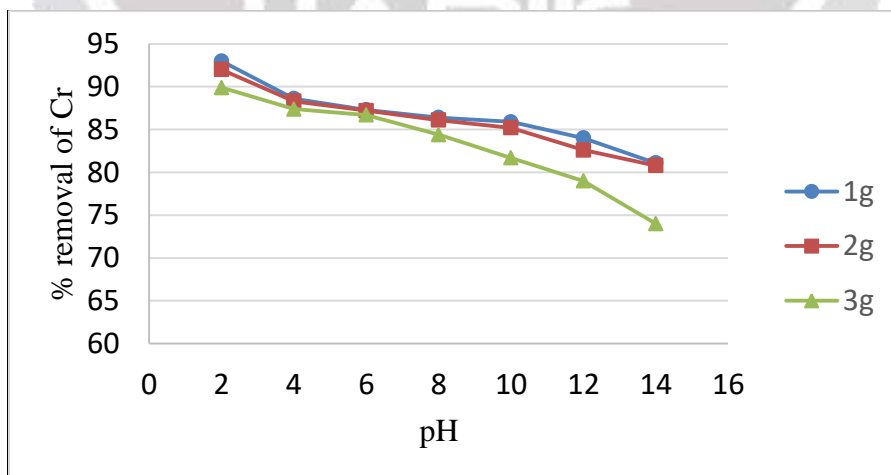


Fig 8. Effect of pH

The maximum percentage removal of chromium (VI) ions on the adsorbent was observed at pH 2 and significantly decreased at higher pH values. Better adsorption capacity observed at low pH values due to the large number of H⁺ ions present at these pH values, which in turn neutralize the negatively charged hydroxyl group (OH⁻) on adsorbed surface thereby reducing the hindrance to the diffusion of dichromate ions. At higher pH values, the reduction in adsorption may be possible due to abundance of OH⁻ ions.

7. CONCLUSIONS

Low-cost adsorbents require simple alkali/and or acid treatment. According to the pH variation studies the adsorption process is highly pH dependent. The effect of various process parameters showed that the percentage of adsorption decreased with increase in initial metal ion concentration, pH etc... Cr removal efficiency increases with increase in agitation time and adsorbent dosage. Maximum Cr removal achieved at an agitation time of 150 min, pH of 2, initial concentration of 10 mg/l. Orange peels can be used as efficient adsorbent for Cr (VI) removal from waste water. This adsorbent is not effective for the treatment of large waste water volumes.

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