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# Role of Rice Husk Silica Powder for removing Cr (VI) in a Tannery Industry Wastewater

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**Abstract:** Present study dealt the removal of Cr (VI) in a tannery industry wastewater using rice husk silica powder as adsorbent. The experimental investigations have been carried out by using rice husk silica powder for different adsorption dosage, different contact time, different agitation speeds and different concentrations (dilution ratios). The results showed that the maximum percentage removal of Cr (VI) in the tannery industrial wastewater at an optimum adsorbent dosage of 15 g, contact time of 150 min., agitation speed of 750 rpm and dilution ratio of 5. Further, the experimental data on removal of Cr (VI) from tannery industry wastewater was validated with the Cr (VI) aqueous solution of same initial concentration of tannery industry waster. Thus, the adsorption method using rice husk silica powder was used effectively for removing Cr (VI) in the tannery industrial wastewater.
**Keywords:** Adsorption, Magnetic Stirrer, Tannery Industry Wastewater, UV Spectrophotometer

## Introduction

Chromium is one of the heavy metals used by modern industries like plastic, pigment, wood preservative, electroplating, leather tanning, cement, mining, dyeing and fertilizer. The wastewater from these industries contains both Cr (III) and Cr (VI). Among them, Cr (VI) is highly toxic, which is carcinogenic that cause lung cancer, as well as kidney, liver and skin damage in human beings and Cr(III) is an essential micronutrient in trace amounts necessary for carbohydrate, lipid and protein metabolism[1]. In addition to chromium, wastewater generated from these industries contains much higher concentrations of properties like total dissolved solids, suspended solids, phenols, chlorides, ammonia, and other heavy metals[2]. The discharged wastewater is generally contaminated the surface water and groundwater, results increased water pollution. The maximum permissible limit of chromium content in drinking water is 0.05 mg/L[3]. Recently, increasing awareness of water and wastewater pollution and its far reaching effects has prompted concerted efforts towards pollution abatement.

There are several processes that can be adopted for the treatment of tannery wastewater such as chemical coagulation[4], precipitation, reduction, adsorption[5,6,7,8], reverse osmosis, nano-filtration, constructed wetland[9], biodegradation etc. But due to certain limitations the above mentioned methods, an alternative method was pursued to treat the effluent coming from the tannery industry. One such method is adsorption method[10,5,8]. In this method, the pollutants or contaminants are adhered into the pores of adsorbents, results reduction of contaminants from the source solutions[6,8]. Many investigators have examined a wide variety of

absorbents like fly-ash, peat, sawdust, brown coal, bagasse, activated carbon to remove chromium from tannery industry wastewater[11]. When compared to other pollutants in the tannery industry wastewater, Cr (VI) removal had been the target of significant attention in the last few years because of its toxicity. This study mainly focused on removal of Cr (VI) from tannery industry wastewater using rice husk silica powder. Also, the experimental data on removal of Cr (VI) from tannery industry wastewater was validated with the Cr (VI) aqueous solution of same initial concentration of tannery industry waster.

## Materials and Methods

### *Adsorbent Preparation*

Rice husk collected from mill was mixed together to form homogeneous mixture. Then, homogeneous mixture of rice husk was thoroughly washed with tap water to clean dirt and mud. The cleaned rice husk was mixed with 1.0 M HCl in the ratio of 100g rice husk per 1 litre acid and heated to the temperature of 100 °C for 2 hours. At the end of 3 hours reaction, the trace of HCl acid within the treated rice husk was removed by washing with tap water. Then, it was dried in an oven at 130 °C for 24 hours. During, this period, rice husk ash was obtained from the rice husk and the colour of rice husk ash is in black. Further, the rice husk ash was heated to a temperature of 600 °C for 6 hours to obtained silica. The obtained silica from the rice husk was in white colour. The rice husk silica was further grained to fine particles of uniform geometrical size of 0.10 mm, which were used for treating removal of Cr (VI) from tannery industry wastewater. The physical and chemical properties of rice husk silica were presented in (Table- 1).

**Table 1: Physical and Chemical Properties of Rice Husk Silica**

| **Properties** | **Values** |
|---|---|
| **Physical Properties** | |
| Specific surface, $m^2/g$ | |
| pH | 186 |
| Moisture content, % | 6.0 |
| Density, $g/cm^3$ | 0.7 |
| | 2.20 |
| **Chemical Properties** | |
| $SiO_2$ | 95.3 % |
| K | 1.4 % |
| Ca | 0.7 % |
| Fe | 0.5 % |
| Other Impurities | 2.1 % |

### *Collection of Wastewater Sample*

**Table 2: Characteristics of Tannery Industry Wastewater**

| **Sl.No.** | **Characteristics** | **Values** |
|---|---|---|
| 1 | pH | 7.6 |
| 2 | TDS | 12350 mg/L |
| 3 | TS | 16625 mg/L |
| 4 | COD | 8256 mg/L |
| 5 | BOD | 5689 mg/L |
| 6 | Sulphate | 852 mg/L |
| 7 | Chromium | 292 mg/L |

For the present study, the wastewater samples were collected from tannery industrial estate of Pallavaram ('originally PallavaPuram), which is a town and a second-grade municipality located in the suburbs of Chennai. It forms a part of the Tambaram Taluk of Kanchipuram District and is located 17 kilometres from Chennai city. Pallavaram is known for its cantonment and bustling residential colonies. The latitude and longitude are 12 58' 34" and 80 11' 01" respectively. The samples were collected with the help of air tight sterilized bottles, took to the laboratory and then they were stored for analyzing Cr (VI). The initial concentration of Cr (VI) in tannery industrial wastewater was found to be 292 mg/L, which was found by using

the PerkinElmer UV/Vis Spectrophotometer with the wave length of 540 nm [12]. The characteristics of tannery industry wastewater are given in (Table- 2).

***Experiment al Arrangement***

In this study, all experiments were performed at pH of 7, silica particle size of 0.10 mm to investigate the adsorption capacities rice husk silica powder on removal of Cr (VI) from tannery industry wastewater. The experiments were conducted for different process parameters like adsorbent dosage of 5, 10, 15, 20 g, contact time of 30, 60, 90, 120, 150, 180 min., agitator speed of 250, 500, 750, 1000 rpm and dilution ratio of 0, 1, 2, 3, 4, 5. Tannery industry wastewater was taken in 6 glass beakers of 250 ml capacity and was kept on the magnetic stirrer apparatus for different adsorbent dosage, contact time, different agitations speed and different concentration dilutions. The treated samples with various process parameters were filtered and the settled particles were removed. After treating by rice husk silica powder, clear samples after settlement (24 hours) were further tested by a digital spectrophotometer to find out the reduction in concentrations of chromium in the wastewater. The adsorption removal percentage of Cr (VI) by rice husk silica powder was calculated by using the following formula:

$$\text{Percentage Removal} = \frac{(C_1 - C_2)}{C_1} X\ 100 \qquad (1)$$

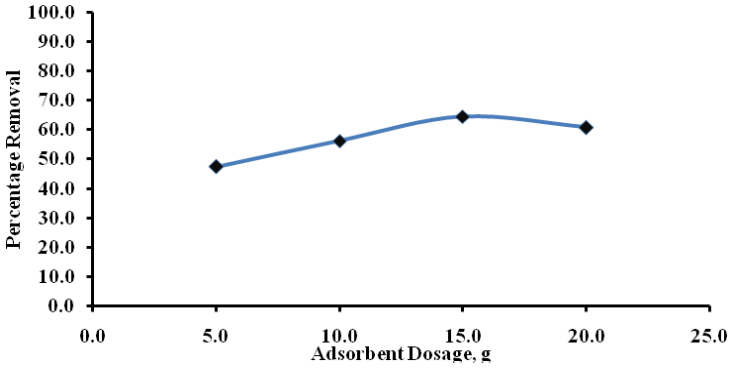
in which $C_1$ is the concentration of Cr (VI) before treatment with rice husk silica powder and $C_2$ is the concentration of Cr (VI) after treatment with rice husk silica powder.

## Results and Discussions

In the present study, Cr (VI) in the tannery industrial wastewater was reduced using the method called adsorption. The selected process parameters by these adsorption methods are different adsorption dosage, different contact time, different agitation speed and different concentrations (dilution ratios). The results are presented below.

### Effect of adsorption dosage

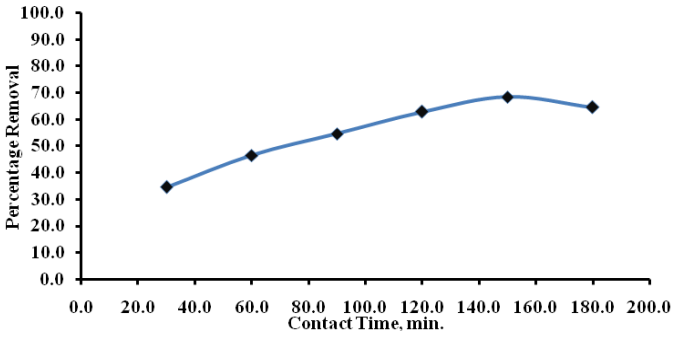
**Figure 1: Effect of adsorption dosage on removal of Cr (VI) in tannery industry wastewater**




The (Figure- 1) show the effect of adsorption dosage in removal of Cr (VI) from tannery industry wastewater. The selected adsorption dosage was 5, 10, 15 and 20 g for the agitation speed of 250 rpm, contact time of 90 min., and initial Cr (VI) concentration of 292 mg/L ('0' dilution ratio). From (Figure- 1), it may be observed that the percentage removal of concentration of Cr (VI) by rice husk silica powder with the adsorption dosage of 5, 10, 15 and 20 g was found to be 47.4, 56.3 and 64.5 and 60.8% respectively. Further, it was found that the optimum adsorption dosage for which, maximum removal of Cr (VI) in tannery industry wastewater is 15 g.

**Effect of contact time**

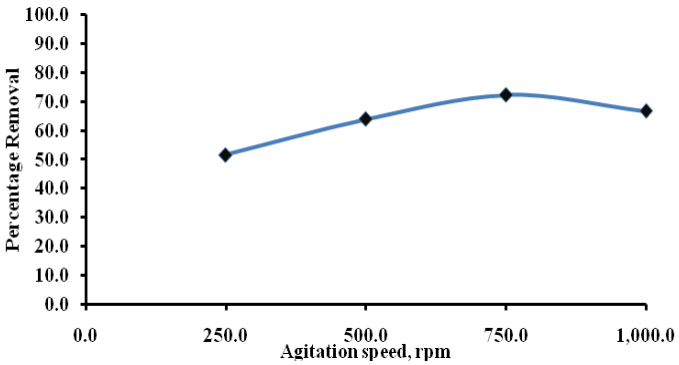
**Figure 2: Effect of contact time on removal of Cr (VI) in tannery industry wastewater**




The (Figure- 2) shows the effect of contact time in removal of Cr (VI) from tannery industry wastewater. The selected contact time was 30, 60, 90, 120, 150, and 180 min. for the agitation speed of 250 rpm, adsorption dosage of 15 g, and initial Cr (VI) concentration of 292 mg/L ('0' dilution ratio). From (Figure- 2), it may be observed that the percentage removal of concentration of C (VI) by rice husk silica powder with the contact time of 30, 60, 90, 120, 150, and 180 min. was found to be 34.5, 46.5, 54.6, 62.8, 68.4 and 64.6 % respectively. Further, it was found that the optimum contact time for which, maximum removal of Cr (VI) in tannery industry wastewater is 150 min.

**Effect of agitation speed**

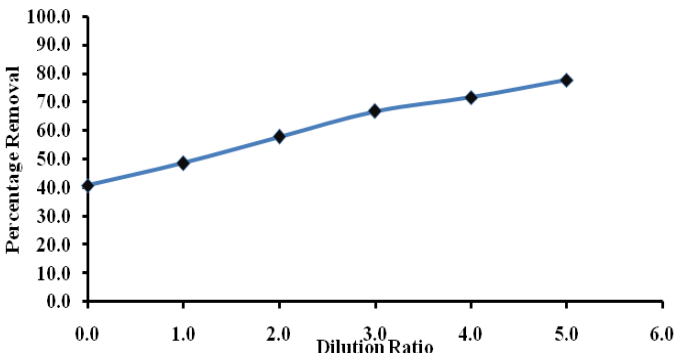
**Figure 3: Effect of agitation speed on removal of Cr (VI) in tannery industry wastewater**




The (Figure- 3) shows the effect of agitation speed in removal of Cr (VI) from tannery industry wastewater. The selected agitation speed was 250, 500, 750 and 1000 rpm for the contact time of 150 min., adsorption dosage of 15 g, and initial Cr (VI) concentration of 292 mg/L ('0' dilution ratio). From (Figure- 3), it may be observed that the percentage removal of concentration of Cr (VI) by rice husk silica powder with the agitation speed of 250, 500, 750 and 1000 rpm was found to be 51.6, 63.9, 72.3 and 66.7 % respectively. Further, it was found that the optimum agitation speed for which, maximum removal of Cr (VI) in tannery industry wastewater is 750 rpm.

**Effect of Concentration (dilution ratio)**

**Figure 4: Effect of concentration (dilution ratio) on removal of Cr (VI) in tannery industry wastewater**

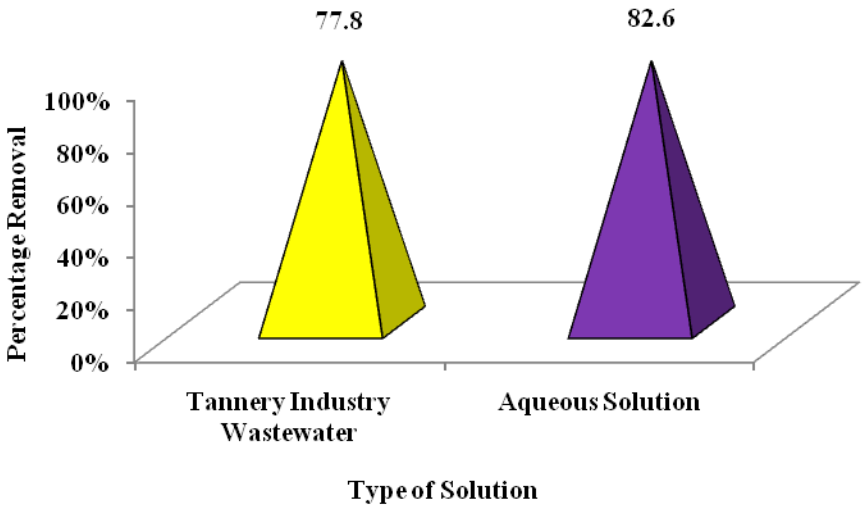


The (Figure- 4) show the effect of concentration (dilution ratio) in removal of Cr (VI) from tannery industry wastewater. The selected dilution ratio was 0, 1, 2, 3, 4, and 5for the contact time of 150 min., adsorption dosage of 15 g, and agitation speed of 750 rpm. From (Figure- 4), it may be observed that the percentage removal of concentration of Cr (VI) by rice husk silica powder with the dilution ratio of 0, 1, 2, 3, 4, and 5was found to be 40.8, 48.6, 57.8, 66.8, 71.6, and 77.8 % respectively. Further, it was found that the optimum dilution ratio for which, maximum removal of Cr (VI) in tannery industry wastewater is 5.

**Validation of Experiment**

Validation of experiment is required to verify the finding of similarities against the observed values of an experimental investigation. This study is used to check the degree of similarity between the experiments at optimum adsorbent dosage of 15 g, contact time of 150 min., agitation speed of 750 rpm and dilution ratio of 5 on removal of Cr (VI) in a tannery industry wastewater using rice husk silica powder with the new experiments (separate experiments) conducted against the same optimum values of adsorbent dosage, contact time, agitation speed and dilution ratio on removal of Cr (VI) in an aqueous solution.

**Figure 5: The Maximum Removal Percentage Cr (VI) in a tannery industry wastewater, Cr (VI) in the aqueous solutions by rice husk silica powder with an adsorbent dosage of 15 g, contact time of 150 min., agitation speed of 750 rpm and dilution ratio of 5**




The maximum removal of Cr (VI) in a tannery industry wastewater and an aqueous solution by rice husk silica powder at the optimum values of selected parameters is shown in (Figure-5). The results (Figure- 5) showed that the maximum removal percentage of Cr (VI) in an aqueous solution by rice husk silica powder at the optimum conditions is greater than (82.6 %) the results of Cr (VI) removal in a tannery industry wastewater (77.8 %) by rice husk silica powder. From (Figure- 5), it may be noted that the high values observed in a Cr (VI) aqueous solution than in a tannery industry wastewater is due to there are no competitive ions present in aqueous solution than in a tannery industry wastewater, where the competitive ions like chloride, sulphate are presented (Table- 2). Thus, the validation results indicated that the experiments were reproducing capability.

## Conclusion

In the present study, experiments have been conducted for removal of Cr (VI) in tannery industrial wastewater using rice husk silica powder as adsorbent. To know the ability of rice husk silica powder for removing Cr (VI) in the tannery industrial wastewater, the experiments were conducted with varying adsorbent dosage, contact time, agitation speed and dilution ratio. The results showed that the maximum percentage removal of Cr (VI) in the tannery industrial wastewater at optimum adsorbent dosage of 15 g, contact time of 150 min., agitation speed of 750 rpm and dilution ratio of 5 respectively by rice husk silica powder was 64.5, 68.4, 72.3, and 77.8 %. Also, the experimental data on removal of Cr (VI) from tannery industry wastewater is validated with the Cr (VI) aqueous solutions of same initial concentration of tannery industry waster. The results of validated experiments showed that the experimental investigation done for this study may be reproduced for removing Cr (VI) from tannery wastewater or from any chromium based industrial wastewater.

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