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Application of rice husk for the removal of chromium from Metal Injection Molding industry effluent

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ABSTRACT

Rice husk was utilized as adsorbent for removal of Chromium from Metal injection Molding Industry effluent which is one of the heavy metal utilized during manufacturing process. Adsorption was carried out in a batch experiment with initial concentration of Chromium by varying the amount of adsorbent, pH, reaction time and certain physicochemical parameters. Upon treatment with different dosage of rice husk it was found that effluent treated with 6gm of rice husk for a period of 2 hours at pH7, showed maximum reduction of 90.74%. Due to its good uptake capacity, Rice husk has proved to be an excellent low cost adsorbent for accumulating Chromium from effluent. Scanning electron microscopic (SEM) analysis was carried out for structural and morphological characteristics of rice husk. Brunauer Emmett Teller (BET) analysis was carried out for the Specific surface area, Pore volume and Average pore diameter of rice husk.

KEYWORD: Metal Injection Molding Effluent, Heavy metal, Rice husk, Specific surface area.

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INTRODUCTION

Environmental pollution due to development in technology and urbanization is one of the most important problems of this century[1]. Toxic metals are often discharged by a number of industrial processes, which in turn lead to water pollution. Whenever toxic heavy metals are exposed to the natural eco-system, accumulation of metal ions in human bodies will occur either through direct intake or food chains[2]. Chromium compounds are released from many industries like electroplating, leather tanning, metal finishing etc, which are easily soluble in water and enter the living cells. The toxicity of chromium depends on its oxidation state and water quality. The tri and hexavalent chromium, Cr (VI) was found to be more toxic and it readily passes through the red blood cell membrane[3]. As determined by the National Toxicology Programme (NTP),and International Agency for Research on Cancer (IARC), Cr (VI) is a human carcinogen[4]. Generally Cr (VI) is removed from waste water by various methods such as chemical precipitation, electrochemical reduction, sulphide precipitation, concentration, ion exchange, reverse osmosis, electro dialysis, solvent extraction , evaporation etc.

Adsorption technology is eco friendly in nature which utilizes low-cost bio sorbent to reduce toxic heavy metals, which includes no chemical sludge, reusability of biomaterial, etc. Adsorption is a unit process that occurs when a vapor or liquid solute collects on the open surface of a solid or a liquid (adsorbent), forming a molecular or atomic layer thick film (the adsorbate). Adsorbent is a substance that adsorbs a solid substance endowed with the property of attaching other substances to its surface without any covalent bonding. In the present investigation powdered rice husk was used as adsorbent for the removal of Chromium from the Metal injection Molding Industry effluent. The aim of the present study was to investigate the applicability of adsorptive treatment using available rice husk for the removal of chromium from industrial wastewater and the effect of various parameters such as, initial metal concentration, adsorbent dosage and pH.

2. MATERIAL AND METHODS:

2.1. Sample collection

The effluent was collected from Metal injection molding industry at Doddaballapura taluk, Bangalore rural Dist, Karnataka State. Rice husk was collected from a rice mill at Ripponpete, Shivamogga Dist , Karnataka State.

2.2. Preparation of Adsorbent

Rice husk was washed with distilled water and dried in an oven at about 60^0C for 4h. It was washed again with acetone and NaOH (0.3M) to remove dirt and other contaminants, dried in an oven at about 60^oC for 4h and crushed until powdered fine particles are obtained. The powdered sample of Rice husk was examined by XRD (X-Ray Diffraction), SEM and BET analysis to assess the purity of the expected phases and the degree of crystallization i.e. size, compositions, and crystal structure.

2.3. Batch experiment:

Batch experiment was conducted to determine the adsorption capacity of metal. 100ml of sample in conical flasks was kept for 2hours in heavy rotatory shaking apparatus. Samples were filtered through Whatman No. 41 filter paper and measured in AAS. The percent removal of chromium from sample was calculated using **Eq**:**1**

$$\text{Percent removal} = \frac{(C_o - C_i)}{C_o} \times 100 \qquad \textbf{(Eq 1)}$$

Where, Co is initial concentration and C_i is final concentration of chromium metal. Further experiments were conducted on the percentage of removal of heavy metals depending upon the results obtained from the Rice husk (RH) present in sample[5] .

3. RESULT AND DISCUSSION:

3.1. Physico-chemical parameters:

Table No 1: "Characterization of Metal Injection Molding Industry Effluent ".

S.NO	**Parameter**	**Before treatment**	**After treatment**
1	pH	1	7
2	Temperature (^{0}C)	28.9	24.4
3	Biological Oxygen Demand (mg/l)	30	25
4	Chemical Oxygen Demand (mg/l)	1250	956

3.2. Characterization of rice husk:

X- Ray diffraction (XRD)

Characterization of rice husk was performed by powder X- Ray diffraction (Rigaku Diffractro meter) using Cu-K∝ radiation (105406A°) in a $\theta - 2\theta$ configuration. Powdered rice husk was examined and the average crystalline size was found to be around **28nm** respectively. The pattern obtained from XRD analysis is presented in fig: 1 and the average size of rice husk powder was calculated using Debye Scherrer's formula equation.

$$D= (K\lambda / (\beta cos\theta)) \quad \textbf{(Eq.2)}$$

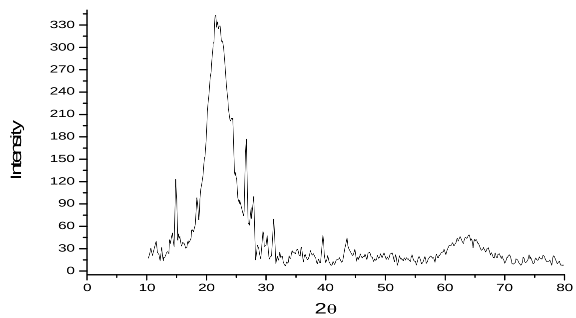


Fig 1: XRD of the powdered rice husk

Scanning Electron Microscope (SEM)

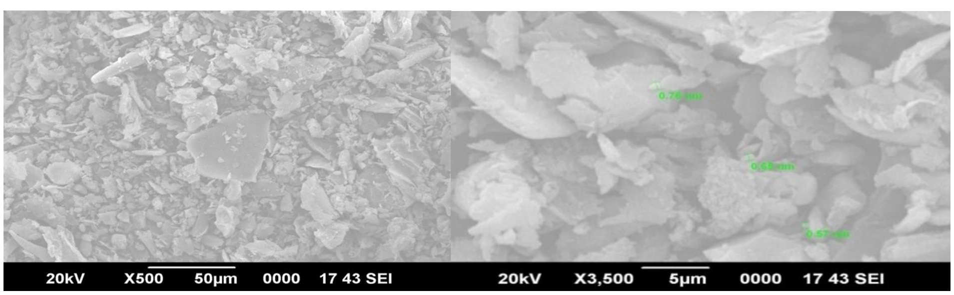
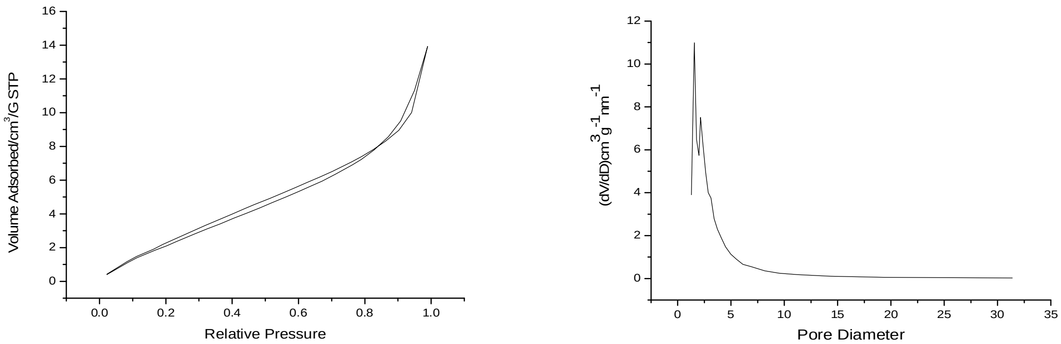


Fig 2: Scanning Electron Micrograph of powdered rice husk.

SEM image of powdered rice husk is shown (Fig:2) which determines the morphology of rice husk. The obtained image revealed a cluster shape with sharp edges and aggregation particles.

3.3. Bet Surface Area Analysis:

A Specific Surface Area (SSA) of rice husk was measured at 77 K by Brunauer–Emmett–Teller (BET) nitrogen adsorption–desorption (NOVA-1000 version 3.70 Instrument). Figure 3**a** shows N2-adsorption/desorption isotherm plot and the Barret-Halenda (BJH) pore size distribution plot respectively. The isotherm obtained was similar to type-IV behavior . The BET surface area analysis results were found to be 13.386m^2/g. The surface area obtained for rice husk was efficient to carry out the removal of chromium, which was directly proportional to the surface area available. The pore size distribution curve shows two peaks which indicate the presence of different pore size distribution with in 5nm range which is illustrated in Fig 3**b** [6, 7].



a **b**

Fig 3: Bet surface area analysis. (a) adsorption desorption 77 K , (b) Pore volume distribution of rice husk

3.4. Effect of Initial Concentration of Effluent on Rice Husk:

Initially experiments were carried out with different concentration of the effluent *i.e*100% (raw effluent) ,75%, 50%, and 25% .Using 5g of Rice husk 100 ml solution was kept for treatment at a contact time of 2 hours at pH7 in heavy rotatory shaking apparatus. After treatment Chromium reduced to 38.85% in 100% concentration, 48.44%(in 75% concentration), 86.44% (in 50% concentration) and 23.01% (in 25% concentration).

The result revealed that reduction efficiency increases with decreasing concentration of chromium in sample from 38.85% to 86.44% for rice husk i.e. from 100% to 50% concentration, due to the saturation of sorption sites on adsorbent *i.e* metal adsorption depends on the nature of the adsorbent surface. Based on the result further studies have been conducted.

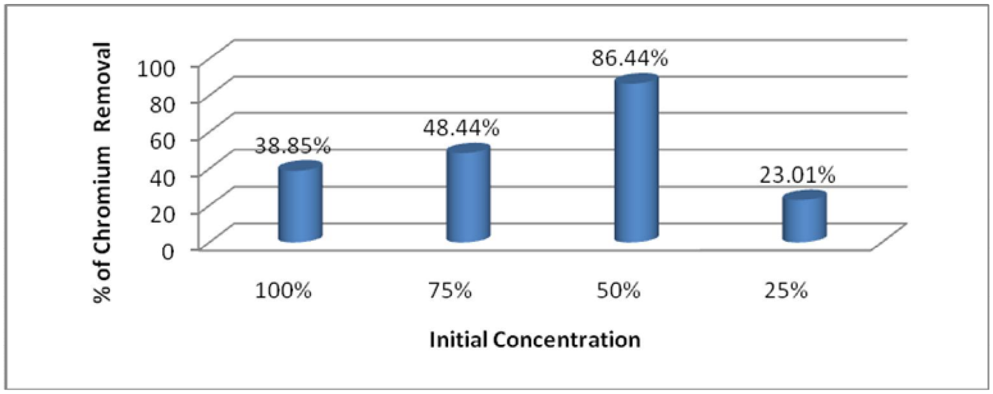


Fig: 4 Effect of Initial concentration of effluent using rice husk 5g/100ml at pH7.

3.5. Effect of Adsorbent

The effect of adsorbent was carried out with doses of rise husk from 1- 10g/L in a conical flask for 2hours in heavy rotatory shaking apparatus. After treatment Chromium reduced to 42.99% in 1g and 62.19%, 71.96%, 76.68%, 86.44%, 90.70%, 86.91%, 87.57%, 87.14%, 87.85%, in 2to 10g of rice husk respectively.

The result indicates that the adsorption efficiency increased from 42.99% to 90.70% with adsorbent dosage from 1gm to 6gm. There is a sudden increase in percentage removal of chromium by 90.70%. This is due to greater availability of surface area active sites *i.e* the increase in adsorption rate can be explained by the fact that the adsorbent media had a limited number of active sites which become saturated at a certain concentration. Here saturation level is at 6g/ 100ml at pH.

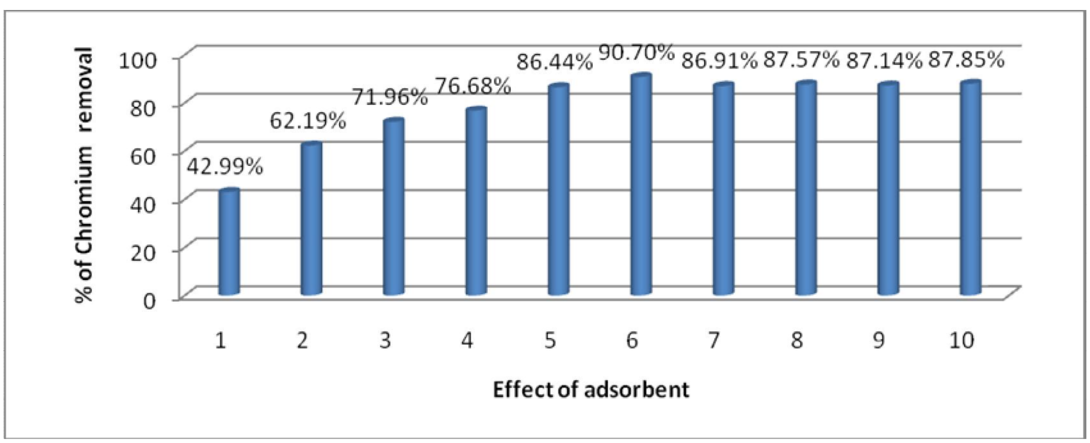


Fig 5: Effect of adsorbent in 50% concentration using rice husk 1-10g/100ml at pH7.

3.6. Effect of pH

In order to study the effect of pH the experiment was carried out at pH 1,3,5,7,9 and 11 using 6gm of rice husk with 50% concentration of 100ml sample. The result revealed that the removal of chromium from effluent increased from 30.42% to 90.74% with increasing pH from 1 to 7 and decreased to 86.54% with further increase in pH up to 11 in 2 hours treatment.

It was observed that the percentage removal of chromium was maximum at pH7. At low pH, high concentration of H^+ ions are present in solution that compete for vacant adsorption sites of the adsorbent. The metal uptake efficiency increased from low pH to pH7 and decreased from pH9 due to formation of soluble hydroxyl complex**.** It was observed that there was a sharp increase in uptake at pH of 7 thus indicating that chromium removal is enhanced in neutral condition.

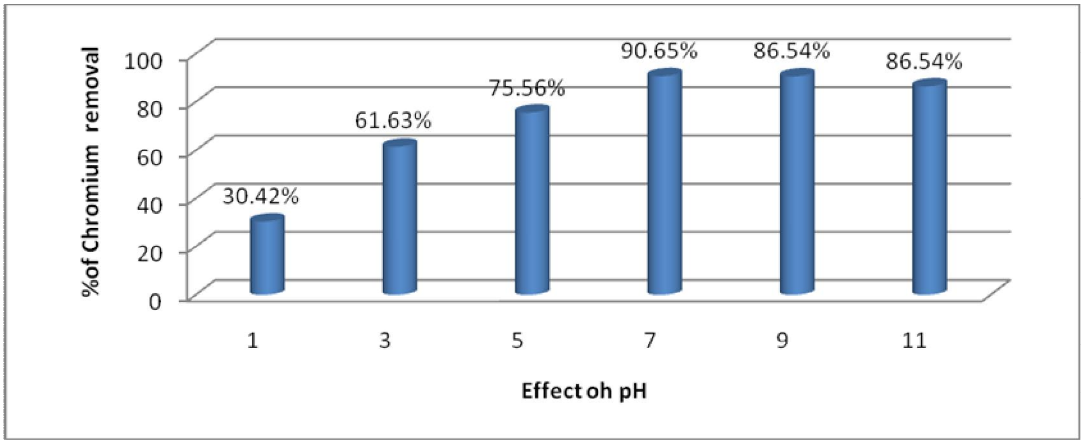


Fig 6: Effect of ph in 50% concentration of effluent at 6gm of rice husk

4. CONCLUSION

The role of rice husk in the removal of chromium from metal injection molding industry effluent has been investigated. The maximum removal efficiency of Chromium using rice husk was obtained at pH 7 for 6g/100ml in 2 hours at 50% concentration. The experiment shows that rice husk can be effectively used to remove heavy metals from the industrial waste water without chemical treatment.

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