

## COLOUR REMOVAL OF DIRECT RED DYE EFFLUENT BY ADSORPTION PROCESS USING RICE HUSK

M. THIRUMARIMURUGAN, A. MERLY XAVIER & R. T. KANNADASAN

Associate Professor, Head of Department, Coimbatore Institute of Technology, Coimbatore-641014,  
India

### ABSTRACT

To show that rice husk could be employed as low-cost and effective adsorbent for the removal of Direct Red 23 from dye effluent and also to study the effect of concentration of dye solution and the effect of amount of adsorbent on the percentage removal of dye. Azo dyes and their degradation products such as aromatic amines are highly carcinogenic. Adsorption of dyes is a new technology for treatment of waste water containing different types of dyes. Adsorption process is adopted for removal of direct red 23 dye from the dye effluent using rice husk as the adsorbent in treated and untreated form. The process involves: washing and drying of rice husk at 105° c, followed by soaking in 0.6 M Citric acid for 2 hours and heated to 120 °C. Further it is dried and washed repeatedly to obtain treated rice husk. This treated and untreated rice husk are used for removal of Direct Red 23 dye. Dye solutions of different concentrations were prepared and a known amount of adsorbent were added to study the Effect of concentration of dye solution and effect of amount of adsorbent on the percentage of removal of Direct Red 23.

**KEYWORDS:** Rice Husk, Azo Dyes, Hydrophobicity.

### INTRODUCTION

Azo dyes and their degradation products such as aromatic amines are highly carcinogenic [9]. Adsorption of dyes is a new technology for treatment of wastewater containing different types of dyes.[7]. The goal of this research is to develop a new and efficient adsorbent of direct dyes. Thus, rice husk, a commonly available agriculture waste, was investigated as viable materials for treatment of synthetic Direct F. Scarlet (Direct Red 23) containing industrial wastewater. Rice husk has many advantages such as its granular structure, chemical stability and its local availability at very low cost and there is no need to regenerate them due to their low production costs. The main constituents of rice husk are: 64-74% volatile matter and 12-16% fixed carbon and 15-20% ash[1]. Hence rice husk can be used as an effective adsorbent. Proper treatment of the dye plant effluent is thus, a matter of concern before discharge. This led to an intensive search for the best available technology, which can be used for the removal and remediation of dyes. In addition, it makes the treatment of industrial effluent to be an important target for industry and environment protection. Different treatment methods are described in the literature, including filtration, flocculation, chemical precipitation, ion exchange, membrane separation, and adsorption [11]. Practically, dye removal process requires the following potential advantages for the adsorbent: (1) a large accessible pore volume, (2) hydrophobicity, (3) high thermal

and hydrothermal stability, (4) no catalytic activity, and (5) easy regeneration. New approaches based on the use of natural, inexpensive sorbent materials for effluent treatment have been reported. However, the use of these materials is still limited, although they show good adsorption capacity relative to that of the other expensive treatment processes ([4]. The adsorption process is one of the efficient methods to remove contaminant from effluent[7]. The process of adsorption has an edge over the other methods due to its sludge free clean operation and complete removal of dye even from dilute solutions. Activated carbon is the most widely used adsorbent for this purpose because of its extended surface area, microporous structure, high adsorption capacity and high degree of surface reactivity. However, commercially available activated carbons are very expensive. In addition, the laboratory preparation of activated carbons have been accompanied by a number of problems such as combustion at high temperature, pore blocking, and hygroscopicity. This has led to search for cheaper and simplest substituents. Rice husk, an undesirable agriculture mass residue in Egypt, is a by-product of the rice milling industry. It is one of the most important agricultural residues in quantity. It represents about 20% of the whole rice produced, on weight basis of the whole rice[2]. The estimated annual rice production of 500 million tones in developing countries, approximately 100 million tones of rice husk is available annually for utilization in these countries aloe. Traditionally, rice husks have been used in manufacturing block employed in civil construction as panels and was used by the rice industry itself as a source of energy for boilers [3].However, the amounts of rice husk available are so far in excess of any local uses and have posed disposal problems. It was chosen because of its granular structure, chemical stability and its local availability at very low cost and there is no need to regenerate them due to their low production costs. The main constituents of rice husk are: 64-74% volatile matter and 12-16% fixed carbon and 15-20% ash [2]The rice husk composition are: 32.24% cellulose, 21.34% hemicellulose, 21.44% lignin, 1.82% extractives, 8.11% water and 15.05% mineral ash (Govindarao 1980; Rhman et al. 1997; Nakbanpote et al. 2000).The mineral ash is 94.5-96.34% SiO<sub>2</sub>. The purpose of this work is to investigate the adsorption capacity of the untreated and activated rice husk on adsorption of direct dyes from aqueous solution. Direct F. Scarlet (Direct red 23) dye was selected for the adsorption experiment due to its presence in several industrial effluents such as textile, tannery, paper, soap, cosmetics, polishes, wax etc. As Direct F. Scarlet has diazo group, it has toxicity and carcinogenic nature. The dye (DR-23), dose will not allow sunlight to passthrough and thereby affects the photosynthesis of aquatic plants. Modern dyes are resistant to conventional biological treatment but these azo dyes are reduced to colorless primary amines by this treatment. These primary amines are even more toxic than the original dye. The equilibrium and kinetics of DR-23 adsorption on rice husk were investigated. The Langmuir model was used to fit the equilibrium isotherm. The batch contact time method was used to measure the adsorption rate and kinetic parameters were then evaluated.

## **MATERIALS AND METHODS**

### **Preparation of Adsorbents**

Rice husk was obtained from local rice mills and was washed several times with water followed by filtration. The cleaned rice husk was oven dried completely at 105°C, then cooled and sieved to 250-500 µm size, which was used without further treatment. Another part of same size fraction of rice husk[5] was exposed to activation using citric acid which was reported as follows: 100 g of rice husk were soaked in 0.6M citric acid for 2 hr at 20°C. [8]The acid-husk slurry was dried overnight at 50°C and the dried husk was then heated to 120°C. The reacted product was washed repeatedly with distilled water (200 ml per g of husk) to remove any excess of citric acid followed by oven drying overnight at 100°C.

### PREPARATION OF DYE SOLUTION

Direct F. Scarlet(Direct Red 23) was used without further purification. Its molecular formula is  $C_{35}H_{25}N_7Na_2O_{10}S_2$  and its color index C.I. 29160. A stock solution of the dye was prepared by dissolving 1 gram of dye in 1000 ml distilled water to make a stock solution of 1000 mg/l. The experimental solution was prepared by diluting definite volume of the stock solution to get the desired concentration. For the preparation of 50 ppm solution from stock solution, the stock solution is diluted by 20 times i.e. 5 ml of stock solution is diluted to 100 ml. Similarly 100 ppm and 150 ppm of solution is prepared.

### PROEDURE

The experimental set up involves the usage of glasswares(Conical flasks, Measuring cylinders, Pipettes, Standard flasks, Funnel, Stoppered bottles, porcelain dish and test tubes etc..) made of Borosil and certain equipment and instruments such as UV-VIS Spectrophotometer, Centrifugal Separator, Dry air Oven, Muffle Furnace, Mechanical Shaker and Weighing Machine. Dye solutions of different concentrations (50ppm, 100ppm, 150ppm) were prepared from the stock solution by diluting it with required amount of water depending on concentration and they were taken in various labeled stoppered bottles. The concentrations of these standard concentration solutions (50ppm, 100ppm 150ppm) were measured using UV-Vis Spectrophotometer at 507nm. Then three kinds of studies were done, i) Effect of Concentration of Solution. ii) Effect of Amount of Adsorbent. iii) Effect of Treated and Un-Treated Rice Husk. Particular amount of treated and untreated rice husk were added to each of the respective labeled bottles as defined below :

A = 2 gram Un-Treated Rice Husk + 100 ml 50ppm soln

B = 2 gram Un-Treated Rice Husk + 100 ml 100ppm soln

C = 2 gram Un-Treated Rice Husk + 100 ml 150ppm soln

D = 4 gram Un-Treated Rice Husk + 100 ml 100ppm soln

E = 6 gram Treated Rice Husk + 100 ml 100ppm soln

1 = 2 gram Treated Rice Husk + 100 ml 50ppm soln

2 = 2 gram Treated Rice Husk + 100 ml 100ppm soln

3 = 2 gram Treated Rice Husk + 100 ml 150ppm soln

4 = 4gram Treated Rice Husk + 100 ml 100ppm soln

5 = 6 gram Treated Rice Husk + 100 ml 100ppm soln

These bottles were shaken physically and then followed by mechanical shaking using a mechanical shaker for about 2 hours using a mechanical shaker and let it still for few hours. A small amount was withdrawn from the respective bottles and then was centrifuged at 3000 rpm for about 10 min. Then these samples were analyzed for concentration dye contents using UV-Spectrophotometer at 507 nm. The respective values gives us the study for Effect of Concentration of Solution and the Effect of amount of Adsorbent for Un-Treated and Treated Rice Husk.

## RESULTS AND DISCUSSIONS

The results obtained from the present investigation revealed the ability of rice husk in treating azo dye effluents, e.g. Direct Red-23 dye, using rice husk activated with citric acid, which was capable of removing Direct Red-23 dye. Adsorption is highly dependent on the contact time, adsorbent dose and dye concentration. The adsorption isotherm of DR-23 onto rice husk biomass is described by the Langmuir isotherm model. Kinetics of adsorption follows Lagergren first order kinetic model with film diffusion being the constitutive rate-controlling step. The monolayer adsorption capacity obtained from Langmuir isotherms for DR-23 was relatively higher for the citric acid [6] treated rice husk compared to that obtained without chemical treatment. Consequently, safely can point to the use of this natural material due to abundance and very cheap biomass. This leads to its superiority as a potential sorbent in removal of some coloured dyes from waste waters. Thus from the above conducted experiment it can be concluded that the rice husk can be used as a very effective absorbent in both treated and un-treated form. The experiment was conducted and the values were tabulated, from the tabulated values the following conclusions are being done. The values of the absorbance from the UV-Vis Spectrophotometer for all the study bottles are plotted in the graph that shows the amount of colour removed by the respective adsorbent and its amount. The values show that more the concentration of dye, more color is removed for a given amount of adsorbent. This is because for higher concentration of solution, higher the number of dye molecules to interact with the adsorbent particles. The values also show that the more amount of adsorbent more the amount for colour removal. This is because of more amount of adsorbent particles to interact with the dye particles. It also infers that the Treated rice husk removes more colour compared to the Un-Treated rice husk. This is because of more effective adsorptive capacity for the Treated rice husk compared to the Un-Treated rice husk. This project can be further continued by making further studies on the colour removal of Direct Red 23 dye by adopting other processes such as flocculation, chemical precipitation, ion exchange, membrane separation. Further studies is also to be continued on increasing the adsorption capacity of the rice husk by treating it with other acids. Studies have to be further continued to find out if rice husk can also be used for removal of other dyes. Conclusively, the expanding of rice husk ash in the field of adsorption science represents a viable and powerful tool, leading to the superior improvement of pollution control and environmental preservation.

The absorbance values of standard solutions are as follows:

**Table 1: Absorbance Values of Standard Solutions**

CONCENTRATION	ABSORBANCE
50	0.818
100	1.565
150	2.351

The absorbance values of 10 stoppered bottles are as follows:

**Table 2: Absorbance Values of Dye Solutions After Adsorption**

Label	Absorbance
A	0.655
B	1.159
C	1.719
D	0.754
E	0.511
1	0.576
2	0.997
3	1.422
4	0.559
5	0.464

### EFFECT OF CONCENTRATION OF SOLUTION

Amount of adsorbent added = 2 g

**Table 3: Effect of Concentration of Solution**

INITIAL CONC.	UNTREATED			TREATED		
	ABS.	CONC (PPM)	% REMOVAL	ABS.	CONC (PPM)	% REMOVAL
50	0.655	42	16	0.576	37	26
100	1.159	74	26	0.997	63.5	36.5
150	1.719	110	26.67	1.422	91.5	39

**EFFECT OF AMOUNT OF ADSORBENT****Table 4: Effect of Amount of Adsorbent**

INITIAL CONC.	UNTREATED			TREATED		
	ABS.	CONC (PPM)	% REMOVAL	ABS.	CONC (PPM)	% REMOVAL
2	1.159	74	26	0.997	63.5	36.5
4	0.754	48	52	0.559	36	64
6	0.511	32.5	67.5	0.464	30	70

Solution considered = 100 ppm

**REFERENCES**

1. Armesto, L., A. Bahillo, K. Veijonen, A. Cabanillas and J. Otero. 2002. Combustion behavior of rice husk in a bubbling fluidized bed, *Biomass & Bioenergy* 23: 171-179.
2. Daifullah, A. A. M., B. S. Girgis, H. M. H. Gad. 2003. Utilization of agro- residues (rice husk) in small wastewater treatment plans. *Material letters* 57: 1723-1731
3. Della, V. P., I. Kuhn, D. Hotza. 2001. Caracterizacao de cinza de casca de arroz para uso como materia-prima na fabricacao de refatarios de silica. *Quim Nova* 24: 778-782.
4. Dushenkov, V., P. B. A. N. Kumar, H. Mott and I. Raskin. 1995. Rhizo filtration: the use of plants to remove heavy metals from aqueous streams. *Environmental Science and Technology* 29: 1239-1245.
5. Govindarao, V. M. H. 1980. Utilization of rice husk - a preliminary analysis. *J. Science Industrial Research* 39: 495-515.
6. Marshall, W. E., L. H. Wartelle, D. E. Boler, M. M. Johns and C. A. Toles. 1999. Enhanced metal adsorption by soybean hull modified with citric acid. *Bioresource Technology* 69: 263-268.
7. Malik, P. K. 2003. Use of activated carbons prepared from sawdust and rice-husk for adsorption of acid dyes: a case study of acid yellow 36. *Dyes and Pigments* 56: 239-249.
8. Marshall, W. E. and L. H. Wartelle. 2003. Acid recycling to optimize citric acid modified soybean hull production. *Industrial Crops and Products* 18: 177- 182.
9. Mohamed, M. M. 2004. Acid dye removal: Comparison of surfactant-modified mesoporous FSM-16 with activated carbon derived from rice husk. *J. Colloid and Interface Science* 272: 28-34.