Colour Removal of Direct Red Dye Effluent by Adsorption Process Using Rice Husk

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***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 ℃, followed by soaking in 0.6 M citric acid for 2 hours and heated to 120 ℃. 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 dyes. 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.**

***Index Terms*—Direct red dye, rice husk, adsorption, effluent treatment, microporous.**

I. 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 substituent. 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 tons in developing countries, approximately 100 million tons 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% SiO2. 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,

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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 pass through and thereby affects the photosynthesis of aquatic plants. Modern dyes are resistant to conventional biological treatment but these azo dyes are reduced to colourless 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 which were then evaluated.

II. 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 ℃, then cooled and sieved to 250 µm to 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 hours at 20 ℃. [8]The acid-husk slurry was dried overnight at 50 ℃ and the dried husk was then heated to 120 ℃. 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 ℃.

Preparation of Dye Solution

The molecular formula of dye is $C_{35}H_{25}N_7Na_2O_{10}S_2$ and its colour index is 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 50ppm 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 100ppm and 150ppm of solution WASS prepared.

III. Prodedure

The experimental set up involves the usage of glass wares (Conical flasks, Measuring cylinders, Pipettes, Standard flasks, Funnel, Stopper 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 labelled stopper bottles. The concentrations of these standard concentration solutions (50 ppm, 100 ppm 150 ppm) were measured using UV-Vis Spectrophotometer at 507 nm. 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 labelled bottles as defined below:

A=2gram Un-Treated Rice Husk + 100 ml 50ppm SOLN
B =2gram Un-Treated Rice Husk + 100 ml 100ppm SOLN
C=2gram Un-Treated Rice Husk + 100 ml 150ppm SOLN
D=4gram Un-Treated Rice Husk + 100 ml 100ppm SOLN
E=6gram Treated Rice Husk + 100 ml 100ppm SOLN
1=2gram Treated Rice Husk + 100 ml 50ppm SOLN
2=2gram Treated Rice Husk + 100 ml 100ppm SOLN
3=2gram Treated Rice Husk + 100 ml 150ppm SOLN
4=4gram Treated Rice Husk + 100 ml 100ppm SOLN
5=6gram 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 and was let 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 value gives us the study for Effect of Concentration of Solution and the Effect of amount of Adsorbent for Un-Treated and Treated Rice Husk.

IV. 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. It was found that 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, safety 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.

TABLE I: Absorbance Values of Standard Solutions

CONC.	ABSORBANCE
50	0.818
100	1.565
150	2.351

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 value shows that more the concentration of dye, more colour 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.. It also infers that the Treated rice husk removes more color 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 color 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.

TABLE II: ABSORBANCE VALUES OF DYE SOLUTIONS

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

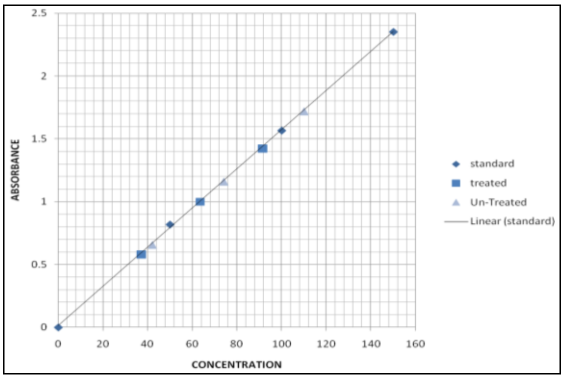

Fig. 1. Effect of concentration of solution.

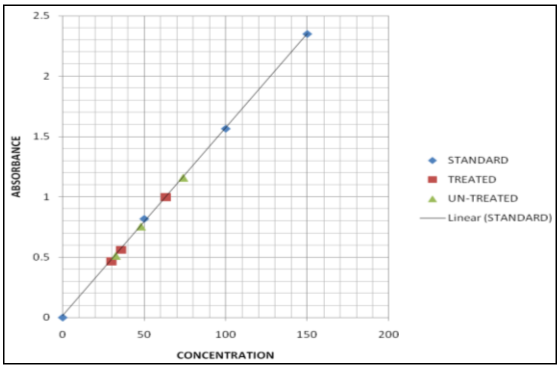

Fig. 2. Effect of amount of adsorbent.

TABLE III: 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

Amount of adsorbent added = 2g

TABLE IV: 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 = 100ppm

A. Effect of Concentration of Solution

The effect of concentration of solution is shown in Table III. Also the effect of concentration of solution is plotted in the graph which is shown as Fig. 1.

B. Effect of Amount of Adsorbent

The effect of amount of adsorbent is shown in Table IV also plotted in the graph which is shown as Fig. 2.

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