STUDY ON COMPARATIVE ADSORPTION EFFICIENCIES OF RICE STRAW AND COCONUT HUSK (FIBRE) BY USING CONGO RED DYE

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Abstract

Adsorption of congo red from aqueous solution onto rice straw (RS) and coconut husk fibre (CCH) under batch conditions was investigated. Before sorption process, the physicochemical properties of RS and CCH fibre such as moisture content, ash content, bulk density and pH were determined by standard methods. The samples was characterized by SEM. Adsorption was studied as a function of amount of adsorbent, contact time, pH and various concentrations with time. It was carried out at pH 6. A synthetic solution of 25 mg/L of the dye was used. The optimum contact time was 120 min and 0.2g was a suitable dose of sorbent.The sorption properties of congo red were spectrophotometrically determined.The highest removal percent of congo red by rice straw powder (80.31%) and coconut husk fibre powder (74.96%) were observed.

Keywords: Rice straw, Coconut husk, Sorption, Congo red

Introduction

Pollution; environmental pollution, the addition of any substance (solid, liquid, or gas) or any form of energy (such as heat, sound, or radioactivity) to the environment at a rate faster than it can be dispersed, diluted, decomposed recycled or stored in some harmless form. The major kinds of pollution are air pollution, water pollution, and land pollution. Water pollution is the presence of harmful materials in water, such as sewage, dissolved materials, waste from farms, factories and crude oil spilled from oil tankers (Adamson, 1967). The three main substances that pollute water are nitrates from fertilizers, sewage and detergents. Most dye materials are irritants to the skin, eyes, and respiratory system and may be toxic by inhalation and ingestion (Bharathi and Remesh, 2013). Synthetic dyes are extensively used in textile dyeing, paper printing, color photography, pharmaceutical, food, cosmetic and other industries (Sharma*et al*., 2010). Rice is the world's second largest cereal crop and produces the largest amount of crop residues (Soest, 2006). Rice, rice husk and rice straw are the main products of rice cultivation and processing. Rice straw and coconut husk (fibre) are considered extremely effective for the removal of impurities (Binod, *et al.,* 2010). The initial dye concentration, pH, contact time and dosage effects were studied aiming to obtain the best adsorption capacity by rice straw powder and coconut husk powder. Dried rice straw and dried coconut husk biomass were prepared using low cost carbon source rice straw powder and coconut husk powder biomass were used as adsorbents for the removal of acidic dye (Congo red) from aqueous solution.The aim of the research work is to study the adsorptions efficiencies of rice straw powder and coconut husk fibre powder to be used as effective sorbents for the colour removal of acidic dye (Congo red).

Materials and Methods

Sampling and Preparation

The rice straw and the coconut husk were collected from Kanpya Village, Magway Township, Magway Region. Firstly the samples were cut into small pieces. Then they were washed with tap water to remove the attached dusts and other impurities. The washed rice straw

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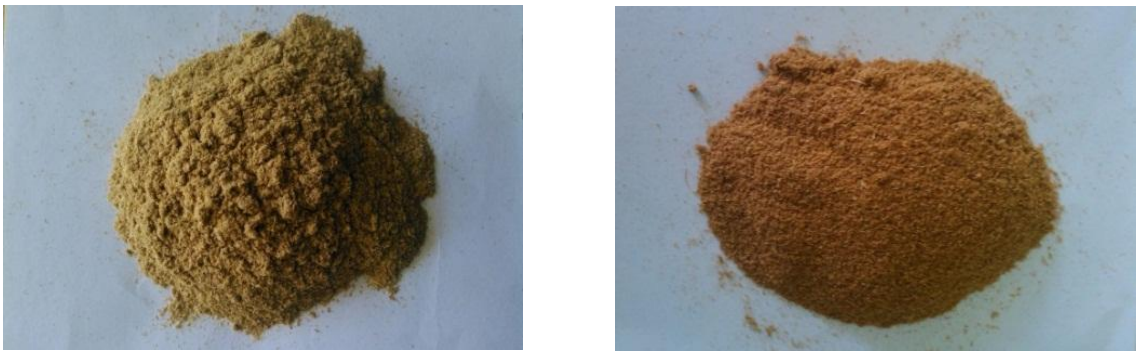
and coconut husk were dried and ground in the mechanical grinder to form the fine powder. The powder was sieved and a size fraction in the range of less than 100 μm was used in all the experiments. This powder was soaked (0.01 g/mL) in 5% w/v bleaching powder for 24 hours. The mixture was filtered and the powder residue was continuously washed with distilled water until the pH of the solution is nearly neutral. This filtered biomass was first dried at room temperature and then in oven at 60 ºC for 6 hours. Figure 1 (a) and (b) shows the photographs of rice straw powder and coconut husk fibre powder. The dried biomass rice straw powder and coconut husk powder were stored in air-tight glass bottles to protect them from moisture.



(a) (b)

Figure 1 Photographs of (a) rice straw powder (b) coconut husk fibre powder

Determination of Physicochemical Properties of Rice Straw and Coconut Husk

The physicochemical properties of RS and CCH fibre such as moisture content, ash content, bulk density and pH were determined by standard methods.

Characterization of Rice Straw and Coconut Husk by SEM

The surface morphologies of RS and CCH fiber were studied by SEM. The SEM micrographs were taken with (JEOL-JSM-5610, Japan).

Sorption Studies of Congo Red by Rice Straw and Coconut Husk

A stock solution of 100 mg/L (congo red solution) was prepared by dissolving 100 mg in 1 L distilled water. By serial dilution, the dye solutions congo red within the concentration range of 0.80 mg/L to 50 mg/L were prepared.

Determination of Maximum Absorption Wavelength of Congo Red Solution

The spectrophotometer was first calibrated with blank solution of distilled water. Maximum wavelength of congo red solution (25 mg/L) was determined by spectrophotometer at various wavelengths.

Construction of a Standard Calibration Curve

Series of standard (congo red) solution were prepared by serial dilution. The absorbance of standard solutions was measured at the wavelength of 500 nm by means of spectrophotometer. The standard calibration curve was constructed by plotting the absorbance versus concentration of the congo red solution.

Effect of pH on Adsorption of Congo Red by Two Types of Sorbents

The solution of congo red (25 mg/L) was prepared and the range of pH (3-8) was adjusted by the adding of 0.1 M sodium hydroxide and (0.1 M) hydrochloric acid. Each 50 mL of congo red solution was mixed with 0.2 g of adsorbent (rice straw powder or coconut husk fibre powder) in the flasks. The flasks were shaken with electronic shaker at room temperature for 2 h and the sample solution was prepared by filtration. The residual content of congo red in the filtrate was determined by spectrophotometrically.

Effect of Initial Concentration on Adsorption of Congo Red by Rice Straw and Coconut Husk

Accurately weighed sample (0.2 g) was placed in separate conical flasks. Then 50 mL of congo red solution initial concentration (5 mg/L- 40 mg/L) was added into each conical flask and was shaken with electric shaker. The residual content of congo red in the solution was determined by spectrophotometrically.

Effect of Contact Time on Adsorption of Congo Red byRice Straw and Coconut Husk

Accurately weighed sample (0.2 g) was placed in separate conical flasks. Then 50 mL of congo red solution (25 mg/L) was added into each conical flask and was shaken with electric shaker. The contact time was varied at interval of 20 min, 40 min, 60 min, 80 min, 100 min, 120 min, 140 min and 160min. The sample solution was separated by filtration. The residual content was determined by spectrophotometrically.

Effect of Dosage on Adsorption of Congo Red byRice Straw and Coconut Husk

The samples of various masses ranging from 0.01 g - 0.30 g were separately placed in the conical flask and 50 mL of standard congo red solution (25 mg/L) was added into each conical flask. In order to attain complete equilibrium, the solutions were shaken with electric shaker for one hour at room temperature. The sample solutions were removed from the sorbent by filtration. The residual content of congo red in the solution was determined by spectrophotometrically.

Results and Discussion

Physicochemical Properties of Rice Husks and Coconut Husks

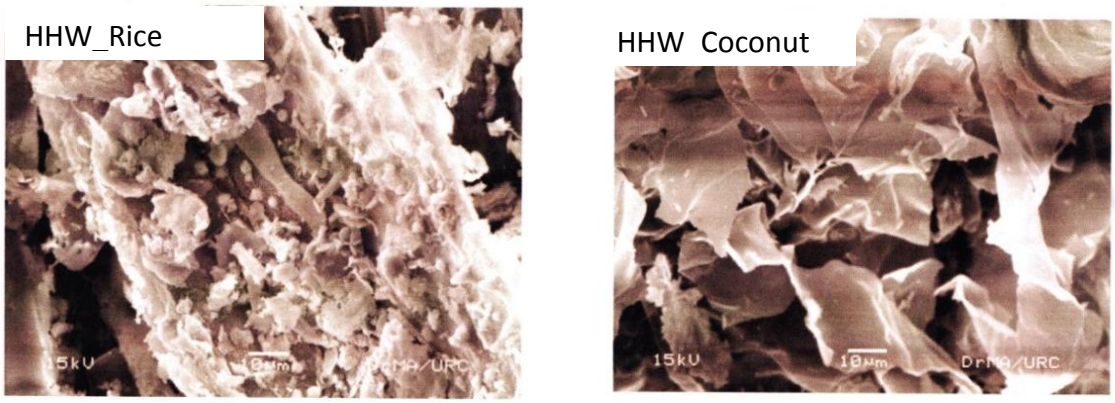
The resulting data of rice straw powder and coconut husk fibre Powdersuch as moisture content, ash content, bulk density and pH value are presented inTable1. According to the results, it was observed that moisture content (%) of rice straw powder is lower than coconut husk fibre powder and ash content (%), bulk density (gcm^{-3}) and pH of rice straw powder are greater than coconut husk fibre powder.

Table 1 Physicochemical Properties of Rice Straw Powder and Coconut Husk Fibre Powder

No.	Sample	Moisture content (%)	Ash Content (%)	Bulk Density (gcm^{-3})	pH
1.	Rice straw powder	7	18	0.21	7.69
2.	Coconut husk fibre powder	10	3	0.08	7.35

Characterization of Rice Straw Powder and Coconut Husk Fibre Powder by SEM

SEM measurement for surface analysis was carried on rice straw powder and coconut husk fibre powder samples. The SEM micrographs displaying the surface morphology of rice straw powder and coconut husk fibre powder are shown in Figures 2 (a) and (b). In this micrograph, sponges like shaped particle and their sizes (10 μm) were observed.



(a) (b)

Figure 2 SEM images of (a) rice straw and (b) coconut husk

Determination of Wavelength of Maximum Absorption of Congo Red Solution

Wavelength of maximum absorption of congo red solution (25 mg/L) was determined by spectrometer at various wavelengths. From the curve of absorbance versus wavelength (Figure 3), it was found that the maximum wavelength (λ_{max}) of congo red is 500 nm.

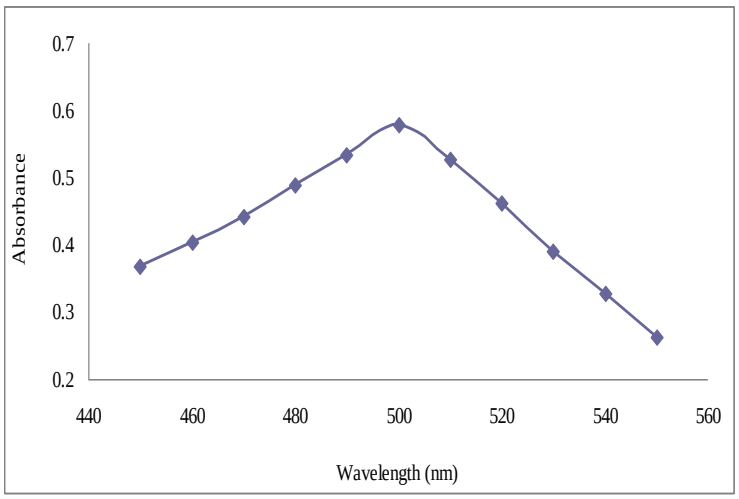


Figure 3 Maximum absorbance wavelength for congo red

Construction of Standard Calibration Curve of Congo Red

Series of standard solution were prepared by serial dilution. The absorbance of standard solutions was measured at the wavelength of 500 nm by means of spectrophotometer, spectrum curve for congo red is presented inFigure4. The data from 0.80 mg/L to 25 mg/L follows the Lambert Beer's Law, but beyond 25 mg/L it deviates from Lambert Beer's Law.

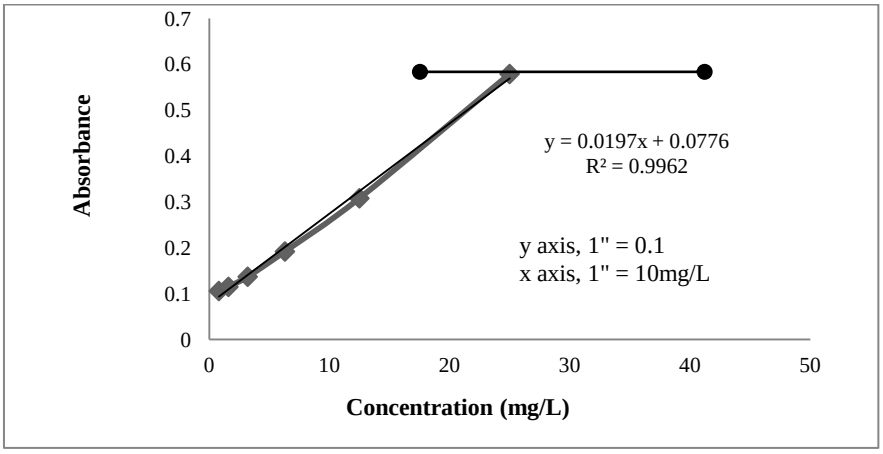


Figure 4 Calibration curve for congo red at λ_{max} = 500 nm

Sorption Properties of Congo Red by Rice Straw Powder and Coconut Husk Fibre Powder

During the sorption process, solute is transferred from solution of the solid phase where its concentration increase until a dynamic equilibrium is reached. The concentration of solute (dye) in the sorbent depends not only on the concentration in solution, but also on some parameters that may influence potentially the sorption equilibria. Dye molecules contain after strongly acidic or basic groups (e.g., sulphonic); which degree of dissociation remains virtually unchanged over a wide pH range.

Effect of pH

The pH of aqueous solution is an important parameter in the adsorption process and thus the effect of pH has been studied by varying it in the range of 3.0 – 8.0. Effect of pH on sorption of congo red by using rice straw powder and coconut husk fibre powder is presented in Figure 5. The maximum percent removals of congo red by rice straw powder and coconut husk fibre powder were observed at pH 6 and decreased substantially with increasing of pH. According to the results, it was found that rice straw powder gave the higher removal percent than that of coconut husk fibre powder at pH 6.

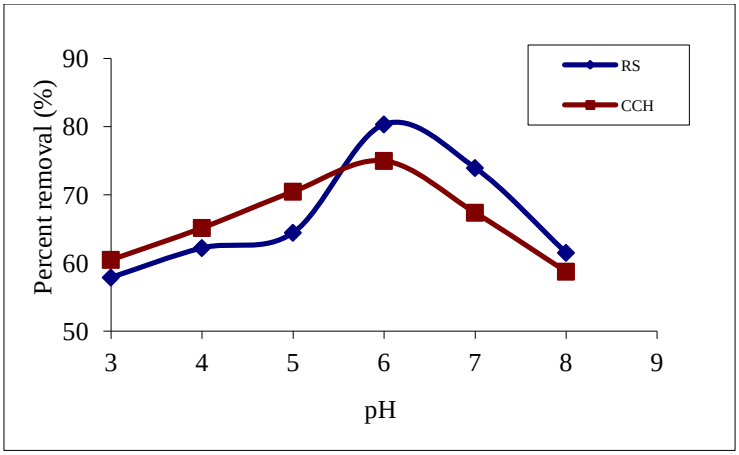


Figure 5 Effect of pH on sorption of congo red by using rice straw powder and coconut husk fibre powder

Effect of Initial Concentration

The effect of initial concentration on percent removal of congo red by rice straw powder and coconut husk fibre powder was studied when other parameters (dosage of sorbent and contact time) were kept constant and varied the initial concentrations ranging from 5 to 40 mg/L. The effect of initial concentration on adsorption of congo red by rice straw powder and coconut husk fibre powder is shown in Figure 6.It can be seen that the lower the initial concentration of congo red solution, the sorption is higher and the higher concentration of adsorbate the sorption capacity is lower.

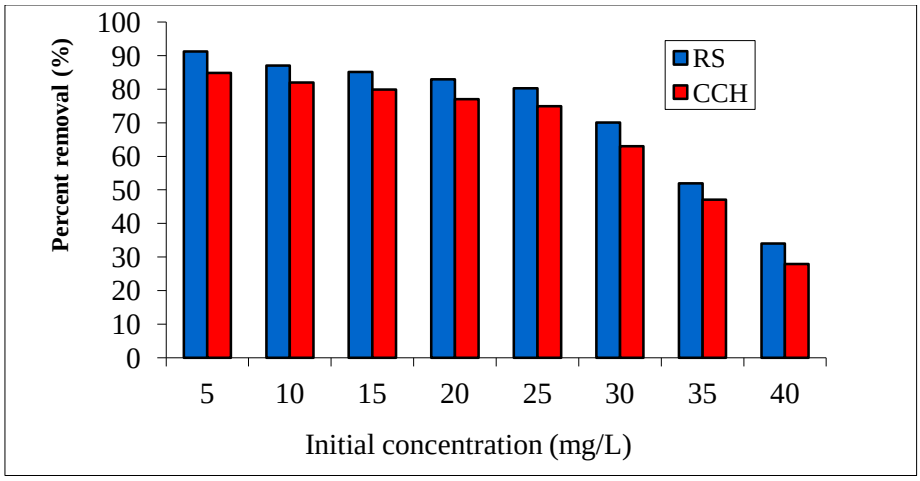


Figure 6 Effect of initial concentration on adsorption of congo red by rice straw powder and coconut husk fibre powder

Effect of Contact Time

The effect of contact time on the extent of adsorption of congo red by rice straw powder and coconut husk fibre powder is shown in Figure 7. The extent of adsorption increase with time of 20 min and attained equilibrium at 120 min when using initial concentration of 25 mg/L at pH 6.

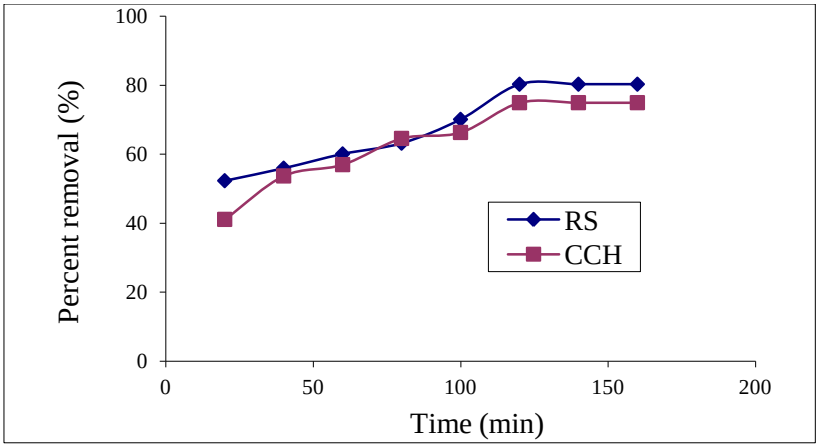


Figure 7 Effect of contact time on the removal of congo red by using rice straw powder and coconut husk fibre powder

Effect of Dosage

In the investigation of effect on dosage on the removal of congo red, the dose sorbent (rice straw powder and coconut husk fibre powder) were varied from 0.01 g to 0.30 g in 50 mL of congo red solution. The effect of dosage of sorbent on the removal of congo red by using rice straw powder and coconut husk fire powder is shown in Figure 8. According to the resulting data, the highest removal percent of congo red were observed when 0.2 g of rice straw powder and coconut husk fibre powder were used. This increase of percentage of adsorption can be explained by the presence of high number of adsorption sites on the area of adsorbent.

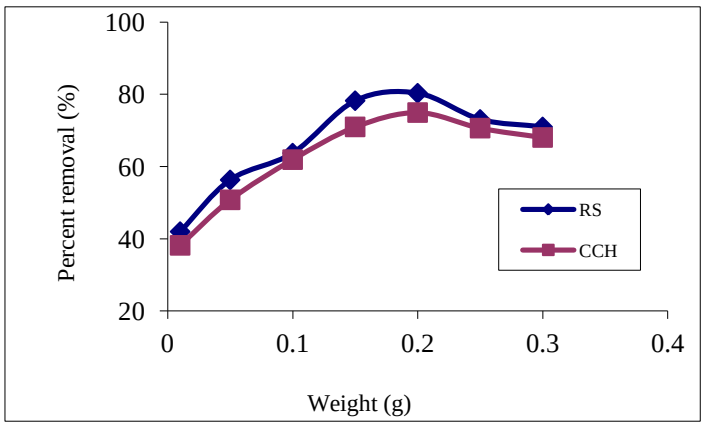


Figure 8 Effect of dosage of sorbent on the removal of congo red byusing rice straw powder and coconut husk fibre powder

Conclusion

In this study, congo red was removed from aqueous solution by rice straw powder and coconut husk fibre powder. Rice straw and coconut husk fibre were collected from Kanpya Village, Magway Township, Magway Region.

The physicochemical properties of rice straw powder and coconut husk fibre powder such as moisture content 7% and 10%, ash content 18% and 3%, bulk density 0.21 g cm^{-3} and 0.08 g cm^{-3} and pH 7.69 and 7.35 were determined respectively.

From SEM micrographs, it was observed that porosity of rice straw powder was higher than that of coconut husk fibre powder. Sorption study was carried out spectrophotometrically. The effects of sorption parameters in the process of sorption were studied with respect to pH, initial concentration, contact time and dosage method.

According to the experimental results, it was found that the highest removal percents of congo red by rice straw powder were (80.31%) and coconut husk fibre powder were (74.96%) when using (0.2g) of sorbents in 50 mL of 25 mg/Linitial congo red solution of pH 6 for 120 min. Thus, rice straw powder and coconut husk fibrepowder can be used as effective sorbents for the removal of acidic dye from aqueous solution.

It was found that rice straw powder (80.31%) had greater sorption efficiency than coconut husk fibre powder (74.96%).

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