

# Adsorptive Removal of Congo red dye from wastewater using Fenugreek Powder

NehaBhadauria, Arjun Suresh

Amity Institute of Environmental Science, Amity University

## Abstract

The present study analyzed the efficiency of a naturally derived fenugreek powder for removal of Congo red dye from the aqueous solution. The flocculation Studies on Congo Red (CR) a hazardous, textile dye onto Fenugreek Powder and its adsorption was analyzed. Fenugreek Powder is Eco-friendly, biodegradable and locally available in the market. The dye adsorption process was performed in different batches at varying pH, dye concentration, adsorbent concentration and contact time to get the best results. The result showed that the maximum removal of dye was 42.4% with 10mg/l of Fenugreek powder at pH 4.

**Keywords: Congo red dye, Fenugreek, Flocculation**

## 1. Introduction

Industries such as cosmetics, paper, food and textiles use different kinds of dyes to color their products which creates one of the most detrimental problem of wastewater, as color is the foremost pollutant in the water to be recognized, thus most of the countries have mandated to decolorize the wastewater before its discharge into water bodies (Pal et al, 2014). In textile industry, reducing wastewater production is a critical environmental challenge (Suresh, et al., 2019). Textile industry comes next to agriculture in employment engaging around 65 million people and uses different kinds of dyes which eventually generate the problem of wastewater (Dhaif-Allah, et al., 2020).

Congo red is an azo group of dyes which is anionic in nature. Congo red has been extensively used in textile industry and it has number of harmful effects on environment and human. It is carcinogenic and causes irritation in human respiratory system (mohammadietal, 2020). Fenugreek being botanically called as *Trigonella foenum-graecum* is also known as methi in Hindi. Fenugreek is an edible seed and is an annual crop mainly cultivated in India. (Mishra et al;2002) reported the use of fenugreek in the treatment of textile water effluent. As far as we know there are numerous advantages of these low cost, eco-friendly natural polysaccharides. The flocculation behavior of fenugreek for removal of Congo red has not yet been studied therefore; an effort has been made by utilizing these natural polysaccharides in removal of Congo red, a hazardous dye released from textile industry.

## **2. Material and methods**

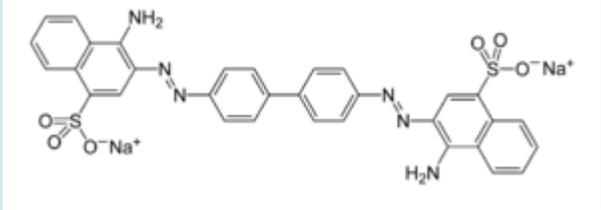
### **2.1. Fenugreek**

Fenugreek is a natural polysaccharide and used as a direct food additive. It is very similar to clover in appearance, grown in North Africa, Asia Minor, India and Pakistan. The small brown seed of fenugreek are medicinally very important. The mucilage is obtained by extraction of milled seeds with cold water. The natural polysaccharides are low-cost materials fairly shear stable and easily available from reproducible agricultural resources and they act as good flocculating agents.

### **2.2. Congo red**

Congo red is the sodium salt of 3, 3'-([1, 1'-biphenyl]-4,4'-diyl)bis(4-aminonaphthalene-1-sulfonic acid)(formula:  $C_{32}H_{22}N_6Na_2O_6S_2$ ; molecular weight: 696.66 g/mol). It is a secondary diazo dye. Congo red is water soluble, yielding a red colloidal solution; its solubility is better in organic solvents such as ethanol.

**Table.1 Characteristics of Congo red dye**

Characteristic	Congo Red
Structure	
Molecular Formula	$C_{32}H_{22}N_6Na_2O_6S_2$
Type of Dye	Anionic
Molecular weight	696.66
Maximum wavelength of absorbance (nm)	496

UV/Vis spectrophotometer (Perkin Elmer Lambda 35) was used to determine the concentration of removal of concentration Congo red. It measures the intensity of light passing through a sample and compares it to the intensity of light before it passes through the sample. The ratio is called the *transmittance*, and is usually expressed as a percentage (%T). The absorbance is based on the transmittance. The instrument in ultraviolet-visible spectroscopy is called UV-visible spectrophotometer and can be configured to measure reflectance. In this case, the spectrophotometer measures the intensity of light reflected from a sample and compares it to the intensity of light reflected from a reference material such as a white tile. The ratio is called the *reflectance*, and is usually expressed as a percentage (%R).

### 2.3. Flocculation Studies

The flocculation efficiency of natural polysaccharides with dye solution was determined at room temperature. The effects of varying polysaccharide concentration, dye concentration, pH and contact time on flocculation capacity of the polysaccharide were studied. The polysaccharide and dye solution were agitated in a flocculator at 100 rpm for one minute and then at 30 rpm for a period of 10 minutes. In each case 100 mL of dye solution was taken with optimum polysaccharide dose. The different dye concentrations chosen for batch experiments were in the range of 1 to 20 mg/L. At definite intervals, the supernatant solution

was taken out and centrifuged. The dye concentration in treated and untreated solutions was measured using UV-VIS spectrophotometer at 497nm. Different concentrations of dye solutions were used for studying maximum percent removal. The maximum percent removal of dye was obtained by contacting the optimum dose of polysaccharides with different concentration of dye solution.

The equation used to calculate the color removal efficiency in the treatment experiments was:

$$\text{Dye removal (\%)} = \frac{C_i - C_f}{C_i} \times 100$$

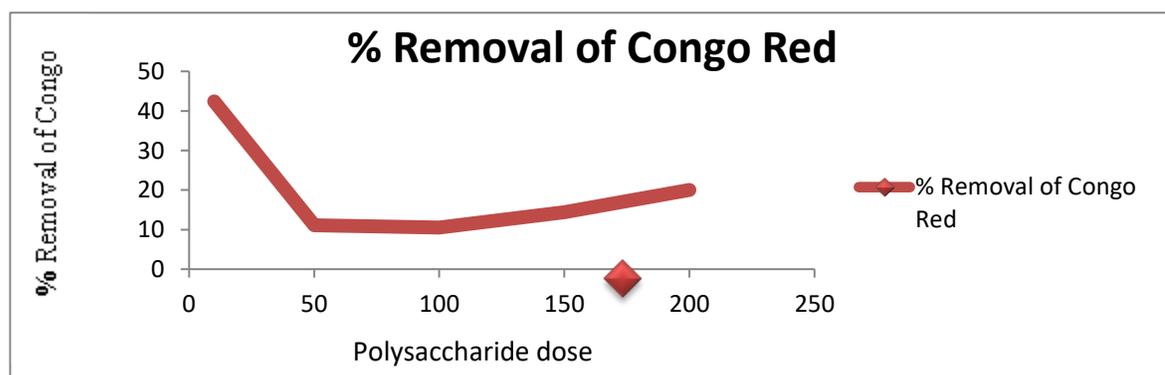
$C_i$

Where  $C_i$  and  $C_f$  were the initial and final concentration of dye solution (mg/L), respectively

### 3.Result and Discussion

#### 3.1 Effect of Polysaccharide Dose

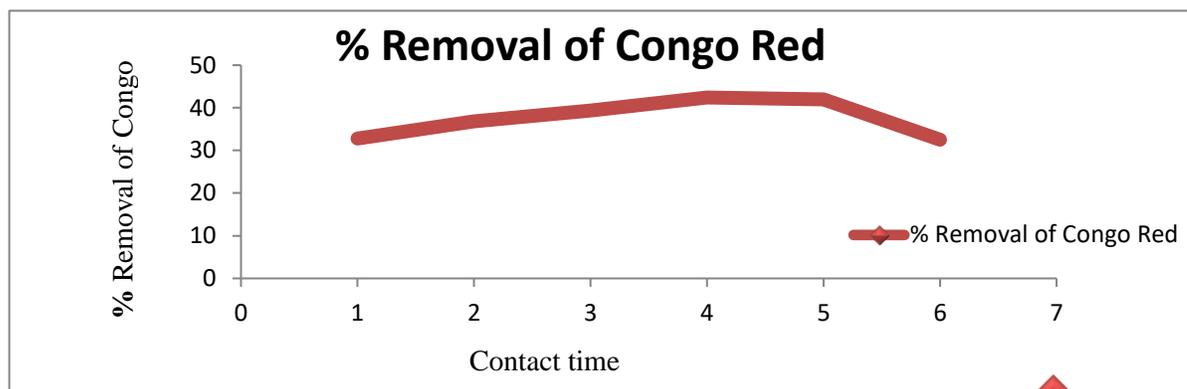
Fig.(3.1) represents the plot of percent removal of Congo red versus polysaccharides dose. It is apparent that with increase in polymer dose, the % removal of dye increases up to a certain dose and after this dose, decreasing trend in dye removal was observed with increase in adsorbent concentration. The most effective dose of adsorbent was found 10 mg/L for Congo red, at which maximum dye removal was seen.



**Fig (3.1) % Removal of dye with varying Polysaccharides dose with dye concentration of 5mg/L**

### 3.2. Effect of Contact Time

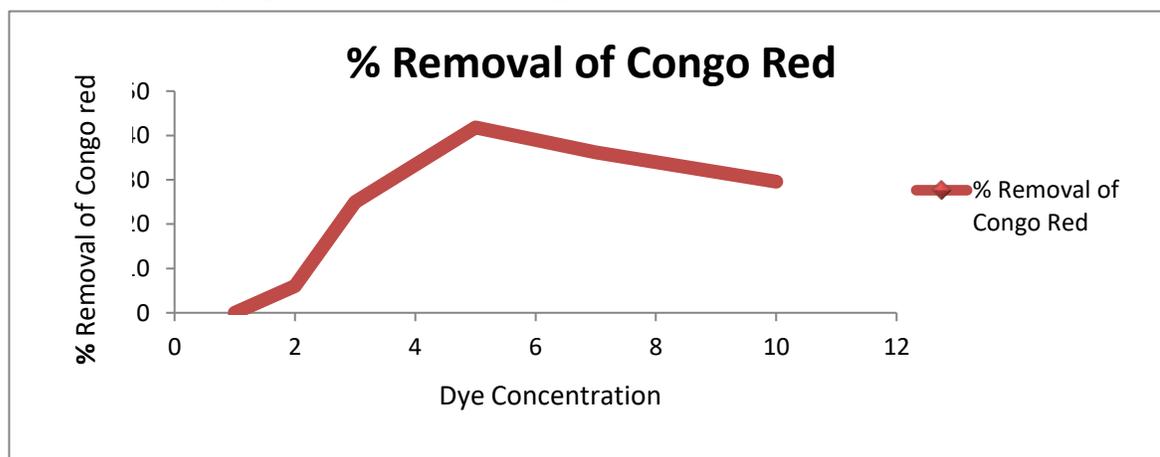
The effect of % removal of dyes with contact time is shown in Fig (3.2). The maximum removal of the dye Congo red was found after four hours. After this duration the percent removal becomes constant or the maximum slightly decreases.



**Fig (3.2) % Removal of dye with varying contact time with dye concentration of 5mg/L at 10mg/L polysaccharide dose**

### 3.3. Effect of Dye Concentration on % Removal

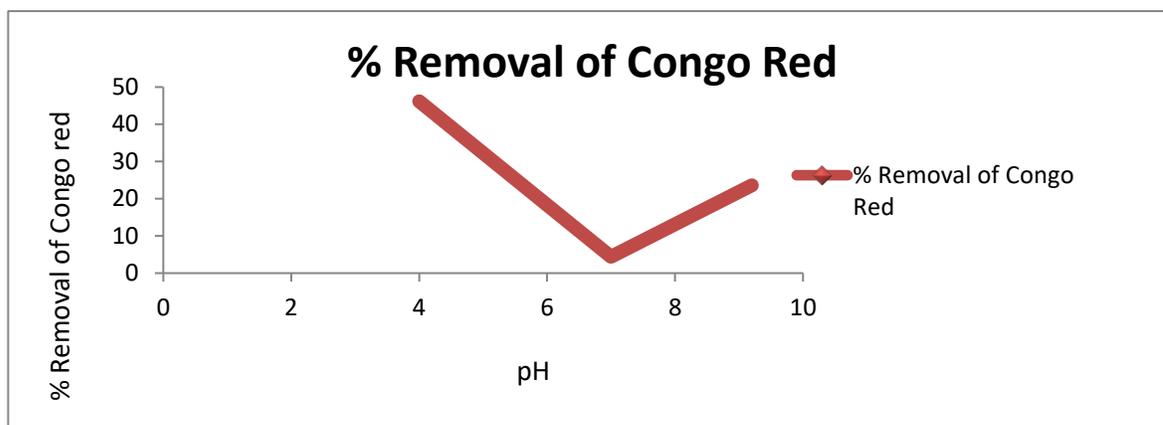
The effect of dye concentration on % removal is presented in Fig. (3.3.) It showed that variation in the concentration of dye from 1 – 10 mg/L, the percent removal decreases from 41.8 to 0 % for Congo red at polymer dose at 10 mg/L respectively. Data related to % removal with varying concentration of dye given.



**Fig (3.3) % Removal of dye with varying dye concentration with polysaccharide dose 10mg/L**

### 3.4 Effect of pH on % Removal

Effect of pH on % removal of dye is shown in Fig. (3.4). The maximum removal of dye was found to be 46.18% for Congo red at acidic pH.



**Fig (3.4) % Removal of dye with varying pH with dye concentration 5mg/L with polysaccharide dose 10mg/L**

The maximum removal of dye occurs at optimum polysaccharide dose because in flocculation process aggregation of polysaccharide particle and dye molecule is an important phenomenon. The optimum polysaccharide dose leads to more aggregation as well as more floc formation that increases the percent removal of dye. Increase in polysaccharide dose leads to decrease in percent removal of dye due to redispersion of aggregated particles and dye molecules and also cause disturbance in particle settling.

pH does not cause any change in flocculation efficiency of polysaccharide in dye removal in that case dye removal occurs due to structural changes in dye molecule. The removal of Congo red takes place at acidic pH which may be due to conversion of dye from solubilized form into non solubilized form. The increase in pH leads to alkaline solution which produces negative ions in solution and causes electrostatic repulsion that prevents aggregation. With increase in dye concentration and contact time the removal of Congo red increases up to an optimum level of polysaccharide dose then it becomes constant or constantly decreasing.

## 4. Conclusion

In this study, flocculants based on natural polysaccharides has been assessed for removal of Congo red dye. Natural polysaccharides Fenugreek was chosen for this purpose. A series of contact time experiments were conducted for testing their efficiency as flocculants. Flocculation studies were conducted to assess the different variables such as concentrations of natural polysaccharides and dye and pH. The maximum removal of Congo red dye observed was 42.4% with Fenugreek. The optimum time for removal was 4 hours. The maximum removal of dye was found at acidic pH.

**Table.2. Flocculation capacity of Fenugreek for removal of Congo red dye**

Natural polysaccharides	Natural polysaccharidesDose mg/L	Dye concentration(mg/L)	Dye Removal %	Optimum pH	Contact Time (Hours)
Fenugreek	10	5	42.4	4	4

The present study covers only Congo red dye for the treatment by the flocculants Fenugreek. It is therefore, recommended to perform flocculation studies on effluents of various industries.

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