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# *Acanthocereus tetragonus* an effective natural coagulant for Decolorization of synthetic dye wastewater

**G. Vijayaraghavan[1], P. Vignesh Kumar[2], K. Chandrakanthan[2], S. Selvakumar[2]**

*1. Chemical Engineering Department, Rajalakshmi Engineering College, Thandalam, Chennai, 602105, Tamilnadu India.*
*2. Chemical Engineering Department, AdhiParasakthi Engineering College, Melmaruvathur, Tamilnadu India.*

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**G.Vijayaraghavan**
vijayaraghavan.g@rajalakshmi.edu.in
**+91 9865220987**

## Abstract

In this present study the effectiveness of Acanthocerous tetragonus (AT) as a coagulant to remove the colour of synthetic textile waste water contains Congo Red (CR) and Direct Blue (DB) dye was analyzed. Experiments were carried out for initial dye concentration of 100-500 ppm and coagulant dose varies between 1-6ml of AT and 1-6gm of Alum .It was observed that the maximum colour removal was attained at 400ppm initial dye concentration and 4ml coagulant dose for AT and 6 gm of alum dose. On comparing with the commercial coagulants like alum this novel natural coagulant AT produced less quantity of sludge. The sludge volume index (SVI) of AT and Alum was 30 and 45 mL/gm in Direct blue dye solution and 35 and 48 mL/gm for Congo red dye solution respectively. Based on the experimental results, it was decided that the natural coagulants like AT will be a very effective one, compared to metallic salts like alum.

## 1. Introduction

In this present situation a huge threat in textile industry is waste water and our aim is to resolve the issue faced [1]. There are several methods available for treating the wastewater however coagulation is one of the cheap and easiest approach. The main disadvantage of coagulation process is usage of large quantity of chemicals will cause many hazards for the environment and the present study will give a suitable solution to overcome the arising problem [2]. Recent studies proved that many natural coagulants were effective in treating the industrial waste water, because of high efficiency and cost effective.so we are going to approach a procedure to use a natural coagulant in place of commercial coagulant and going to have a short comparison on those. Where as many have tried on using an AT but we are the first to test this on Congo red and direct blue that to in synthetic waste water [3]. The main objective of the present study is to reduce the sludge volume during the coagulation process by the application of plant based natural coagulants. In textile industries the settled sludge will be considered as waste and it affects the environment during disposing so the use of AT in place of other commercial coagulant like alum, Ferrous Sulphate, Calcium hydroxide etc., it will help in reducing large quantity of sludge and it provides an effective result. There are many natural coagulants available like Sargassum, Phaeophyceae, Rhodophyceae, and Chlorophyceae and Acanthocerous tetragonus (AT). As AT is easy available and in enormous amount we choose this and also it shows high effectiveness [4].

## 2. Material and methods

2.1. *Preparation of Synthetic wastewater*

The synthetic waste water sample were prepared by adding a known amount of dye with various initial concentration of 100-500 mg/L with different pH of 4,5,6,8,9 and 10 in distilled water each 100ml sample was treated using different dosage of ALUM and Acanthocerous tetragonus(AT) for this experiment.

*2.2 Direct blue dye*

Direct Blue is an azo dye having IUPAC name as a 4-(4- Amino phenyl) benzamine 6-Amino-4-hydroxynaphthalene2-sulfonic acid (Figure 1). Molecular weight is 830.71. 1gm of Direct Blue dye was dissolved in 1L of double distilled water to obtain stock solution [5]. Later, it was diluted by using distilled water according to the concentration required and pH was adjusted by adding 0.1 M NaOH solution and 0.1 M HCl solution according to the conditions [6].

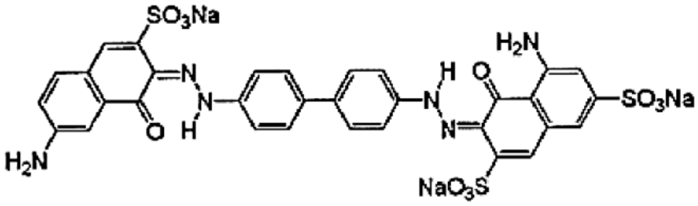



**Figure 1.**Molecular Structure of Direct Blue

*2.3 Congo red dye*

Congo red is an anionic azo dye having IUPAC name as a 1-napthalenesulfonic acid, 3,3-(4,4-biphenylenebis(azo))bis(4-aminodisodium) (Figure 2).The stock solution was prepared in double-distilled water. All the test solutions were prepared by diluting the stock with double- distilled water [7]. 1gm of Congo red dye was dissolved in 1L of double distilled water to obtain stock solution. Later, it was diluted by using distilled water to make the required concentration and pH was adjusted by adding 0.1 M NaOH solution and 0.1 M HCl solution according to the conditions. The Molecular weight is 696.66 g/mol and it is a secondary diazo dye. Congo red is a water soluble dye [8].

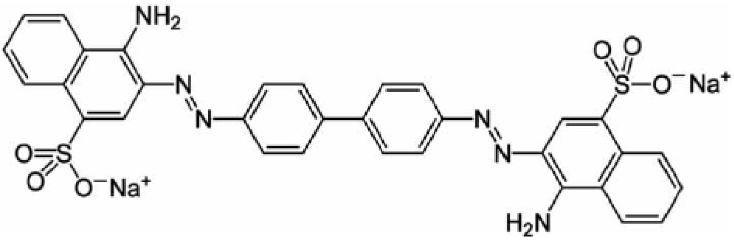



**Figure 2.** Molecular Structure of Congo red.

*2.4 Acanthocereus tetragonus*

Acanthocereus tetragonus is a plant species that belongs to kingdom Plantae under the order of caryophyllales which means it is a member of eudicot species it is categorized by its DNA sequence, its characteristics is another wall development and vessel element with simple performance. The scientific classification is given in Table 1. Acanthocereus is genus of cacti, it is a species having the nature of shrubs with arching stems [9].

**Table 1.** Scientific classification of *Acanthocereus tetragonus*

| KINGDOM | Plantae |
|---|---|
| ORDER | *Caryophyllales* |
| FAMILY | *Cactaceae* |
| GENUS | *Acanthocereus* |
| SPECIES | *A.Tetragonus* |
| BIOLOGICALNAME | *Acanthocereus tetragonus* |

*2.5 Acanthocerous tetragonus: Coagulant preparation*

Acanthocereus tetragonus pads were collected and washed thoroughly with tap water and manually chopped into small pieces after removing the spines. The external skin as well as the inner off-white portion of the cactus pieces were grinded with a food processor and extracted with water in equal weight by volume ratio. It was then filtered using Whatman no. 42 filter paper to remove the fibrous part of the pads and the active ingredient of the coagulant was in the form of residual water extract. Fresh extracts were prepared for each batch run or else the extract will be decomposed. The collected pads can be stored under refrigeration for at least 1 month [10].

*2.6 Experimental procedure*

The suitable dye of 1gm was dissolved in a 1000ml distilled water with various concentration of 100-500 ppm. Using a 1litre measuring jar the settling characteristics of dye was studied with Alum dosage of 1-6gm. as well as the AT dosage 1-6 ml. After adding the coagulant, rapid mixing can be done in a Jar Test set up and the content was transferred in a 1 litre Jar and allowed to settle for 30 min. The readings were taken in triplicate for each individual solution to check repeatability [11]. Neutralization of coagulants is done by its electrostatic repulsive force so that the opposite charges are get attracted and "stick" together so that due to neutralizing electrical charges surrounded in the tiny particles. The supernatant after sedimentation was filtered using Whatman no. 42 filter paper and the filtrate was analysed for absorbance using UV spectrophotometer (Systronics 119 – India) at a maximum wavelength 475 nm for Congo red dye and 611 nm for Direct blue dye. Colour removal efficiency was measured as a decrease in optical density measurement at 475 nm for CR and 611 for DB. The percentage colour removal was calculated using following equation (1):

$$\frac{C_i - C_f}{C_i} \times 100 \qquad (1)$$

The settled sludge volume and MLSS was calculated as per APHA standard procedure [12][13].The experiments were repeated for different coagulant dose and initial concentration of dyes. SVI (ml/gm) is calculated by Equation. (2).

$$SVI = \frac{\text{Settled Sludge Volume, mL/L x 1000 mg/g}}{\text{Suspended solids, mg/L}} \qquad (2)$$

## 3. Results and discussion

*3.1 Effect of pH*

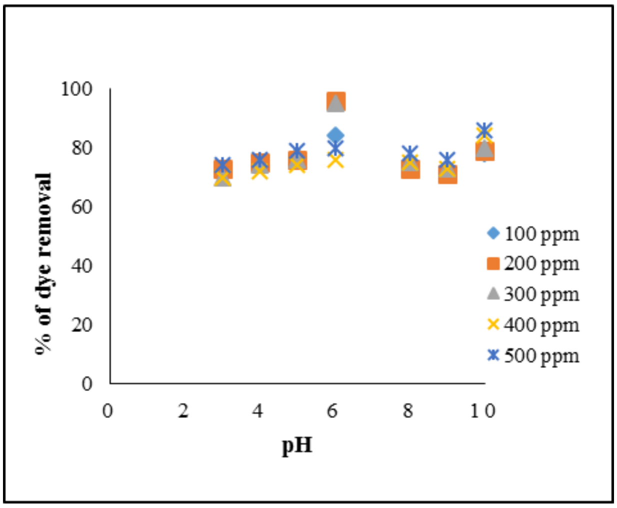
During the coagulation process, the role of pH is very important and it affects the surface charge of coagulants and also the stabilization of the suspension. Figure 3 depicts the effect of pH on the removal of Congo red dye and Direct blue dye with initial concentrations of 100 – 500 mg/L using Acanthocerous tetragonus(Figure 3a) and Alum (Figure 3b). The experiments were conducted using coagulant dose of 1-6 ml/L of AT and 1- 6 gm/L of Alum. It can be noted from the figure that the maximum Congo red dye removal of 96 % was achieved at pH 6 for Acanthocerous tetragonus and 80 % was achieved at pH 6 for Alum. Similarly for direct blue dye removal of removal of 90 % was achieved at pH 4 for Acanthocerous tetragonus (Figure 3c) and 79 % was achieved at pH 4 for Alum (Figure 3d).

*3.2 Effect of initial concentration*

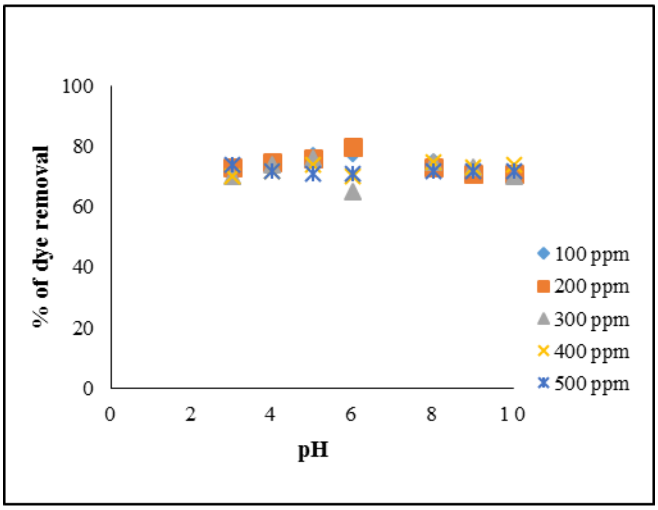
The colour removal yield is a function of the initial dye concentration, using the optimum conditions obtained previously for mixing speed, mixing time, coagulant dose, settling time and pH. The effect of the settling time remained negligible in this present study [14].From the experiment, the initial concentration of 100-500 ppm was analysed for the coagulant dosage of 1-6ml for AT and 1-6gm for Alum. At 500 ppm of initial concentration the maximum dye removal for Congo red dye (96 %) and at 400 ppm direct blue dye (80 %) occurs. A rise in coagulant dose is affecting the re-dispersion of the charged particles in the dye or dislocation of the dye suspension. The increase dosage beyond optimum may also result in change in pH of the medium and may result in re-dissolving sludge. It was observed that *Acanthocereus tetragonus* is a more effective coagulant at higher dye concentration i.e. 500 ppm for Congo red dye and 400 ppm for Direct blue dye.

*3.3 Effect of coagulant dosage*

Coagulation dosage is the important factor to be considered for the determination of optimum condition and the performance of coagulants in the coagulation process. If the dosage is improper the efficiency of the process become poor and it results in wastage of coagulants [15]. If the optimum dosage of coagulant was determined using several trials it will minimize the cost of coagulant. The effect of coagulant dose on colour removal using Acanthocerous tetragonus, Alum dosage was studied by maintaining pH 6 for Congo red dye and pH 4 for direct blue dye and the results are presented in Figure 4. It can be noted from the figure that the percentage colour removal increases with increase in coagulant dose and the maximum colour removal was achieved at the coagulant dose 5 mL of Acanthocerous tetragonus (Figure 4a) and 6gm of Alum (Figure 4a) in Congo dye removal and 6 mL of Acanthocerous tetragonus (Figure 4c) and 4gm of Alum (Figure 4d). The maximum percentage removal of colour and the optimum conditions are given in Table 2.




**(a)**

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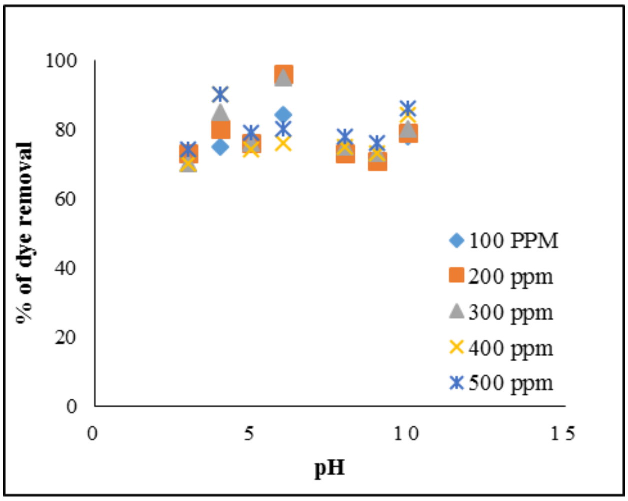
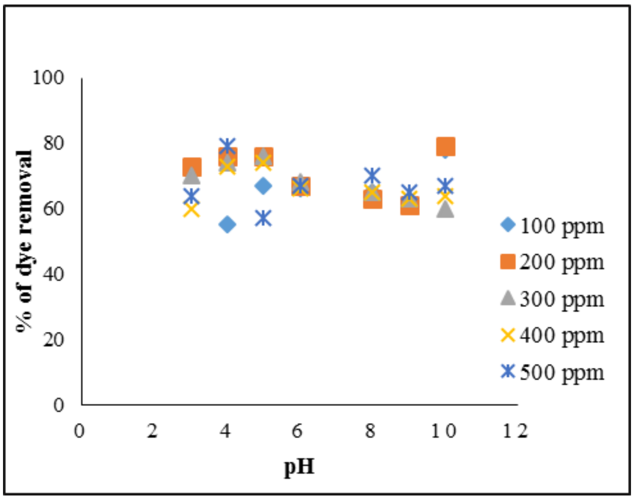



**(c)**




**(d)**

**Figure 3.** Effect of pH on Congo red dye removal using (a) AT and (b) alum and Direct blue 2 dye removal using (c) AT and (d) alum for initial dye concentrations from 100 – 500 ppm.

**Table 2.** Optimum condition for dye removal

| **Coagulant** | **Initial dye concentration (mg/L)** | | **Coagulant dose** | | **pH** | | **% Dye removal** | |
|---|---|---|---|---|---|---|---|---|
| | **CR** | **DB** | **CR** | **DB** | **CR** | **DB** | **CR** | **DB** |
| *Acanthocerous tetragonus* (AT) | 500 | 400 | 5ml | 6ml | 6 | 4 | 96 | 90 |
| Alum | 500 | 400 | 6gm | 4gm | 6 | 4 | 80 | 79 |

*3.3 Sludge Volume Index (SVI)*

The Sludge Volume Index (SVI) was calculated using equation 2 and the values for AT and Alum was found to be 35 and 48 mL/gm for Congo red dye solution and 30 and 45 mL/gm in Direct blue dye solution respectively. It was observed that the role of initial dye concentration influences the value of SVI. On comparing these values it was observed that the AT produces less quantity of sludge on comparing with the commercial coagulant Alum. A lower sludge index indicates better settling ability. The handling of large quantity of sludge after coagulation process will be overcome by using AT as a coagulant.

*3.4 Coagulation Mechanism*

The coagulation mechanism may be due to anyone or combination of the following: (i) double layer compression (ii) sweep flocculation or enmeshment within colloidal floc (iii) adsorption and charge Neutralization by oppositely charged ions and (iv) adsorption and interparticle bridging in case of polymeric coagulant [9]. Since Acanthocereus tetragonus is a bio coagulant contains a natural polymer, it follows sweep flocculation mechanism during slow settling and adsorption and interparticle bridging mechanism may leads to a gel formation which results in the less quantity of sludge.

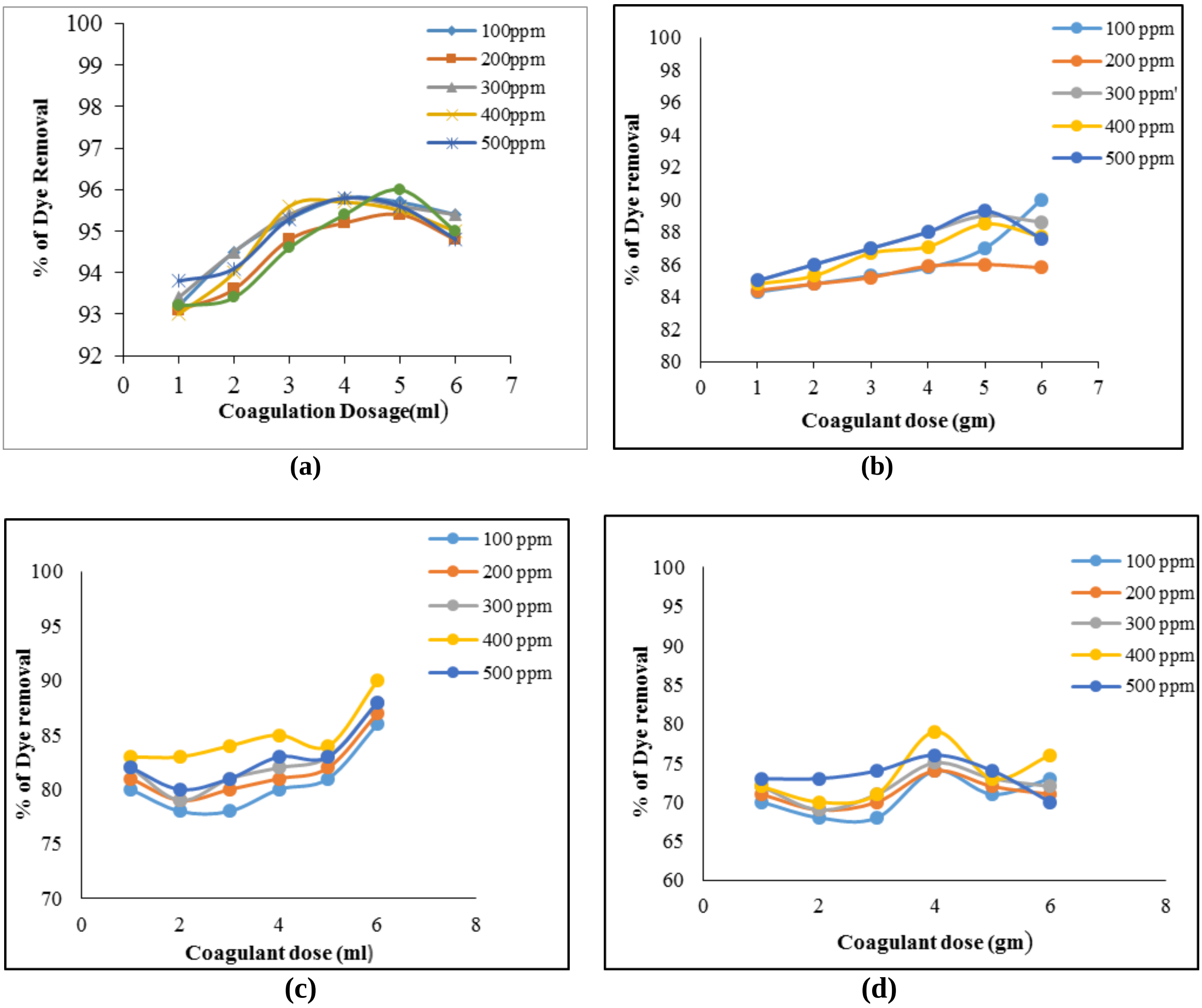



**Figure 4.** Effect of Coagulant dose on Congo red dye removal using (a) AT and (b) alum and Direct blue 2 dye removal using (c) AT and (d) alum for initial dye concentrations from 100 – 500 ppm.

## Conclusion

The effectiveness of AT as a coagulant for the removal of synthetic dyes were studied the experimental results showed that AT is equally efficient in removal of CR and DB compared to commercial coagulant ALUM. The analysis were carried out with an initial dye concentration of 100-500ppm and coagulant dose varies between 1-6 ml of AT and 1-6 gm of ALUM for direct blue dye. At 500 ppm of initial concentration the maximum dye removal for Congo red of pH 6 (96 %) at the coagulant dose 5 mg/L of Acanthocerous tetragonus and 6gm of Alum. At 400 ppm Direct blue dye at pH 4 (80 %) occurs at the coagulant dose 6 mL/L of Acanthocerous tetragonus and4gm of Alum. The Sludge Volume Index (SVI) of AT and Alum was 35 and 48 mL/gm for Congo red dye solution and 30 and 45 mL/gm in Direct blue dye solution respectively. It was observed that the role of initial dye concentration influences the value of SVI. In future, the current research may outspread its range by scrutinize with other plant based natural coagulants.

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