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INVESTIGATION ON THE REMOVAL OF DIRECT RED DYE USING *ASPERGILLUS NIGER AND ASPERGILLUS FLAVUS* UNDER STATIC AND SHAKING CONDITIONS WITH MODELING

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Abstract: Direct red dye belong to an important group of synthetic dye used in textile industries. They are considered as recalcitrant compound for degradation. In the present study batch experiment was conducted for the decolorization of direct red dye using *Aspergillus niger and Aspergillus flavus* under static and shaking conditions. At 50 mg/L 97% and 87 % decolorization was achieved with *Aspergillus niger* in 48 hrs at static and shaking condition but in case of *A. flavus* percentage of decolourization was found to be 78 %and 83 % in 48 hrs in static and shaking condition respectively. During the adsorption isotherm studies decolorization followed Freundlich model for both the organisms with regression coefficient value of 0.833 and 1. This study brings out the ability of *Aspergillus sp*. to degrade reactive dyes and reinforces the potential of this group of fungi for the decolorisation of textile effluents.
Key words: Synthetic dye; Decolorization; Adsorption isotherm, Freundlich model.

1. INTRODUCTION

Dyes are widely used in the Textiles, rubber product, paper, printing, color photography, Cosmetics and many other industries. Textile dyes enhances the quality of human lifestyle on an extent [1]. Almost 10% to 15% of the total dyes consumed in the textile industry are lost during dyeing. But on the same side at a negative point most of the textile industries operate with pure cotton fibers or cotton fibers mixed with polyester. Many dyes and other substances present in textile effluents are polluting the environment. Further disposal of the dyes from the industries into the environment causes serious damage, since they may significantly affect the photosynthetic activity of hydrophytes by reducing light penetration and also they may be toxic to some aquatic organisms due to their recalcitrant nature [2].Therefore, industrial effluents containing dyes must be treated before their discharge into the environment. Consequently, large quantities of dye-containing effluents are released in the

environment. Such effluents discolor water bodies and increase biochemical oxygen demand of the contaminated water. In addition, anaerobic degradation products of some dyes may be carcinogenic or mutagenic [3].

A number of biotechnological approaches have been suggested by recent research as of potential interest towards combating this pollution source in an eco – efficient manner, including the use of bacteria or fungi, often in combination with physicochemical processes [4-7]. Biotreatment depicts a cheaper and environmentally friendlier alternative for colour removal in textile effluents. The ecofriendly microbial decolorization and detoxification is a alternative to the physical and chemical methods. The kinetics of decolorization and the environmental factors affecting the decolorization rates is relatively scarce[8]. A wide variety of microorganisms are capable of decolorization of a wide range of dyes some of them are as bacteria: *Escherichia coli* NO3, *Pseudomonas luteola*, *Aeromonas hydrophila*; Fungi: *Aspergillus niger, Phanerochaete chrysosporium, Aspergillus terricola*, *P.chrysosporium* ; yeasts: *Saccharomyces cerevisiae*, *Candida tropicalis, C. lipolytica* ; algae: *Spirogyra* species , *Chlorella vulgaris* , *C. sorokiniana*, *Lemna minuscula*, *Scenedesmus obliquus, C. pyrenoidosa and Closterium lunula* [9]. The present study aims to investigate the potential of fungal cultures isolated from effluent water which is contaminated with textile dyes for the decolorization of synthetic textile dye under static and shaking conditions with respect to various parameters.

2. MATERIALS AND METHODS

2.1 Materials

Reactive red and Direct Red which are commonly used in textile industries and were collected from textile industry, Thirupur, Tamil Nadu, India. Water sample was collected from effluent treatment area of textile dye contaminated area of Pallipalayam, Erode District. In the present study, the absorbance value for Reactive red and Direct Red were measured using UV-visible Spectrophotometer. All chemicals used were of highest purity available and of analytical grade.

2.2 Isolation of Micro organisms

Collected samples were serially diluted and a series of dilutions were made. From the dilutions, 1ml volumes were pippeted onto Potato Dextrose agar and Czapek Dox agar and incubated at 28°C for three days. After three days, the fungal species

were isolated from the agar plate and sub-culturing was done to obtain a pure culture for further studies.

2.3 Decolorization of Various Dyes

Synthetic dye solutions were prepared for decolorization studies for Direct and reactive red dyes were mixed in 100 ml of synthetic water in each conical flask at different concentrations (50 mg/L, 100 mg/L and 200 mg/L respectively) and the isolated organisms which had been showing higher growth was inoculated. The conical flasks were incubated under two different conditions. One set of each was incubated at static condition, 37ºC and pH7. Other set of conical flasks were incubated in shaker with 150 rpm, 37 ºC and pH7. The absorbance values were taken for analyzing the % of decolorization and average decolorization rate. The OD values was taken at maximum absorbance values of each dye at 24^{th} hr 48^{th} hr,72^{nd} hr and 96^{th} hr.

Decolorization activity was calculated using following formula

$$\%Decolorization. = \frac{OD.valueforControl - OD.value.for..sample}{OD.valuefor..control} \times 100 \qquad \text{(Eq. 1)}$$

$$Average..decolorization. = \frac{C \times \%D \times 1000}{100 \times t} \qquad \text{(Eq.2)}$$

where C, initial concentration of dye (mg/l); *%D*, dye decolorization (%) after time *t* [10].

2.4 Adsorption studies:

Adsorption capacity at different aqueous equilibrium concentration for the isolated fungal cultures can be explained by the adsorption isotherm studies. Adsorption isotherm experiments were carried out with two different dyes, namely Direct Red and Reactive Red. The experiments were performed by interacting varying concentrations of dye solutions (50-500 mg/L) with isolated fungal cultures (1 x 10^8 CFU/mL) in a rotary shaker at 150 rpm for 4 h. The interaction was followed by centrifugation at 10,000 x g for 10 min. The supernatants were carefully collected and the amounts of dye left in the supernatant were calculated using UV-visible spectrophotometer. The amount of Direct Red and Reactive Red adsorbed at equilibrium ‘qe’ (pg/cell), was calculated by the following equation.

$$qe=\left(\frac{C_0-Ce}{N}\right)\times V \qquad \text{Eq. (3)}$$

where C_o and C_e (mg/L) are the initial and equilibrium concentrations of dye solutions. V is the total volume of the solutions and N is the number of cells used for the study.

3. RESULTS AND DISCUSSION

3.1 Isolation and identification of the strains:

From the environmental samples, two fungal species of *Aspergillus* genus were isolated. Those strains were identified through biochemical, morphological and staining techniques as *Aspergillus flavus* and *Aspergilus niger* respectively. The strains were maintained at 37ºC in Patato dextrose agar slants and were used for the further studies.

3.2 Effect of initial dye concentration on Percentage of dye removal

The initial dye concentration is an important variable that can affect the adsorption process. Adsorption of dyes at different initial concentrations leads to the determination of the adsorption capacity of the adsorbent. Higher the concentration of dye, higher the degradation time for decolorizing. Hence, in this study the effect of initial concentration on adsorptive removal of dyes by *A. niger and A. flavus* was evaluated by interacting different concentrations of dyes with fungal spores cells. It was evident that, at 50 mg/ml concentration, *A.niger* gave 100% decolorization at 24 hrs and *A.flavus* gave 98% decolorization

3.3 Effect of contact time on adsorption and Percentage of dye removal

The contact time between adsorbate and adsorbent is the most important design parameter that affects the performance of adsorption processes. The effect of contact time on the adsorption of Direct Red was studied to determine the time taken by *A. niger and A.flavus* cells to remove 250 mg/L of Direct Red solution at pH 7. The fungal species reached maximum adsorption and % removal within 3 h and thereafter it remained constant

3.4 Effect of different dye concentrations on decolourization

The decolourization performance of Direct red by *A. niger and A. flavus* was also studied at various increasing dye concentration (50, 100, 250mg/L). From Fig 1-4 it was observed that the rate of decolourization decreased with increasing dye concentration. At 50 mg/L Direct red dye concentration shows 97% and 87 % decolourization with *Aspergillus niger* in 48 h at static and shaking condition but in

case of *A. flavus* showed that percentage of decolourization was observed only 78-83 % in the 48 h in static and shaking condition respectively. The time required for decolourization varied from 24 to 120 h. when the dye concentration was high as 200 mg/L, almost 100 % of the dye was removed in 120 h. This means that an acceptable high color removal can be achieved by the *A. niger and A. flavus* strain in an extensive range of triphenylmethane dye concentrations. Lower decolourization percentage at high dye concentration was reported and expected to be due to the inhibitory effects of high dye concentration [11]. Our results compared with) the consortium shows 58 and 48% decolourization of adsorbed reactive navy blue HE2R at 800 and 1000 mg/L concentrations in 72 h [12] Though *Aspergillus flavus* seem to give high initial decolorization, *Aspergillus niger* gave a better decolorization at static condition.

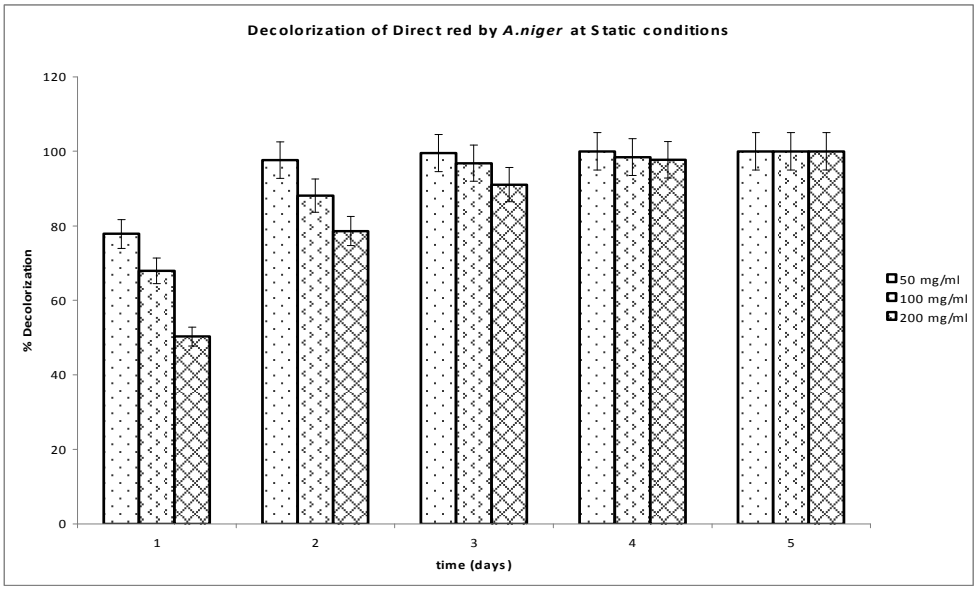

Fig 1 : Decolorization of Direct red by *A.niger* at static conditions

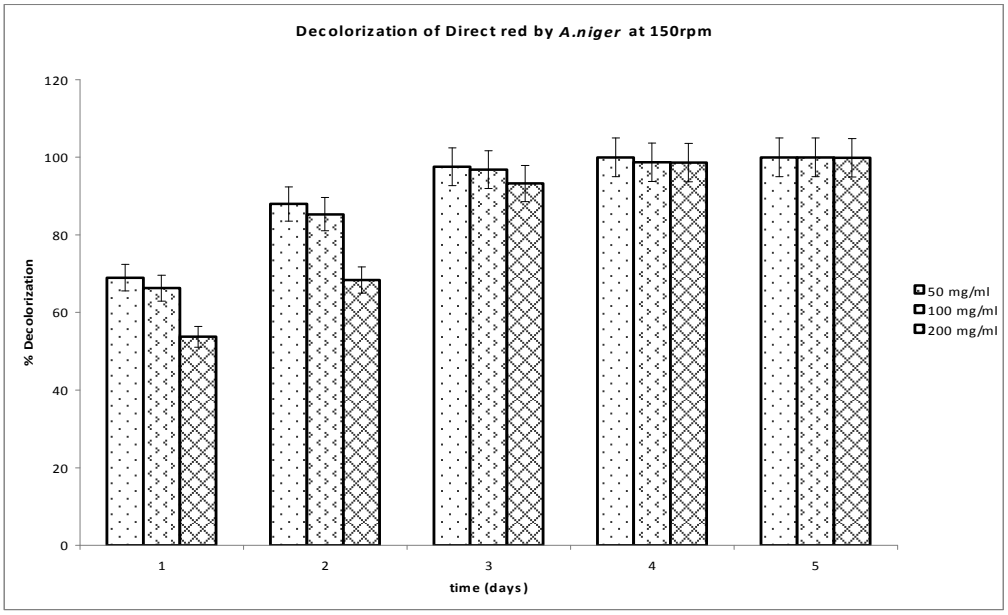

Fig 2 : Decolorization of Direct red by *A.niger* at 150 rpm

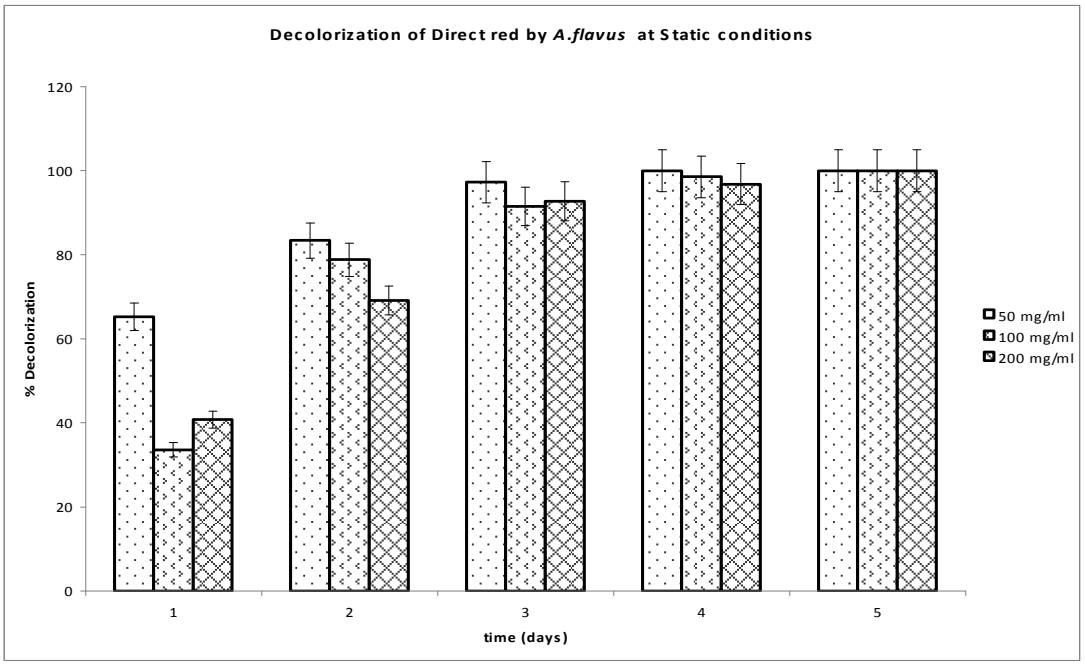

Fig 3: Decolorization of Direct red by *A.flavus* at static conditions

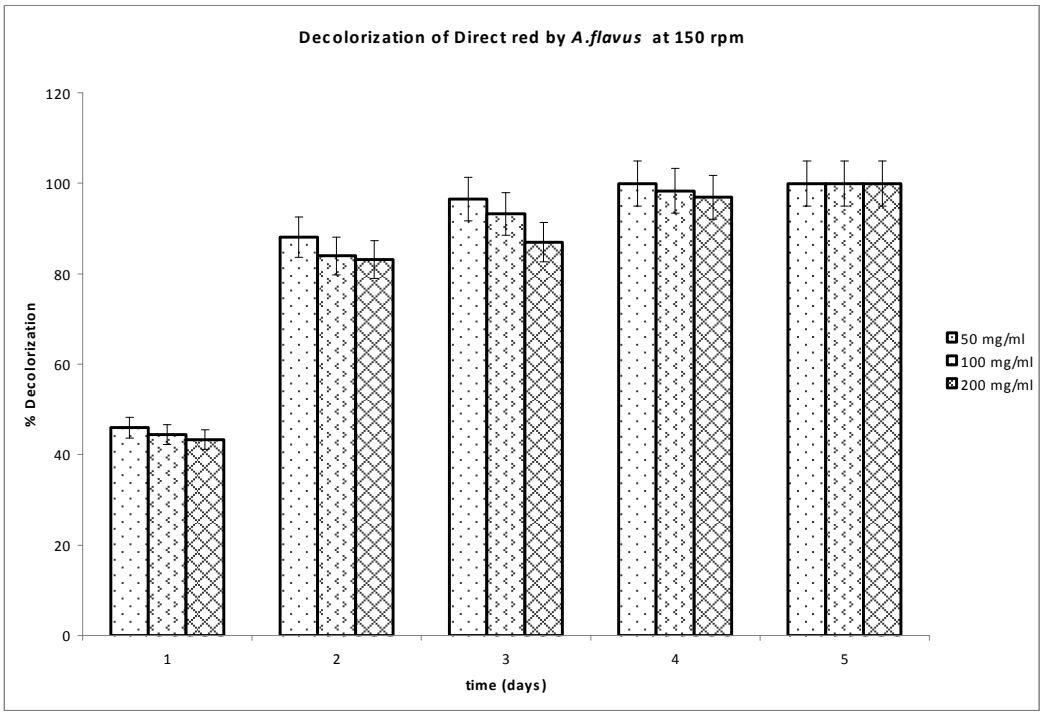

Fig 4: Decolorization of Direct red by *A.flavus* at 150 rpm

3.5 Adsorption isotherm

Adsorption capacity at different aqueous equilibrium concentration can be explained by the adsorption isotherm studies. The adsorption process is normally described by the Freundlich and the Langmuir isotherms. The adsorption data were fitted to linearized forms of both Freundlich and Langmuir isotherms to find out the optimum isotherm relationship. Fig. 5 & 6 shows adsorption isotherms of Direct red. The Freundlich adsorption isotherm model assumes the multilayer of adsorption process.

The Freundlich equation is an empirical equation and can be expressed as follows:

$$q = k_F C_e^{1/n} \qquad \text{Eq. (4)}$$

Where 'C_e' is the amount of dye left in the supernatant after the interaction with fungal cells (mg/L), 'qe' is the equilibrium of adsorption (pg/ cell); 'K_F' is the Freundlich constant (pg/cell) (L/mg) $^{1/n}$. A linear form of Eq. (3) can be obtained by taking logarithms.

$$Log\ q = 1/n\ Log\ C_e + Log\ k_F \qquad \text{Eq. (5)}$$

Fig. 5 & 6 shows the plot of 'log q_e' versus 'log C_e' enables the constant 'K_F' and exponent 1/n to be determined. The Freundlich isotherm constants were also manually calculated solving the simultaneous equations. The Freundlich isotherm describes multilayer of adsorption and is not restricted to the formation of the monolayer. The Freundlich equation predicts that the dye concentration on the adsorbent will increase so long as there is an increase in the dye concentration in the interaction medium.

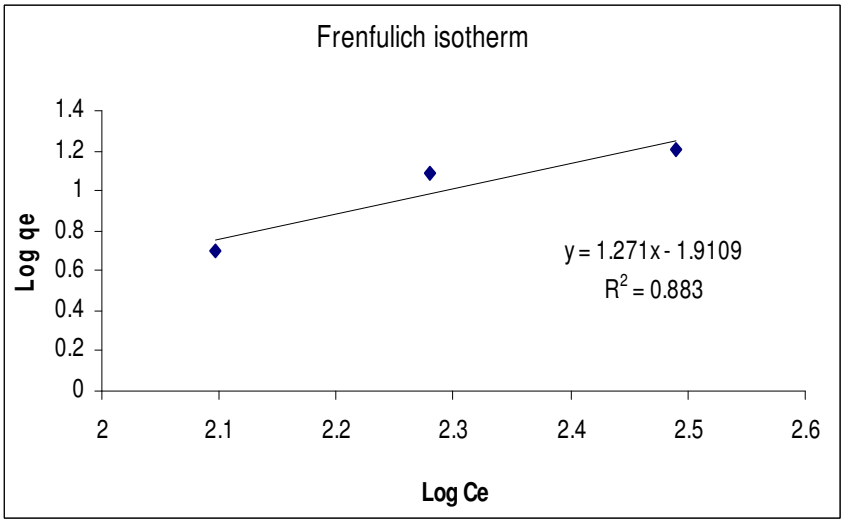

Fig 5: Adsorption isotherm of direct red by *A.niger*

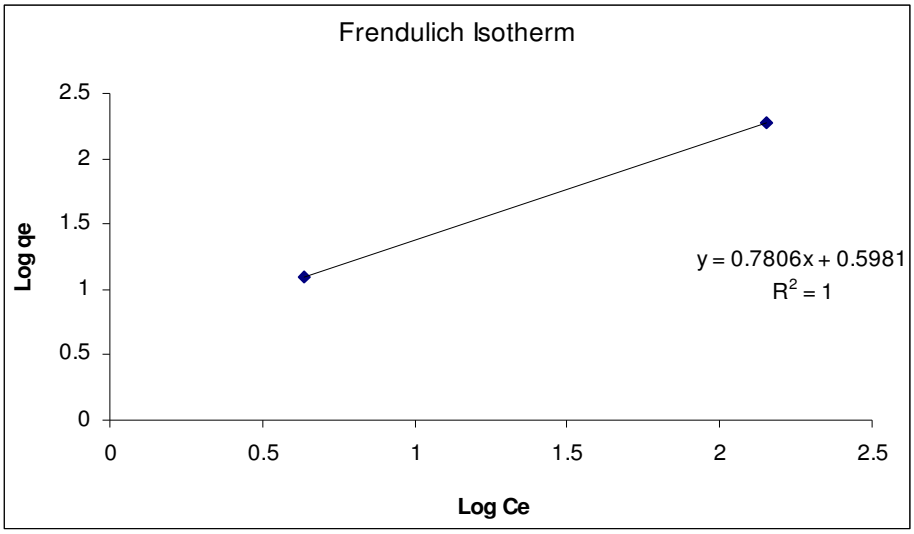

Fig 6: Adsorption isotherm of direct red by *A.flavus*

4. CONCLUSION

Isolated organisms *Aspergillus niger and Aspergillus flavus* has the ability to decolorize the direct red dye Here we have studied the adsorptive removal of Direct and Reactive red by, a ecofriendly microbes under various parameters. *Aspergillus niger* decolorizes the dyes in static condition potentially followed by *A.flavus* at shaking growth condition. The adsorption isotherm fitted well to Freundlich model.

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