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Optimization Studies on the Biodegradation of Textile Dye Congo red using Fungal Strains

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Abstract— Dyes are extensively used in the textile industry because of their wide variety of color shades, ease of application and minimal energy consumption. The discharges of dyes into the environment is aesthetically displeasing, impede light penetration, damage the quality of the receiving streams and may be toxic to treatment processes, to food chain organisms and to aquatic life. In this study fungal strain like Aspergillus flavus and Aspergillus niger were used to degrade Congo red textile dyes. Physico-chemical parameters were optimized for the decolorization process by changing one parameter at a time. For A.flavus and A.niger, the optimum temperature, pH, carbon source, nitrogen source and inoculum volume were found to be 31°C, pH 8, 1% maltose, 1% yeast extract, and 2% inoculums respectively. Extent of decolorization recorded by A.niger under optimal conditions was found to be 93.21%, Aflavus was found to be 88.23% .The study has confirmed the potential of the above fungi in the decolorization of Congo red and opened scope for future analysis of their performance in the treatment of textile effluent.
Keywords— Biodegradation, Congo red dye, Aspergillus flavus, Aspergillus niger, Optimization

I. INTRODUCTION

Textile effluent includes dyes, detergents, grease, oils, sulfates, solvents, heavy metals, other inorganic salts and fibers in amounts depending on the processing regime. Textile dye effluent has a strong color, high pH, high temperature, high COD (Chemical Oxygen Demand) and low biodegradability [1]. Pollution caused by dye effluent is mainly due to the durability of the dyes in the wastewater. Many physical and chemical methods including adsorption, coagulation, flocculation, electrolysis, precipitation, and oxidation have been used for the treatment of dye-contaminated effluents [2], [8]. These methods, nevertheless, may generate a considerable quantity of sludge or may easily cause secondary pollution due to excessive chemical usage. Therefore, it may be economical to develop substitute means of dye decolorization, such as degradation due to its reputation as on environmentally friendly and widely acceptable treatment technology. The various organisms which degrade dyes are fungi, bacteria and actinomycetes. The dyes are completely decolorized by these organisms in 8 to 10 days [3]. Microorganisms can play a really important role in decay and ultimate mineralization of these dyes. Biotreatment offers a cheaper and environmentally friendly alternative for color removal in textile effluent [4], [9]. In order to develop an economic decolorization process, optimizations of process parameters like nutritional sources, pH, and temperature were found [5], [6]. The current work proposes to look into the potential of fungi for decolorization of textile dyes under aerobic conditions and optimize the operation parameters.

II. MATERIALS AND METHODS

A. Textile mill Effluent and Chemicals

The textile mill effluent was collected from a dyeing unit situated in Tirupur region, Tamilnadu, India. The wastewater was stored at 4°C in airtight plastic containers. Congo red dye is used in the present studies. A stock solution of the dye 1000 ppm was prepared by dissolving 100 ml of dye in 100 ml of distilled water and this stock solution was preserved and used for further study. All chemicals used in this study were of AR grade.

B. Micro organism and Growth conditions

The fungal strain *Aspergillus flavus* (MTCC 3783) and *Aspergillus niger* (MTCC 3783) for biodegradation of Congo red obtained from IMTECH, Chandigarh, India. The strains were maintained in Modified Czapek Dox agar media with a composition of sucrose 30 g/l, sodium nitrate 2 g/l, magnesium glycerophosphate 0.50 g/l, potassium chloride 0.50 g/l, dipotassium sulfate 0.35 g/l, ferrous sulfate 0.01 g/l and agar 12 g/l at 30ºC for 7 days.

C. Experiment

50 ml of MCDM medium was amended separately with textile dye (200 mg/l) and subsequently inoculated with 3% fungal suspension. The flasks were kept in mechanical shaker and incubated at 30°C for 7 days. Samples were drawn at 2 days

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intervals for observation. The samples were centrifuged at 8000 rpm for 10 minute and decolourization was observed by measuring absorbance of the supernatant with the help of spectrophotometer.

D. Decolourization Activity

Decolourization activity was estimated according to the following rule.

$D = [(A_0 - A_1) / A_0] \times 100$

Where,

D= Decolourization in %; A_0 = Initial absorbance; A_1 = Final absorbance

III.RESULTS AND DISCUSSIONS

A. Effect of Temperature on colour reduction

To study the effect temperature, experiments were performed at different temperatures, pH was maintained constant (pH 5.0).Temperature was varied from 25°C to 37°C. The results are presented in the Fig.1. Which indicated that as the temperature increased from 25°C to 37°C, initially there was an increase in dye degradation rate up to 31°C and afterward the color removal was decreased. The maximum color reduction was observed in the temperature range of 31°C. Maximum decolourization was recorded from the 3rd day to 5th day and thereafter little change in degradation rate was recorded in all cases. The decolourization pattern indicated that the degradation was highly temperature dependent. The maximum color reduction was near about 86%, recorded after the incubation period of five days under shaking conditions. Reference [7] also reported that 36°C of temperature gave the maximum color reduction of Congo red.

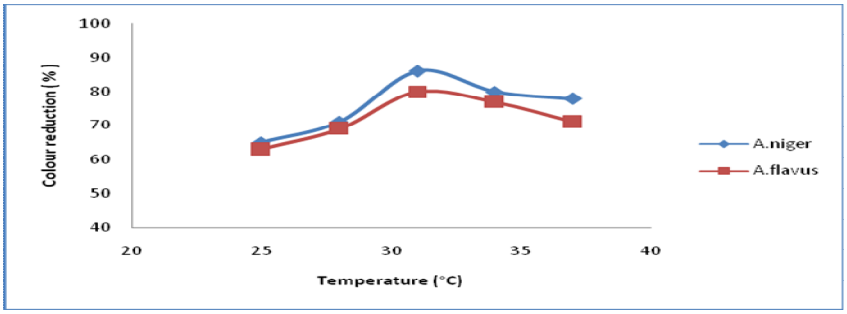

Fig.1 Effect of temperature on decolourization of Congo red using *A.flavus* and *A.niger* under optimum conditions (pH 5.6, 120rpm, 144h)

B. Effect of pH on colour reduction

The effect of pH on color reduction by fungal was investigated in the range of pH 4 to pH 9, and the temperature was maintained at 31°C. It is evident from Fig. 2. That as pH increases from acidic conditions, i.e. pH 4 to pH 9, the maximum percent decolourization increased up to near about 91.45%. The pH 8.0 was found to be optimum for decolourization of textile wastewater. The maximum removal of color was observed on the 7th day for all studied pH. In general percent color removal was increased from 1st to 7th days. There was no significant change in percentage removal after 5th days, this 5th day can be considered as optimum. Reference [10] found that *Bacillus subtilis* and *Achromobacter xyloxidans* are more efficient for color removal from textile mill waste water and concluded pH 7 is optimum value.

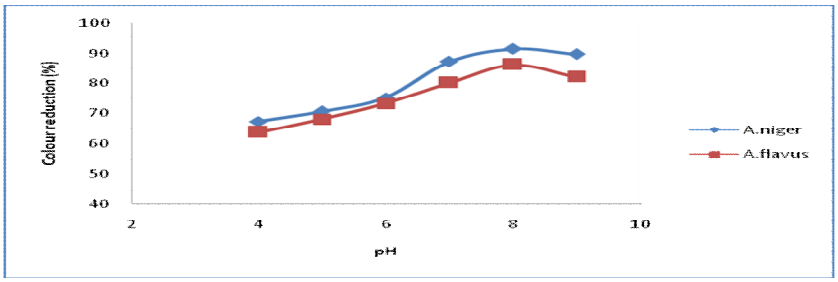

Fig.2 Effect of pH on decolourization of Congo red using *A.flavus* and *A.niger* under Optimum conditions (pH 5.6, 120 rpm, 144 h)

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C. Effect of Carbon source on colour reduction

Fig.3 illustrates the effect of different carbon sources on decolourization of Congo red by *Aspergillus flavus* and *Aspergillus niger*. Maltose has emerged as the ideal carbon source for the two strains of fungi, all recording highest rates of decolourization. Sucrose was recorded least percentage decolourization by the two strains and Fructose supported medium level of activity. Of the two fungal strains tested, *A. niger* exhibited highest activity recording 93.21% reduction in color among all the combinations tried.

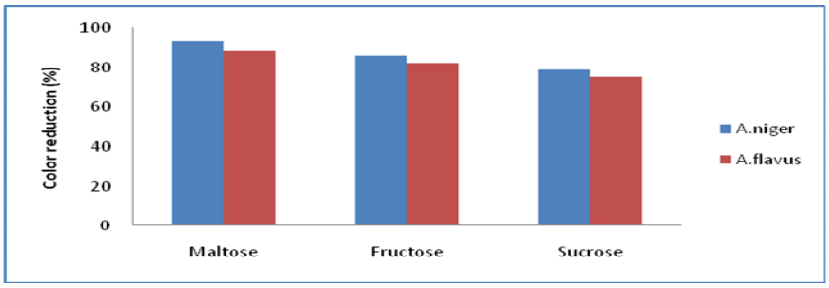

Fig.3. Effect of different carbon sources on decolourization of Congo red using *A.flavus* and *A.niger* under Optimum conditions (pH 5.6, 120rpm, 144h)

D. Effect of Nitrogen source on colour reduction

Effect of different nitrogen sources such as yeast extract, peptone and beef extract on decolourization of Congo red by *A.flavus* and *A.niger* is illustrated in Fig. 4. Among the three nitrogen sources evaluated, yeast extract appeared to support the decolourization process by two fungal strains, recording more than 90% decolourization. However, *A.niger* exhibited highest percentage decolourization when compared *A.flavus*. Reference [6] observed that *P. chrysogenum* exhibited highest percentage decolourization when the yeast extract was used as a nitrogen source, recording 90 % decolourization of the red 3BN dye.

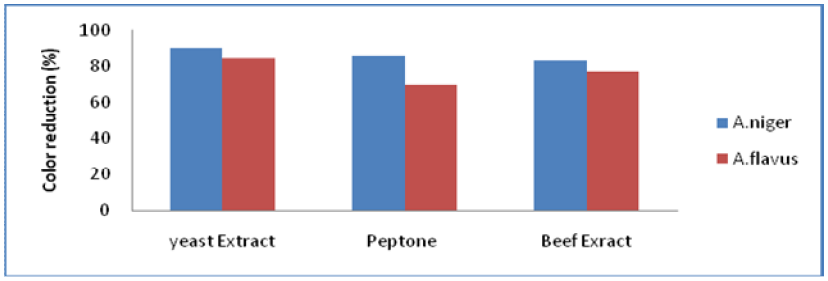

Fig.4. Effect of different nitrogen sources on decolorization of Cango red using *A.flavus* and *A.niger* under optimum conditions (pH 5.6, 120rpm, 144h)

E. Effect of Inoculums on colour reduction

The influence of the volume of inoculum on decolourization of the dye by *A. flavus* and *A. niger* is presented in Fig.5. From the data it is observed that *A.flavus* and *A.niger* are equally effective in the decolorizing Congo red and the optimum volume of inoculum was found to be 2% for *A.flavus* and *A.niger*.

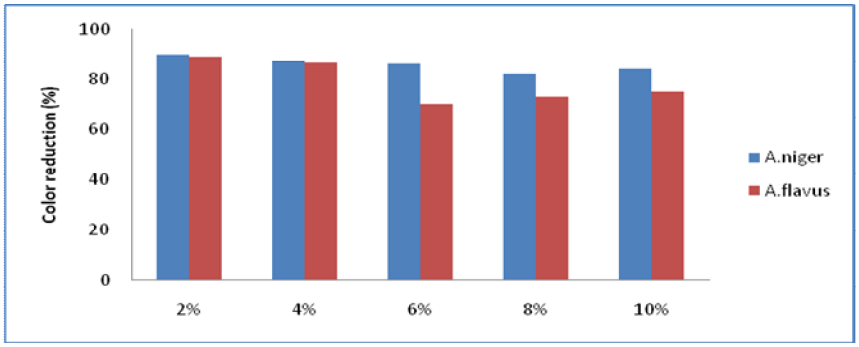

Fig.5. Effect of different inoculums volumes on decolourization of Congo red using *A.flavus* and *A.niger* under Optimum conditions (pH 5.6, 120rpm, 144h)

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IV. CONCLUSIONS

In this report, the ability of the fungal strain *Aspergillus flavus* and *Aspergillus niger* were investigated for the treatment of Congo red textile dye. The process parameters temperature, pH, carbon source, nitrogen source and inoculum volume were optimized by Classical method. At the optimized condition, a maximum color removal of 93.21% and 88.23% was obtained with using *A.niger* and *A.flavus* as a fungal species. Various other process parameters like additional carbon, nitrogen source and inoculum volume were also optimized.

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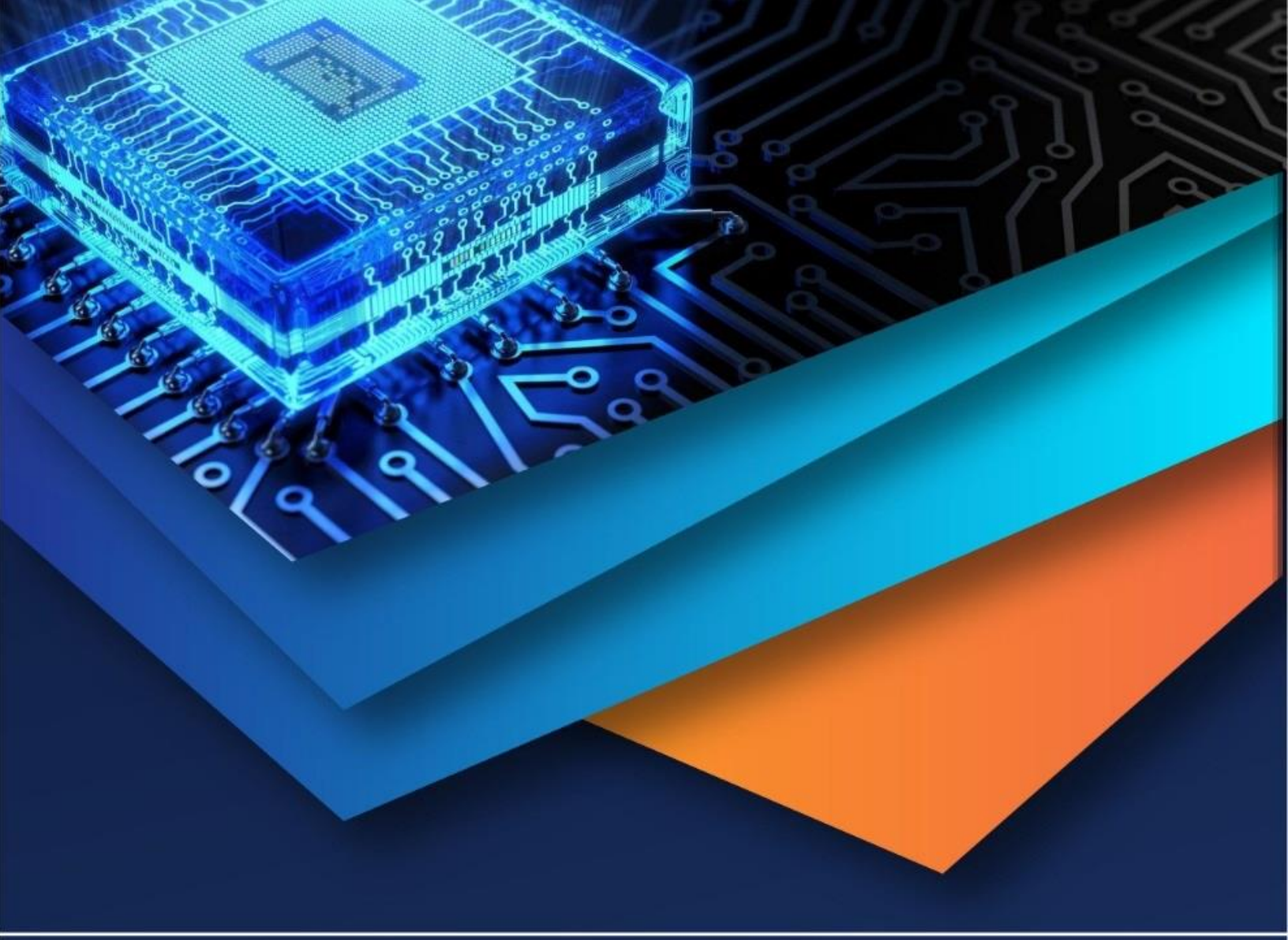

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