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Biosorption of textile effluents and dyes

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ABSTRACT

This research paper reports the biosorption potential of fungal isolates, Aspergillus flavus, Aspergillus wentti, Basidiomycetes and Acremonium kiliense to decolorize textile effluent and aqueous solution of synthetic dyes-Acid blue and Yellow MGR, used for cotton dyeing in textile industries. Screening was carried out and decolorization efficiency was determined on Potato Dextrose Agar and Yeast Glucose Peptone broth medium containing 100ppm of the dyes and 50 ml of the textile effluent. During batch decolorization process, fungal biomass weight and change in pH was also observed. Among fungal biomass weight, Aspergillus wentii showed increased dry weight (24.40 mg/ml), and in pH reduction, Aspergillus flavus showed maximum pH reduction (3.37). Maximum decolorization of Acid blue dye was achieved in 24h by Acremonium kiliense (99.58%). Among the strains used Acremonium kiliense was found to be very effective in removing the Acid blue dye (99.58%), Yellow MGR (86.11%) and textile effluent (90.98%) in PDA medium under shaking conditions. The research work reports that fungi can be used for bioremediation of dyes and is a viable alternative process for the treatment of textile effluent.

Keywords: *Acremonium kiliense*, *Aspergillus wentti*, *Basidiomycetes*, Biosorption, Synthetic Dyes, Effluent.

INTRODUCTION

India is one of the main producer and consumer of synthetic organic chemicals including dyes. Synthetic dyes are used extensively in textile dyeing, paper printing and color photography and also as additives in petroleum products. A wide variety of synthetic dyes namely azo, polymeric, anthraquinone, triphenylmethane and heterocyclic dyes are used in textile dyeing processes. Worldwide, more than 10,000 dyes and pigments are used in dyeing and printing industries. The total world colorant production is estimated to be 8, 00, 000 tonnes per year and at least 10% of the used dyestuff enters the environment through waste water [1, 2]. The presence of these dyes in the aqueous ecosystem is a cause of serious environmental and health concerns [3, 4]. Dyes may also significantly affect photosynthetic activity in aquatic life by reducing light penetration intensity and are toxic to some aquatic fauna and flora due to the presence of aromatic amines, metals, chlorides, etc., [5].

Several methods are used to treat textile effluents to achieve decolorization. These include physicochemical methods such as filtration, coagulation, carbon activation and chemical flocculation [6]. Although many physicochemical techniques of decolorization have been developed over the last 20 years, few have been implemented by the textile industries due to their high cost, low efficiency and inapplicability to a wide variety of dyes. A definite solution of the color problem of textile effluents would provide a marked competitive advantage for this industrial sector. Since

no single process is able to decolorize all textile effluents, a solution for each situation should be considered, possibly involving a combination of different methods [7]. Microbial decolorization and degradation has appeared as an eco-friendly and cost-competitive alternative to chemical decomposition processes [8, 9, 10, 11, 12, 13, 14]. The objective of this research work is to achieve decolorization by biological process that could most likely provide higher color removal rate and to evaluate the percentage removal of color, pH reduction and biomass weight.

MATERIALS AND METHODS

2.1 Dyes

The synthetic textile dyes used for the study are Yellow MGR and Acid blue obtained from Hindustan CIBA GEIGY, Mumbai. All the reagents used were of analytical grade.

2.2 Effluent source

Effluent was collected from the dyeing industries at Tirupur, Tamil Nadu, India. The effluent was collected in airtight plastic bottles and filtered to remove large suspended particles and stored at 4±1°C until use. The effluent irrigated soils were collected for isolation of fungal strains at a depth of 1cm in sterile polythene bags and were isolated by dilution plate method and identified by Lacto phenol cotton blue staining method. The fungal isolates were identified as *Aspergillus flavus, Aspergillus wentii, Basidiomycetes and Acremonium kiliense*. For cultivation and maintenance of fungi, Yeast-glucose peptone (YGP) and Potato Dextrose Agar (PDA) medium were used.

2.3 Analytical Method-UV- Spectrophotometric Analysis

The color removal was analyzed using UV-VIS spectrophotometer (model: Hitachi U 3210) at λmax of 480nm and 540nm for Yellow MGR and Acid Blue dyes, and at 480nm for textile effluent, respectively.

2.4 Decolorization by whole cultures (*in situ*) and pH reduction

The dye decolorization studies were carried out using 50ml of effluent containing PDA/YGP broth and Yellow MGR/Acid Blue dye and were inoculated with spore suspension of the fungal strain adjusted to 10^6 spores/ml and incubated at 37^{o}C in a rotary shaker (model :TOS-4838F) at 170 rpm for 24h. 5ml of Samples were withdrawn for every 6h intervals for 24h, centrifuged at 10,000 rpm for 10 min and the supernatant was analyzed in UV-Visible Spectrophotometer at their respective λmax and the change in pH was observed (model: Digital pH meter111E). All the experiments were performed in duplicate. Controls were maintained without dye.

Percentage of decolorization was calculated as

$$\frac{A_i - A_f}{A_i} \times 100$$

Where, A_i is the initial absorbance of dye (mg/l) and A_f is the final absorbance of dye concentration (mg/l) at different time intervals.

2.5 Determination of Fungal Biomass

Biomass production was evaluated by determining the dry weight of fungal mycelia. The dye decolorized culture medium was filtered under aseptic conditions by Whatmann no.1 filter paper, washed twice with distilled water and dried at 60^{o}C in a hot air oven and weighed (mg/50ml). The dried fungal biomass was used for growth determination.

RESULTS AND DISCUSSION

3.1 Optimization of medium

The fungal isolates *(Aspergillus flavus, Aspergillus wentii, Basidiomycetes and Acremonium kiliense)* were studied with two different liquid medium [Yeast-glucose peptone (YGP) and potato dextrose broth (PDA)] for decolorization experiments. The growth of the fungal strains, pH reduction and related decolorization efficiency were monitored in the experiments. Figure: 1c showed that, PDA proved to be more effective when compared to YGP medium. PDA medium enhances the growth of fungal strains than the YGP medium. The concentration of C and N sources, C/N ratio, and vitamins are the important factors in medium formulation for the enhancement of

fungal growth and sporulation. Although potato dextrose agar (PDA) are the most common media for growth and sporulation of fungi [15].

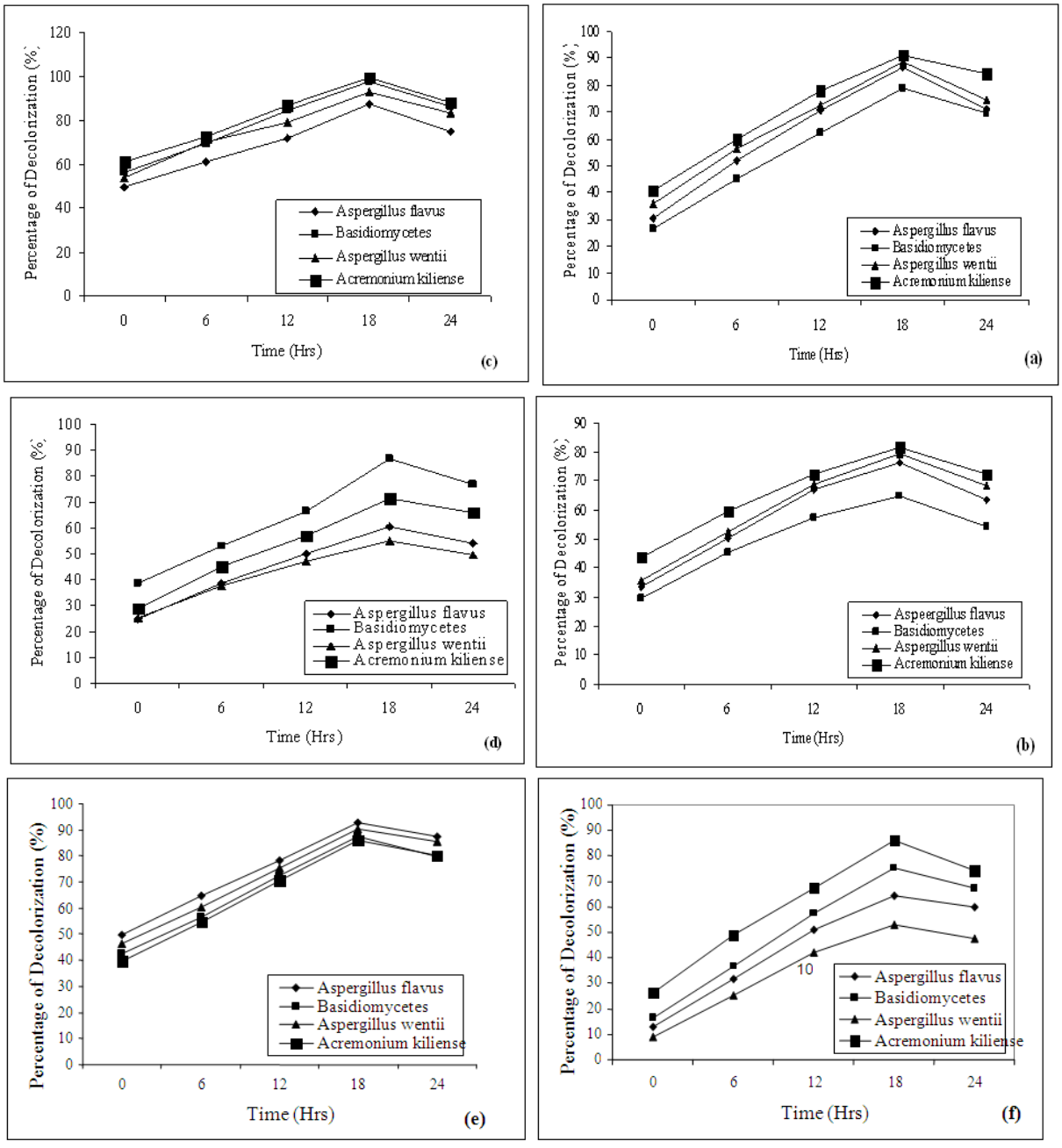

Fig.1. Effect of Incubation Period on Percentage Decolorization of Fungal Isolates in (a) Effluent + PDA Medium, (b) Effluent + YGP Medium, (c) Acid blue + PDA Medium, (d) Acid blue + YGP Medium, (e) Yellow MGR + PDA Medium,(f) Yellow MGR + YGP Medium.

3.2 Decolorization Kinetics

The fungal strains showed the decolorization of textile dyeing effluent and dyes (Yellow MGR and Acid Blue dye) in the concentration of 100 ppm to more than 85%. The highest percentage of decolorization was shown in Acid blue dye amended with PDA medium by *Acremonium kiliense* (99.58%), followed by *Basidiomycetes* (98.10%), *A. wentii* (93.05%) and *A. flavus* (87.85%) (Figure: 1c). The highest percentage of decolorization of effluent by fungal

isolates using PDA medium was showed by *Basidiomycetes* (78.86%), followed by *Acremonium kiliense* (90.98%), *A. wentii* (88.58%) and *A. flavus* (86.55%) (Figure: 1a). The percentage decolorization of Yellow MGR dye amended with PDA Medium showed the order of *Acremonium kiliense* (86.11%), *Basidiomycetes* (87.4%), *A. wentii* (90.48%) and *A. flavus* (92.54%) (Figure: 1e). Biodegradation and biosorption are two major mechanisms for dye removal, which can be utilized by most fungi such as *T. versicolor* [16]. In some fungal cultures, biosorption is the major dye removal mechanism, as in the case of *Aspergillus niger* [17]. Among the fungal isolates, the highest decolorization efficiency of the suspended culture of *Acremonium kiliense* showed maximum color removal of 85.97% in both medium.

3.3 pH Studies

In PDA medium containing effluent, *Acremonium kiliense* showed maximum reduction of pH (3.45), in Yellow MGR dye, *Aspergillus flavus* showed maximum pH reduction (3.37) and in Acid blue, *Basidiomycetes* showed maximum pH reduction (4.22). In YGP medium containing effluent, the maximum pH reduction was shown by *Aspergillus wentii* (3.77). In Yellow MGR and Acid blue, *Acremonium kiliense* reduced the pH to 3.58 and 4.03 respectively. The decolorization rate of dyes decreased with decreasing pH towards acidic [18].

3.4 Biomass production

The biomass production of test organisms denotes that biomass increased with incubation period. The results revealed that the fungal isolate *Aspergillus wentii* showed increased biomass weight (24.40 mg/ml) in PDA medium containing dye effluent, Yellow MGR dye (38.80 mg/ml) and Acid blue (26.20 mg/ml) respectively. In YGP medium containing dye effluent, *Aspergillus wentii* showed an increased biomass weight of 38.80 mg/ml and in Yellow MGR and Acid blue, *Basidiomycetes* showed increased biomass weight of 24.20 mg/ml. Decolorization of dye involved adsorption of the dyes at the initial stage followed by decolorization through microbial metabolism [19, 20, 21]. Microorganisms were used for decolorization of dyes and effluents [22]. Growth media enhanced the adsorption capacities of fungus. Among the fungal isolates, *Aspergillus wentii* showed increased dry weight (24.40 mg/ml) in effluent, (38.80mg/ml) in Yellow MGR dye and (26.20 mg/ml) in Acid blue dye containing PDA medium.

CONCLUSION

The present study reports that fungal strains isolated from the dye-contaminated soil were effective dye-decolorizers. It is proved that fungal cells have greater efficiency in decolorizing the dyes and textile effluents, and has the capacity to reduce the pH, which in turn increases the percentage of color removal.

Aspergillus flavus reduced the pH of Yellow MGR dye in PDA medium (3.37) and *Acremonium kiliense* reduced the pH of acid blue dye in YGP medium (3.70). *Acremonium kiliense* showed greater percentage of decolorization (99.58%) in Acid blue dye containing PDA medium as well as in textile effluent (90.98%).

The results indicate that the decolorization rates were proportional to the cell biomass activity, which may be due to enzyme production within the medium itself. Hence it is proved that *Aspergillus flavus* is an effective strain in decolorizing Yellow MGR and similarly *Acremonium kiliense* is an effective strain in decolorizing Acid blue. Among these fungal strains, *Acremonium kiliense* was found to be more effective in decolorizing effluent and textile dyes (85.97%) in both medium.

The appropriate process of ‘Biosorption’ has developed as an interesting and highly effective field offering the best prospect in this regard. The fungal metabolism may seem to change pH for the production of secondary metabolites with a consequent decrease in the pH and increase in color removal of treatment processes.

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