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Exploring indigenous Fungi for sustainable bioremediation of textile Dye

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ABSTRACT
Textile dyes are considered as major environmental pollutants due to their complex chemical structures and resistance to natural degradation. In the present work fungal isolates were isolated and evaluated for biodegradation and decolourization of textile dyes for remediation purpose. Two fungal isolates Aspergillus niger and Aspergillus flavus were tested for their dye degradation efficiency against Remazol Brilliant Blue R (RBBR) and Methyl Violet dyes. Aspergillus niger showed better decolourisation efficiency of Remazol brilliant blue R(96.05%) and methyl violet (95.16%) than Aspergillus flavus. FTIR analysis confirmed the structural changes of the treated dye samples by shifting, disappearance and presence of peaks of the functional groups which indicated the biodegradation of the dye molecules. Enzyme analysis showed positive laccase and lignin peroxidase activity in both fungal isolates whereas manganese peroxidase activity was not significant. Phytotoxicity analysis using Vigna radiata seeds showed increased germination percentage after fungal treatment compared with untreated dye samples, indicating reduced toxicity. Statistical analysis viz. ANOVA, DMRT and paired t-test supported efficacy of the fungal treatment. The study indicates the potential of Aspergillus niger and Aspergillus flavus for eco-friendly and sustainable remediation of textile dyes.
Keywords -Mycoremediation Textile dye degradation, Biosorption, Laccase, FTIR, Phytotoxicity.

1. INTRODUCTION

The growth of textile industries has led to the constant discharge of dye containing effluents in the environment. Synthetic dyes are widely used in textile processing due to high stability, good coloration and resistance to fading. However, their complex chemical structures, particularly aromatic rings and synthetic components, are very persistent and hard to degrade naturally[1,2,3]. The presence of these dyes in aquatic systems affects the water quality, reduces the light penetration, interferes with the photosynthetic processes and may cause toxic effects on living organisms. [4,5,6]

Dyes have been widely removed by conventional treatment methods, such as physical adsorption, chemical oxidation, coagulation and filtration [7,8,9]. But often these methods require high inputs of energy, costly chemicals and can create secondary waste products. Therefore, environmentally sustainable biological approaches have gained attention for the effective treatment of textile dye-contaminated wastewater [10,11]. Mycoremediation is an emerging biological technology that employs fungi to remove and transform a broad spectrum of environmental contaminants. The fungi have some unique characteristics that include the large mycelial networks, capability to adapt to different environmental conditions, and the ability to secret extracellular enzymes [12,13,14,15,16]. Fungi remove dyes by several processes such as biosorption onto fungal biomass, bioaccumulation and enzymatic degradation [17]. Functional groups of amino, hydroxyl, phosphate and carboxyl groups present in the cell walls of fungi increase the binding of dye molecules by electrostatic

interactions and ion exchange mechanisms [18,19].

The dye-degrading potential of fungi belonging to the genus Aspergillus has been widely studied. Aspergillus niger is especially recognized for its synthetic dye removal ability owing to its powerful biosorption capacity and secretion of extracellular oxidative enzymes[20,21,22]. Similarly, Aspergillus flavus has also shown potential to degrade textile dye under suitable environmental conditions [23,24]. These fungi can survive in extreme conditions and this makes them good candidates for bioremediation of wastewater.

The textile dye degradation is mainly due to ligninolytic enzymes such as laccase, lignin peroxidase and manganese peroxidase [25,6]. The enzyme catalyzes oxidative reaction that modify complex dye structure, degrading them to less toxic and simpler compounds. However, the enzyme production and dye degradation efficiency are highly dependent on environmental factor such as pH, temperature, dye concentration, incubation period and enzyme concentration [27,28]. Therefore, optimization of these parameters is important for improving fungal mediated dye removal.

Although several fungal species have been reported for dye decolorization, a complete evaluation of fungal isolates involves assessing degradation efficiency, enzymatic activity, structural transformation and reduction in toxicity after treatment. Decolorization alone cannot be taken as an evidence of degradation because decolorization may also occur by adsorption. Structural modifications in dye molecules upon treatment with fungi were identified using analytical techniques like Fourier Transform Infrared (FTIR) spectroscopy. Moreover, phytotoxicity evaluation gives important information about toxicity of degraded products.

2. Material and methods

Sample Collection

Soil sample was collected from textile industrial site of Kasare Vanya Silk Mill Pvt Ltd., located at Urkura Raipur, Chhattisgarh, India. The samples were collected from a depth of 5-10 cm below the surface using sterile hoe and spatula. The collected samples were aseptically transferred into Zip lock polythene bag and then transported to the laboratory. All samples were stored in refrigerator for further use. The Collected soil sample was brought to the laboratory and stored at room temperature for 24-48 hours to remove excess moisture. The dried soil sample was crushed using mortal and pestle to obtain fine powder and sieved through a sterile mesh and stored in sterile airtight containers.

Isolation and Purification of Fungal Isolates

Fungal isolates were obtained by the serial dilution agar plating technique. Approximately 1 g of pretreated soil was serially diluted, and aliquots of the diluted suspension were spread onto Potato Dextrose Agar (PDA) plates. The plates were incubated at 28 ± 1°C for 4–5 days. Morphologically distinct fungal colonies were selected and purified by repeated point inoculation on fresh PDA plates under aseptic conditions to obtain pure cultures.

Preparation of Dye Solutions

two synthetic textile dyes, Remazol Brilliant Blue R (RBBR) and Methyl Violet (MV) were used. Stock solution of each dye (1000 mg/L) was prepared by dissolving 1 g of each dye separately in 1000 mL of distilled water. Working dye concentrations were prepared from the stock solutions by appropriate dilution.

Primary Screening for Dye Decolourizing isolate -Primary screening of fungal isolates was done on PDA plates containing either 20 mg/L of RBBR or Methyl Violet. Streptomycin was added to the medium to minimize bacterial contamination. Each purified fungal isolate was inoculated separately on PDA plates with the dye and incubated at 28 ± 1°C for 5–7 days. The decolorization zones around the fungal colonies demonstrated the potential for dye degradation. The isolates were

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