Feasibility study of the use of microbial strains and consortia for the treatment of textile dyes

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ABSTRACT

Textile dyes, when discarded into the environment without proper treatment, actively contribute to pollution. Numerous solutions and methodologies are known to be used in the treatment of places contaminated with dyes through physical-chemical processes such as adsorption to activated carbon, coagglutination, reverse osmosis, advanced oxidation, ozonization, photochemical degradation, processes with electrochemical oxidation, and filtration. However, despite efficiency, these have a high cost and often require additional treatments. On the other hand, biological treatment presents a great alternative in terms of cleaning and low cost. These can be carried out by applying bacteria, fungi, or even enzymes. This project presents a line of research focusing on bacterial consortia, which have the capacity to degrade textile dyes. Taking into account the enzymatic repertoire and the metabolic variability in mixed populations, success tends to be greater with consortia than in individual strains.

Keywords: Textile dyes. Biological wastewater treatment. Azo dyes. Bacterial consortia.

1 INTRODUCTION

The Brazilian textile industry has the largest complete production chain among Western countries[1]. The production processes range from the cultivation of raw materials to the final stages, such as finishing, sewing, and sales. During the production of textile materials, in the dyeing stage, up to 20% of the dyes do not adhere to the fabric fibers and are discarded in the effluents[2]. With this, severe environmental problems are triggered due to the colored element that causes turbidity and the suspended solids in water bodies, deregulating the local ecosystem[3]. Dyes prevent sunlight from penetrating the water, damaging essential processes such as photosynthesis[4]. The textile industry is one of the industrial segments that contributes most to pollution[5]. Textile dyes of synthetic origin have a highly complex chemical structure. When subjected to manipulation processes, those of the azo class can form aromatic amines with carcinogenic and toxic properties[6]. Indigo carmine, commonly applied to dye jeans fibers, is difficult to remove and is chemically stable[7].

Numerous solutions and methodologies have been used in the treatment of textile effluents, such as physical-chemical processes such as adsorption to activated carbon, coagglutination, reverse osmosis, advanced oxidation, ozonization, photochemical degradation, and electrochemical oxidation. However, despite efficiency, these treatments are expensive and often require additional treatments. On the other hand, biological treatment presents a great alternative in terms of cleaning and low cost. These can be performed by bacteria, fungi, or their enzymes.

Due to the necessity of efficient and cost-effective textile wastewater treatment, numerous microorganisms have been described as producing enzymes that are able to degrade dyes, having biological degradation potential to clean contaminated environments. The present work proposes a biological methodology for treating effluents contaminated with textile dyes involving bacterial strains combined in different consortiums.

2 MATERIAL & METHODS

Six bacterial strains were selected for this research project, all of which are part of the laboratory collection and are identified by letters and numbers: A7, C3, C5, C7.1, L3, and L7. The bacteria had their capacity tested in dyes such as indigo carmine and dyes from the azo group, namely: methyl orange, reactive CA red, golden yellow, intense black N, brilliant violet 5R (200 ppm) in decolorization media composed of glucose, as the main source of carbon, salts and 10^7 UCF/mL of bacterial suspension.

Microbial consortia were defined according to one bacterium's behavior on another. Thus, 13 consortia with different combinations have been tested. The strains are cultivated separately in Luria Bertani medium and incubated in aeration (shaking at 150 rpm) for 48 hours at 28ºC. After cultivation, the bacteria are properly inoculated and incubated at 32ºC for 7 days, under aeration conditions (shaking at 150 rpm) and without aeration (static cultivation, as we know that oxygen tension can affect reduction reactions) with aliquots taken in regular intervals of 2, 5 and 7 days, to measure the amount of dye remaining. Flasks without inoculum were incubated without the presence of microorganisms as controls. The decomposition rate of the dyes was evaluated in relation to the absorbance spectra (400 to 800 nm), using the following formula:

$$\frac{(Ao-A)}{Ao} \times 100$$

Where Ao corresponds to the reading of the control without inoculum at the longest absorption wavelength of the dye and A corresponds to the reading of the sample supernatant collected on the same day and wavelength.

3 RESULTS & DISCUSSION

The results demonstrated that cultivation under static conditions is more favorable to degradation processes than under agitation. This fact is evident in most experiments. Initially, the capacity of the strains was tested individually in the presence of dyes to confirm their potential. The results obtained with the methyl orange dye demonstrate that the consortia tested so far achieved rates above 80% on the fifth day of cultivation under static conditions. In comparison, under agitation, this percentage decreases, and only the consortium entitled 9 achieved significant rates (46% on the fifth day). In the degradation of intense black N reactive dye by consortium 5, the same pattern follows, showing rates above 65% on the fifth day of cultivation under static conditions, but on the same day under agitation, the highest percentage was 65%. We found that oxidative stress can affect the redox potential of the media and, consequently, the decolorization activity of microbial enzymes[8].

Table 1 presents data from consortium 1 composed of strains A7 and C7.1 on the discoloration of black reactive dye N, where on the seventh day of cultivation in both conditions (static and agitation) the highest degradation peak was reached. Figure 1 shows the discoloration by consortium 3 of the dyes indigo carmine, methyl orange, reactive black N, reactive red CA, and bright violet, under the static and in agitation in 2, 5, and 7 days. Consortium 3 is composed of the strains A7 and L7.

Table 1 Discoloration by the consortium 1.

Dye reativo black N		
Time/Day	Static	Agitated
T2	66	35,3
T5	72	47
T7	73,5	50

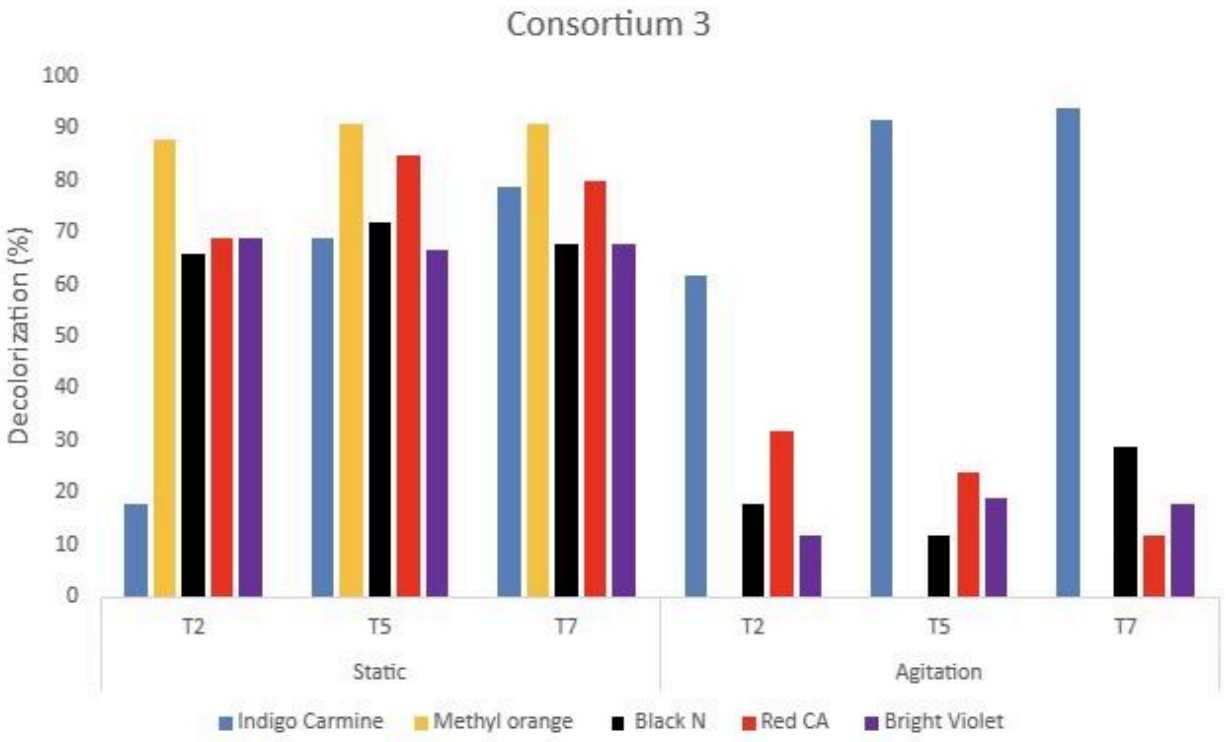

Figure 1 Discoloration by consortium 3 of the dyes indigo carmine, methyl orange, reactive black N, reactive red CA, and bright violet in 2, 5, and 7 days.

4 CONCLUSION

The decolorization tests were carried out under static and shaking conditions, and we found superior efficiency when the consortia were cultivated under static conditions for most of the dyes. The teste consortia were able to decolorize the dye solutions, but the benefits of the mixed population over a single culture need to be analysed.

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