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Application of dried macrofungi for the removal of synthetic dyes from aqueous environment

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Abstract : Synthetic dyes are made of carcinogenic and mutagenic compounds and used in textile, paper and printing industries. Reactive Black 5 (RB5) and Remazol Brilliant Blue R (RBBR) are known to cause asthma and allergic dermatitis. Thus dye decolorization from industrial wastewaters is of utmost importance. Conventional methods *viz.* adsorption, flocculation, coagulation, oxidation, and reverse osmosis are usually inefficient, expensive, of limited applicability which are difficult to dispose off. In the present study, the potentiality of dead macrofungi *Pleurotus platypus* (oyster mushroom) and *Agaricus bisporus* (button mushroom) for dye removal was investigated. The effect of different parameters viz. pH, temperature, biosorbent dosage and initial dye concentration on dye removal was investigated. Application of dried macrofungi as adsorbents can be an effective method for the removal of Reactive Black 5 (RB5) and Remazol Brilliant Blue R (RBBR) from dye bearing wastewater.
Keywords: Decolorization; Reactive Black 5; Remazol Brilliant Blue R; *Pleurotus platypus*; *Agaricus bisporus.*

Introduction

Dyes are synthetic, aromatic, water soluble organic colorants used in various industries such as textile, paper and printing industries. They have complex aromatic structures which make them highly stable and difficult to biodegrade[1]. Around 10^6 tons of dyes are produced annually, of which 1-1.5 $\times 10^5$ tons are released to the environment in wastewater[2]. These dyes include acidic, reactive, basic, azo, anthraquinone based and metal complex dyes. They form complexes with the metal ions which are toxic to fishes and other aquatic life forms. They affect photosynthesis in aquatic life by reducing light penetrations due to the presence of aromatics, metal chlorides etc in them [3]. Synthetic dyes like Reactive Black 5 (azo dye) and Remazol Brilliant Blue (anthraquinoid dye) are the most commonly used dyes in textiles, leather and food stuff. They are harmful in powder form and cause allergic contact dermatitis[4]. They are also reported to cause asthma and rhinitis[5]. Thus decolourization of these dyes is of utmost importance.

Conventional methods for dye decolourization include adsorption, flocculation, coagulation, oxidation, and reverse osmosis[3, 6, 7] but these methods are expensive and produce wastes, which are difficult to dispose off. Conversely, biological processes *viz.* biodegradation, bioaccumulation and biosorption offer attractive options for dye removal. However, bioaccumulation and biodegradation can be unpredictable and sometimes difficult to operate on a large scale as stringent conditions have to be maintained to support microbial growth[8]. Thus over the past few decades, the search for new, cost – effective techniques have been directed towards adsorption.

Adsorption is relatively easy process to operate and possess several advantages including low cost, operation over wide range of conditions and possibility of re- use [9]. Most of the studies for decolorization of dyes from wastewater have been reported using bacteria[10], fungi[11], yeasts[12] and algae[13]. Reports are few on the use of macrofungi for the remediation of synthetic dyes from aqueous environment[14]. There are reports on the use of adsorbents other than microorganisms for the removal of dyes [15-24].

The present study was carried out using dried macrofungi *viz. Pleurotus platypus* (oyster mushroom) and *Agaricus bisporus* (button mushroom) for decolorization of synthetic dyes *viz.* Reactive Black 5 (diazo) and Remazol Brilliant Blue R (anthraquinone) from aqueous environment.

Materials and Methods

Synthetic dyes

The synthetic dyes viz. Reactive Black 5 (RB 5) and Remazol Brilliant Blue R (RBBR) were purchased from HIMEDIA Pvt. Ltd, Mumbai, India. The stock solutions of the dyes were prepared using double distilled water. Experimental solutions of desired concentrations were prepared by dilutions. The pH of the dye solutions were adjusted using 0.1 N HCL and 0.1N NaOH solutions.

Preparation of biosorbents

Fruit bodies of *Pleurotus platypus* and *Agaricus bisporus* were collected, washed thoroughly, dried at 40^0C for 48 hrs and then pulverized with mortar and pestle. The particles of size 425-600 μ m were used for the present study.

Batch adsorption studies

Batch decolorization experiments were performed in 250ml Erlenmeyer flasks containing 100ml of working solutions. The solutions were agitated for desired time at 120rpm at 28°C and withdrawn after the desired time and subjected to centrifugation at 10,000 rpm for 5 min. The residual dye concentration levels were determined by UV-Visible spectroscopy at 590 nm and 592nm for RB5 and RBBR respectively. Negative controls (without any macrofungi) were maintained to prove that decolorization was only by dried macrofungi. Dye decolorization efficiency was calculated as follows

$$\text{Dye Decolorization Efficiency} = \frac{A_0 - A}{A_0} \times 100 \qquad (1)$$

Where A_0 = absorbance of dye at its λ_{max} initially; A= absorbance of the dye after decolorization at its λ_{max}.

Effect of parameters on decolorization

The effects of pH on dye decolorization was studied by varying the pH of the dye containing solution (10mg/l) from 3-8. The effect of biosorbent dosage was investigated by varying the sorbent dosages (0.1, 0.2, 0.3, 0.4, 0.5, 0.6, 0.7, 0.8 g/100mL) in 10mg/l of dye solution. The effect of temperature was studied by keeping 10mg/l of dye solution under different temperatures (18, 28, 37, 45 °C). The effect of initial dye concentration was investigated by varying the dye concentrations from 10-80 mg/l with optimum pH values, optimum biosorbent dosage and at optimum temperature. The decolorization efficiency of the two biosorbents for RB 5 and RBBR were compared under optimal conditions. The decolorization efficiency of *P.platypus* and *A.bisporus* for mixed dye solutions were investigated at optimum pH, biosorbent dosage, temperature and initial dye concentration.

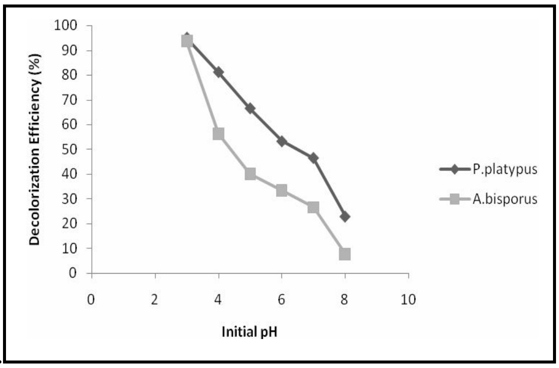
Result and Discussion

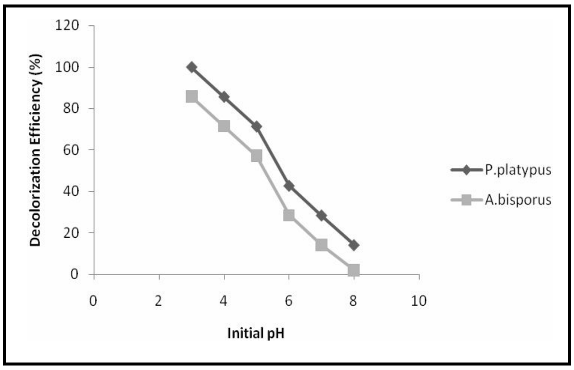
Effect of pH

The effect of pH on dye decolorization of RB5 and RBBR using macrofungi *P. platypus* and *A. bisporus* was tested. In case of RB5, at pH 3, *P.platypus* showed maximum decolourization 95% where as

A.bisporus showed maximum decolourization 93.7% (Fig 1a). *P. platypus* showed 100% decolorization and *A. bisporus* showed decolourization of 85.7% at pH 3 in case of RBBR (Fig 1b).

The better performance under low pH may be due to the protonation of the amino groups of the biosorbent, thus resulting in a net positive charge. Reactive dyes like RB5 and RBBR will release colored negatively charged anions in the solution[25]. Thus the electrostatic force of attraction between the positively charged surface of biosorbent and anionic dye molecules causes an increase in adsorption and thus an increase in dye decolorization at low pH values. However the amine groups become completely protonated at an approximate pH of 7 (pK_a=8.5) . In contrast, decolorization was found to be low at pH 6. This may be due to the presence of other functional groups which results in repulsion towards the negatively charged dyes [26].



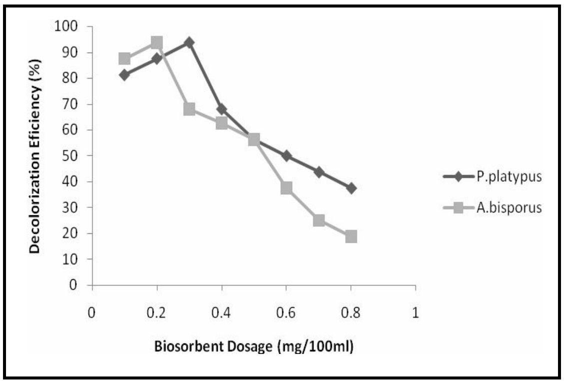


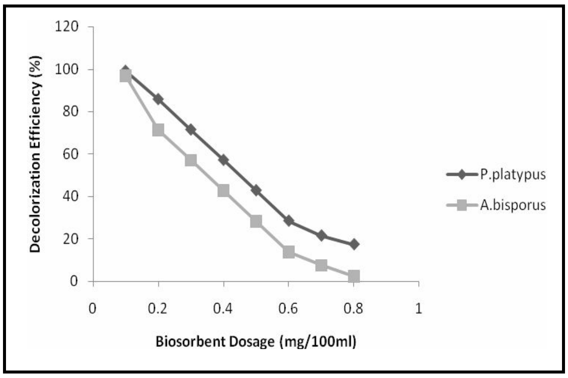
(a) (b)

Fig.1. Effect of pH on decolorization of Reactive Black (a) and Remazol Brilliant Blue R (b)by *P.platypus* and *A.bisporus* (biosorbent dosage 0.1g/100ml ; temperature 28°C ; initial dye concentration 10mg/l).

Effect of biosorbent dosage

The effect of biosorbent dosage on the decolourization of RB5 and RBBR were carried out by varying the biosorbent dosages (0.1, 0.2, 0.3, 0.4, 0.5, 0.6, 0.7 and 0.8g/100ml). Increase in the dosages of both the biosorbents showed an increase in the decolorization efficiency for both the dyes, which may be due to the increase in the number of binding sites with increasing biosorbent dosages. However the increase in decolorization efficiency was only upto an optimum biosorbent dosage beyond which decolorization efficiency decreased due to the saturation of the biosorbent surface with the dye molecules. For RB5 maximum decolorization occurred when 0.3g/100mL of *P.platypus* and 0.2g/100ml of *A.bisporus* was added (Fig 2a). For RBBR maximum decolourization was found on addition of 0.1 g/100ml *P.platypus* and 0.2g/100ml of *A.bisporus* (Fig 2b).This result suggested that *A.bisporus* is more effective in dye decolourization than *P.platypus*. Also RBBR is less recalcitrant than RB5.Similar trend of results have been obtained by Vijayaraghavan et al.[25] on decolourization of RB5 by *C.versicolor* where the optimum biosorbent dosage was found to be 4g.





(a) (b)

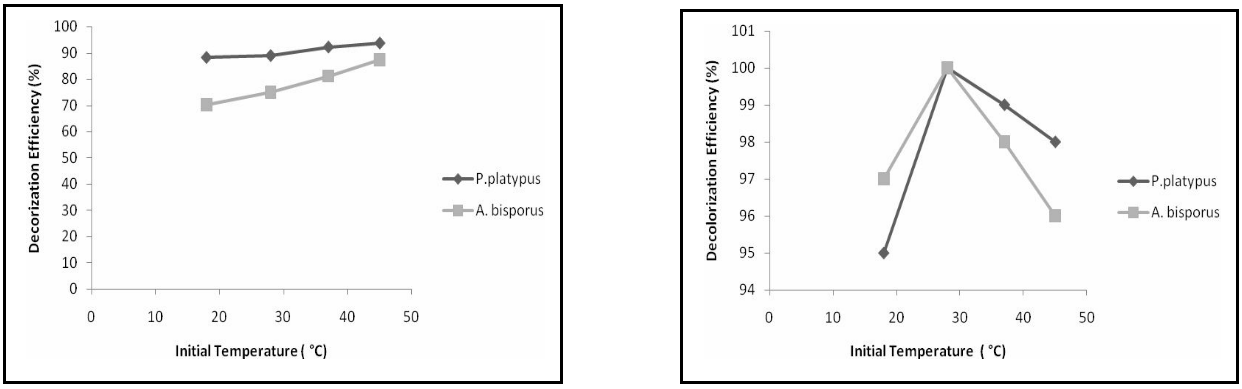
Fig.2. Effect of biosorbent dosage on decolorization of Reactive Black 5 (a) and Remazol Brilliant Blue R (b) by *P.platypus* and *A.bisporus* (pH= 3, temperature =28°C and initial dye concentration = 10mg/l).

Effect of temperature

The effect of temperature on decolorization of dyes was checked at different temperatures (18, 28, 37, 45°C).The results are shown for RB5 (Fig 3a) and RBBR (Fig 3b) respectively. It is found that change in temperature does not have a major effect in the decolorization efficiency of the dye. However, the maximum decolorization was found to take place at 45°C for RB5 using both the macrofugi. The decolourization efficiency increased from 88.3% to 93.7% for *P.platypus* and from

70.2% to 87.5% for *A.bisporus.*

The increase in decolorization efficiency due to increased temperature can be due the increased affinity of the dye molecules towards the binding sites at high temperature. Similar results were obtained for various dye adsorptions using different biosorbents [27,28] . For RBBR however both the biosorbents showed complete decolourization at 28°C, while decrease in decolourization was observed at 18°C and 45°C. This proves that decolourization of RBBR is maximum when the industrial effluent is at a temperature of 28°C.

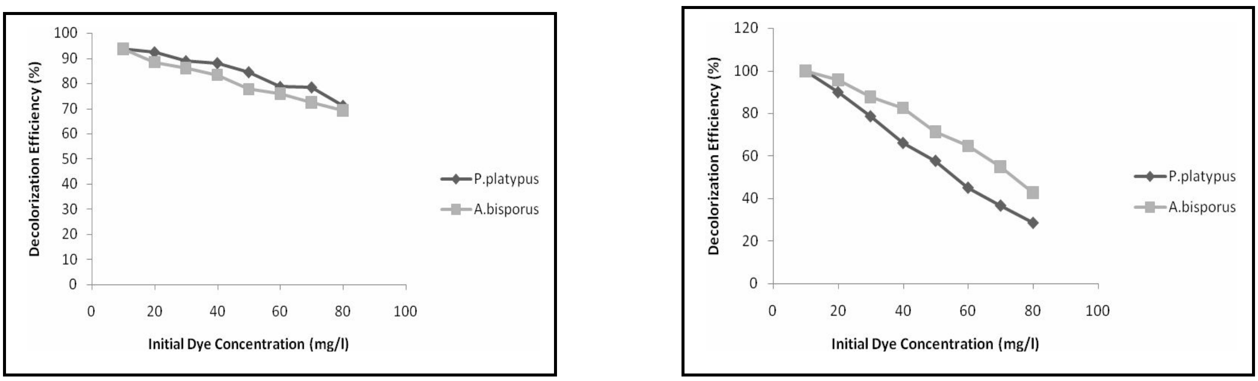


(a) (b)

Fig.3.Effect of temperature on decolorization of Reactive Black 5 (a) and Remazol Brilliant Blue R (b) by *P.platypus* and *A.bisporus* (pH= 3, biosorbent dosage 0.3g/100ml for *P.platypus* and 0.2g/100ml for *A.bisporus* and initial dye concentration 10mg/l).

Effect of initial dye concentration

The effect of initial dye concentrations on decolorization of RB5 and RBBR was investigated by varying the dye concentrations (10, 20, 30, 40, 50, 60, 70, 80 mg/l). The decolorization efficiency of both the biosorbents decreased with increase in the initial concentration of both the dyes. In case of RB5 the maximum decolorization took place at 10mg/l. The decolourization efficiency decreased from 93.7 % to 71.1% for *P.platypus* and from 93.7 % to 69.2% for *A.bisporus* (Fig 4a).Similarly for RBBR maximum decolorization was observed at 10mg/l. The decolourization efficiency decreased from 100 % to 36.8 % for *P.platypus* and from 100% to 55% for *A.bisporus* (Fig 4b).The decrease in decolorization efficiency on increasing initial dye concentration may due to the lack of available active sites required for the high initial concentration of dye.



(a) (b)

Fig.4.Effect of initial dye concentration on decolorization of Reactive Black 5 and Remazol Brilliant Blue by *P.platypus* and *A.bisporus* (pH 3, biosorbent dosage 0.3g/100ml for *P.platypus* and 0.2g/100ml for *A.bisporus* and temperature 45°C).

Decolorization under optimal conditions

The decolorization efficiency of RB 5 and RBBR by *P.platypus* and *A.bisporus* under optimal conditions is depicted in Fig 5. In both cases *P.platypus* had greater decolorization efficiency compared to *A.bisporus*. In case of RB5 *P.platypus* had a decolorization efficiency of 91.6% whereas *A.bisporus* decolorized 83.3% of the dye. For RBBR, *P.platypus* showed complete decolorization under optimal conditions in comparison to 85.7% decolorization efficiency by *A.bisporus*.

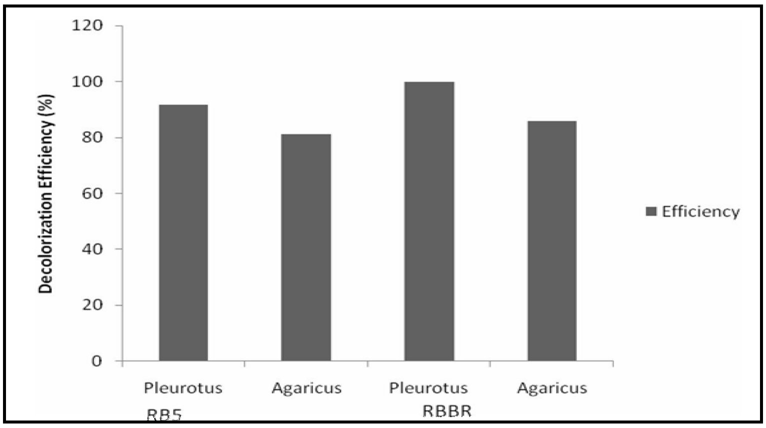


Fig.5 Decolorization efficiency of *P.platypus* and *A.bisporus* on RB5 and RBBR [pH 3;Biosorbent dosage (RB 5: *P.platypus* 0.3gm/100 ml, *A.bisporus* 0.2g/100 ml; RBBR: *P.platypus* and *A.bisporus* 0.1g/100ml); temperature RB 5 45°C, RBBR 28°C; initial dye concentration 10mg/l].

Decolorization of mixed dye

For mixed dye solutions, *P.platypus* was found to serve as more efficient decolorizing agent as it completely decolorized the dye solution whereas *A.bisporus* decolorized 90% of mixed dye solution. The results are depicted in Fig 6.

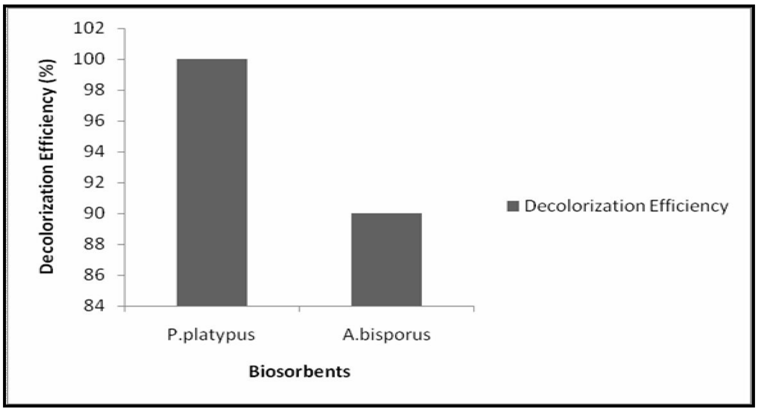


Fig.6.Comparison of decolorization efficiency of mixed dye solution by *P.platypus* and *A.bisporus* (pH 3, biosorbent dosage 0.3g/100ml, temperature 28°C, initial dye concentration 10mg/l)

Conclusion

Effects of various physico-chemical parameters on decolorization of Reactive Black 5 and Remazol Brilliant Blue R by *P.platypus* and *A.bisporus* were investigated. The results indicated that *Pleurotus platypus* served as potential agent for removal of Reactive Black 5 and Remazol Brilliant Blue R from aqueous solutions as compared to *Agaricus bisporus*. The optimal decolorization was noted at pH 3, biosorbent dosage 3g/l, temperature 28°C and initial dye concentration 10mg/l for Reactive Black 5, whereas for Remazol Brilliant Blue R, the optimum pH was found to be 3, biosorbent dosage 1g/ L, temperature 28°C and initial dye concentration of10mg/l. In case of mixed dyes compared with *Agaricus bisporus*, *Pleurotus platypus* used in the study is a promising decolorizing agent for color removal from dye containing aqueous solution.

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