RJC
http://www.rasayanjournal.com

RASĀYAN *J. Chem.*
Vol.3, No.4 (2010),731-735
ISSN: 0974-1496
CODEN: RJCABP

COD REDUCTION AND COLOUR REMOVAL OF SIMULATED TEXTILE MILL WASTEWATER BY MIXED BACTERIAL CONSORTIUM

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ABSTRACT

Textile industries consume substantial volumes of water and chemicals associated with dyeing process. Most of the textile dyes are recalcitrant; thereby create problems in the biological treatment of the textile effluents. This paper reports the potential of mixed bacterial population for the biodegradation of simulated textile dye wastewater. Two bacterial strains isolated from the dye contaminated soil of a local textile industry were used for the decolonization studies. The flasks having 100 ml of dye solution were inoculated with mixed bacterial cultures and incubated for the period of seven days under aerobic conditions in an incubator shaker and different growth conditions like nutrients, temperature and pH were optimized during the experimental setup. More than 70% colour removal from the wastewater samples was achieved after the incubation period of five days, and a little change in decolonization rate was observed thereafter. Majority of chemical oxygen demand (COD) was removed in the subsequent aerobic process. This study shows that it is possible to decolourize a high concentration of textile dyes by using Mixed Bacterial Consortia and a large number of pollutants can be removed up to a great extent.

Keywords: Biodegradation, Textile industry effluent, Bacterial Consortia, pH, COD, Temperature

INTRODUCTION

In textile and paper colouration industries synthetic dyes from residual dye baths are released in to waste streams. It is estimated about 10-15% of dyes goes unused in textile effluents[1, 2]. Azo dyes, characterized by nitrogen to nitrogen double bonds (–N=N–), account for up to 70% of all textile dyestuffs produced and are the most common chromophore in reactive dyes[3]. The reactive azo dyes-containing effluents from these industries have caused serious environment pollution because the presence of dyes in water is highly visible and affects their transparency and aesthetics even if the concentration of the dyes is low. Most of these dyes are toxic and potentially carcinogenic and their removal from industrial effluents is a major environmental problem[4-6]. In mammals azo dyes are reduced to aryl amines by cytochrome p450 and a flavin dependent cytosolic reductase[7]**.** Aromatic amines can be mineralized by means of aerobic treatment by non-specific enzymes through hydroxylation and ring-fission of aromatic compounds[8, 9]. The anaerobic breakdown of azo dyes can lead to reduction of azo bond producing mutagenic and carcinogenic compounds[10]. Therefore, industrial effluents containing dyes must be treated before their release into the environment[11]. Many physical and chemical methods including adsorption, coagulation, precipitation, and oxidation have been used for the treatment of azo dye-contaminated effluents[12]. These methods, however, may generate a considerable amount of sludge or may easily cause secondary pollution due to excessive chemical usage. Therefore, it may be economical to develop substitute means of dye decolourization, such as bioremediation due to its reputation as on environmentally friendly and widely acceptable treatment technology[11]. Some specialized strains of aerobic bacteria have developed the ability to use azo dyes as sole source of carbon and nitrogen[13, 14]; others only reduce the azo group by special oxygen-tolerant azo reductases. *Pseudomonas putida* mt-2 degrades the azo dyes in two steps: an azo-reduction followed by an oxygen-dependent metabolization[15]. Recently Chen et al.[16] have described bacterial strains which display good growth in aerobic or agitation culture. The degradation of azo-dye *p*-

aminoazobenzene by *Bacillus subtilis* has been reported. The results indicate that *B. subtilis* cometabolize *p*-aminoazobenzene in the presence of glucose as carbon source.

The main objective of the present study was to investigate potential of isolated bacterial strains to decolourize the important textile dyes in liquid system under aerobic conditions with an emphasis on the effects of different process operating conditions such as temperature, pH and initial dye concentration on decolouration and degradation efficiency.

EXPERIMENTAL

Chemicals

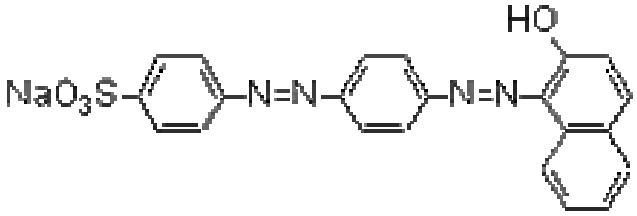
Chemicals used were purchased from Loba-Chemi, Bombay, and were of the highest purity available.

Microorganism, Culture media and culture conditions

The bacterial strains were isolated from dye-contaminated soil collected from within the premises of a textile industry. For the isolation purpose effluent basal media was used. Composition of the effluent basal media was as follows: Yeast extracr: 5.0 gm, Glucose: 5.0 gm, $(NH_4)_2SO_4$: 0.50 gm, KH_2PO_4: 2.66 gm, Na_2HPO_4: 4.32 gm, Dye effluent: 1000 ml, pH 7. The bacterial strains were maintained on nutrient agar plates through fortnightly sub-culturing. These bacteria were identified as *Bacillus subtilis* and *Achromobacter xyloxidans* by the IMTECH, Chandigarh. The cultures used for inoculation into liquid system were incubated on nutrient agar plates for a week under aseptic conditions at 30^0C prior to inoculation into liquid system.

Experimental method

A simulated stock solution of acid red 151 dye was prepared (1000 mg/L) and desired concentrations of the dye were obtained by further dilutions. For liquid cultures nutrient broth was used and for dye degradation studies seven days old cultures were used. Erlenmeyer flasks having 100 ml pre autoclaved textile effluent were inoculated with bacterial strains**.**



Chemical structure of acid red 151

Decolourization assay

Different operational parameters like pH and temperature were optimized in this study. The effect of pH on the biodegradation was in the pH range 4.0 -7.0. The desire pH was maintained using 0.1 N HCl or 0.1N NaOH. The effect of varying temperature was studied at different levels. In all experiments, agitated liquid cultures were grown for 7 days in an incubator shaker. Samples (8ml) were withdrawn at alternate days, centrifuged at 8000 rpm and the supernatant was scanned for absorbance in a UV-Visible spectrophotometer at λ_{max} (512 nm). All the experiments were performed in duplicates. Controls were maintained without dye. The following formula was used to calculate the percentage decolourization (degradation):

$$\% \text{ Decolourization} = \frac{(C_0 - C_e)}{C_0} \text{X } 100$$

Where, C_o is the initial concentration of dye (mg/l) and C_e is the residual dye concentration (mg/l) at different time intervals.

Chemical oxygen demand was also analyzed during the experimental setup by dichromate reflux method, and COD removal was determined.

RESULTS AND DISCUSSIONS

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 26 to 36^0C. The results are presented in the Fig. 1. which indicated that as the temperature increased from 26 to 36^0C, initially there was an increase in dye degradation rate up to 32^0C and afterward the colour removal was decreased. Maximum colour reduction was observed in the temperature range of 32^0C. Maximum decolourization was recorded from day 3rd to day 5th and thereafter little change in degradation rate was recorded in all cases. The decolourizarion pattern indicated that the degradation was highly temperature dependent. The maximum colour reduction was near about 76%, recorded after the incubation period of five days under shaking conditions.

Effect of pH on colour reduction

The effect of pH on colour reduction by bacterial consortia was investigated in the range of pH 5.0 to 9.0, and temperature was maintained at 32^0C. It is evident from Fig. 2. that as pH increases from acidic conditions i.e. pH 5.0 to pH 9.0, the maximum percent decolourization increased upto near about 77%. The pH 7.0 was found to be optimum for decolourization of textile wastewater. The maximum removal of colour was observed at the 7th day for all studied pH. In general percent colour removal was increased from 1st to 7th days. There was no significant change in percentage removal after 5th days, thus 5th day can be considered as optimum.

Chemical oxygen demand removal study

During the experimental setup COD removal was investigated at alternate days. Fig.3. illustrate the removal of COD during the experimental conditions. The COD of the samples was determined by standard dichromate reflux method. The initial COD concentration of the textile effluent was very high compared to their permissible limit, for irrigation and horticultural uses as prescribed by the pollution control board. The COD reduction was found to be near about 81% after the incubation period of 7 days under shaking conditions.

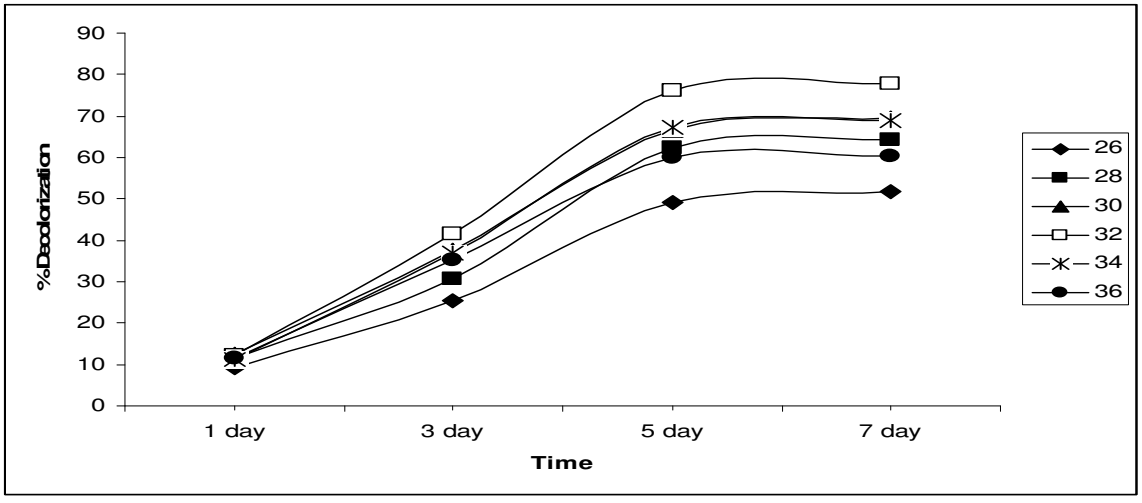


Fig.-1: Effect of temperature on colour reduction of dyeing wastewater.

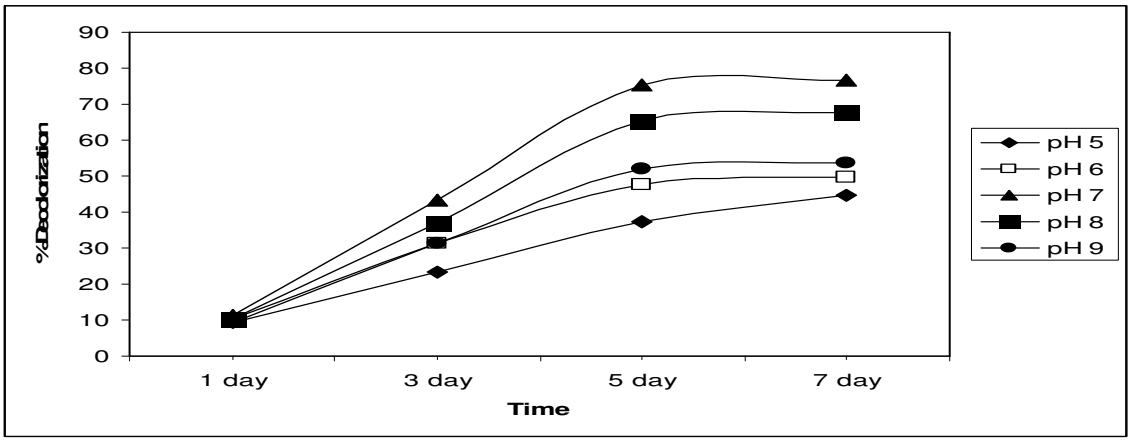


Fig.-2: Effect of pH on colour reduction of dyeing wastewater.

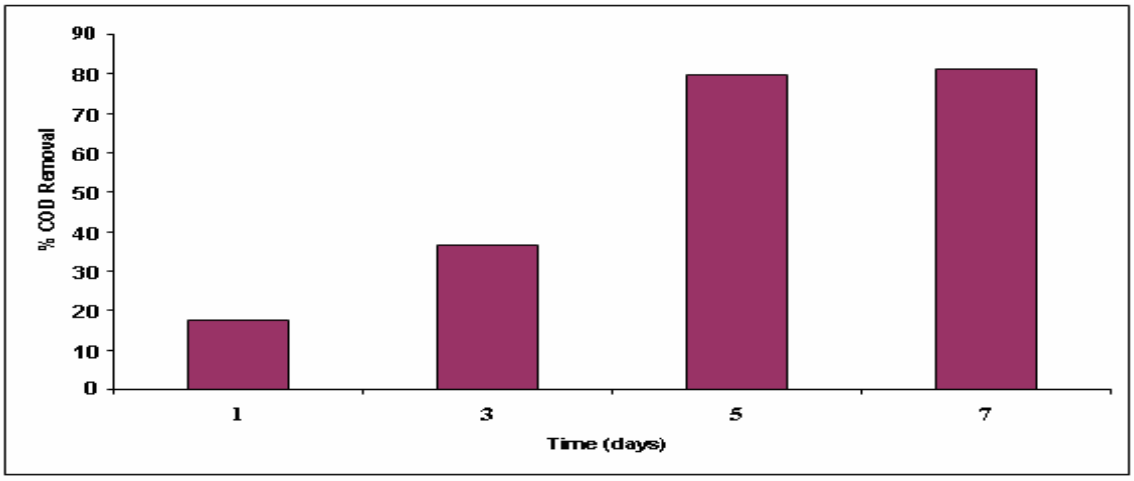


Fig.-3: Removal of chemical oxygen demand (COD) by the bacterial consortia from textile wastewater.

CONCLUSIONS

The study concluded that pH, initial dye concentration and temperature have a significant influence on dye removal efficiency by bacterial consortium. This shows that these bacteria have enormous potential to degrade the textile dyes and resolve the problem of unnecessary dyes and high COD present in the effluents of textile industries. Further pilot scale studies are required with these strains for actual industrial applications, and detailed study is needed to explore the mechanism involved. Thus any bioprocesses based dye removal system using such type of microorganisms should be designed on the basis of these parameters for successful operations.

ACKNOWLEDGEMENT

The authors are deeply thankful to the University Grants Commission (UGC), New Delhi, India for providing the financial assistance for this research work.

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[RJC-682/2010]