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Full Length Research Paper

Microbial degradation of textile industrial effluents

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Textile waste water is a highly variable mixture of many polluting substance ranging from inorganic compounds and elements to polymers and organic products. To ensure the safety of effluents, proper technologies need to be used for the complete degradation of dyes. Traditionally, treatments of textile waste water involve physical or chemical methods. But both physical and chemical methods have many short comings. Biodegradation is an eco friendly activity it can produce little or no secondary hazard. In this work, the *in situ* degradation of textile industrial effluent was carried out. The degradation of two different dyes, blue and green colour has been studied. The isolated organism which showed the ability to degrade dye was characterized and identified as *Paenibacillus azoreducers* using various biochemical techniques. The degradation of dye was confirmed via the decolourisation assay and by the measurement of COD and BOD values. A trickling bed reactor was designed and the treatment of effluent from a textile industry was effectively carried out.

Key words: Biodegradation, textile wastewater, secondary hazard, *Paenibacillus azoreducens*, decolourisation, trickling bed reactor.

INTRODUCTION

Environmental problems such as appearance of colour in discharges from various industries, combined with the increasing cost of water for industrial sector, have made the treatment and reuse of effluent increasingly attractive to the industry. Textile industry is one of the oldest industries in India with over 1000 industries. Taking into account the volume and composition of effluent, the textile wastewater is rated as the most polluting among all in the industrial sectors (Zehra et al., 2003; Vilaseca et al., 2010; Awomeso et al., 2010). In general, the wastewater from a typical textile industry is characterized by high values of BOD, COD, colour and pH (Tufekci et al., 2007; Yusuff and Sonibare, 2004). It is a complex and highly variable mixture of many polluting substances ranging from inorganic compounds and elements to polymers and organic products (Brown and Laboureur, 1983). In-complete use and the washing operations give the textile wastewater a considerable amount of dyes (Mathur et al., 2005). The untreated textile wastewater can cause rapid depletion of dissolved oxygen if it is directly discharged into the surface water sources due to its high BOD value. The effluents with high levels of BOD and COD values are highly toxic to biological life. The high alkalinity and traces of chromium which is employed in dyes adversely affect the aquatic life and also interfere with the biological treatment processes (Brown et al. 1993). It induces persistent colour coupled with organic load leading to disruption of the total ecological/symbiotic balance of the receiving water stream (Puvaneswari et al., 2006). Dyes with striking visibility in recipients may lead to reduced light penetration in aquatic environment which will significantly affect the photosynthetic activity. The high concentration of nitrogen in the textile industrial effluents can cause the eutrophication of closed water bodies. In addition, coloured water is objectionable as it can spoil the beauty of water environments (Andleeb et al., 2010; Ashutosh et al., 2010).

In view of the earlier mentioned adverse effects, the textile industry effluent should be discharged after proper treatment. The dyes are stable to light, heat and oxidizing agents, and it is difficult to remove the dyes from effluents. This makes the effective and economic

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treatment of the effluents containing various dyes an important environmental problem. Traditionally, both physical and chemical methods such as coagulation, ozonation (Lin and Lin, 1993), precipitation, adsorption by activated charcoal, ultrafiltration, nanofiltration (Akbari et al., 2002), electrochemical oxidation, electrocoagulation (Kobya et al., 2003; Alinsafi et al., 2005) etc were used in the treatment of the textile industrial effluents (Vilaseca et al., 2010; Ramesh et al., 2007). But both methods have many short comings (Andleeb et al., 2010; Lorimer et al., 2001; Babu et al., 2007). Chemical methods like coagulation often produce excess amount of chemical sludge which create problems of its disposal. Physical methods like adsorption by activated charcoal often need high capital investment. Hence, most of the physical and chemical methods of effluent treatment are not accepted by the industries due to their high cost, low efficiency and inapplicability to a wide variety of dyes.

Currently, much research has been focused on the biodegradation of the industrial effluents (Andleeb et al., 2010; Melgoza et al., 2004; Sapci and Ustun, 2003). It mainly shows interest towards the pollution control using bacteria, fungi in combination with physicochemical methods (McMullan et al., 2001; Beydilli et al.,1998). The biomass can absorb the chromophores and also these chromophores can be reduced in low redox potential environments. The attractive features of biological treatment are low cost, renewable and regenerative activity and little or no secondary hazard (Sharifi et al., 2001; McKinney et al., 1965; Morias and Zamora, 2005). The conventional biological processes are not effective because the dye content in the textile effluent is toxic to the microorganisms used (Kim et al., 2002; Koch et al., 2002). *In situ* degradation of the effluent is a novel method under the biodegradation process. In this method, the microorganisms isolated from the site of pollution and the same microorganism can be used for the treatment of the effluent (Olukanni et al., 2006; Puvaneswari et al., 2006).

MATERIALS AND METHODS

Collection of the effluent sample

Aseptic techniques were followed during effluent collection. 350 ml samples were collected and put in the sterile reagent bottles (500 ml capacity). The samples were subjected to immediate preliminary analysis. This sample served as the source for the isolation of micro-organism.

Preliminary analysis of effluent

Absorbance, pH, COD and BOD value of the effluent was measured.

Isolation and characterization of the organism

The organisms were isolated from the effluent using the pour plate and streak plate techniques on nutrient agar plates. Pure cultures of the identified organisms were made and characterized by the staining methods, hanging drop technique and the various biochemical tests.

Preparation of mass cultures

To enhance the degradation of effluent, mass cultures of the isolated organisms were prepared from the pure cultures.

Degradation of dyes

Degradation of the dyes was examined through the decolourization assay, determination of pH, COD and BOD values.

Dye decolourization assay

To enhance the bacterial growth, the media was formulated as follows: water- 50 ml and dye- trace amount. To this media, 5 ml of the mass culture was added and kept in overnight incubation at room temperature in the rotary shaker. Degree of decolourization was quantified by measuring the change in optical density at characteristic wavelength of each dye sample:

$$D = \frac{\text{A initial - A final}}{\text{A initial}} \times 100$$

Where, D is decolourisation; A initial is the initial absorbance and A final is the final absorbance.

Design of a trickling filter

A trickling filter was designed considering the waste water characteristics of 25 m^3/d flow rate, BOD value of 600 mg/l. The theoretical BOD reduction efficiency was calculated to 81%. The height of the tank was 6 m and diameter was 2.3 m. The material used for packing was small river rock of 2.5 to 7.5 cm. Packing diameter was 2.3 m and the packing height was 4.5 m. Volume of the reactor to be filled with the packing material was 18.69 m^3 and the quantity required was 24297 kg.

Under drain characteristics

The under drain and support system for rock packing consists of beam and column.

RESULTS

Isolation and identification of microbes from effluent

Isolated organisms were *Bacillus* species and the organism which showed maximum efficiency for dye degradation was identified as *Paenibacillus azoreducens* by using biochemical and 16S rRNA gene sequencing. This organism was observed as pale yellow colour colony on nutrient agar plates (Figures 1 and 2).

The gram staining of isolated organism showed that the organism is gram variant. The results of various

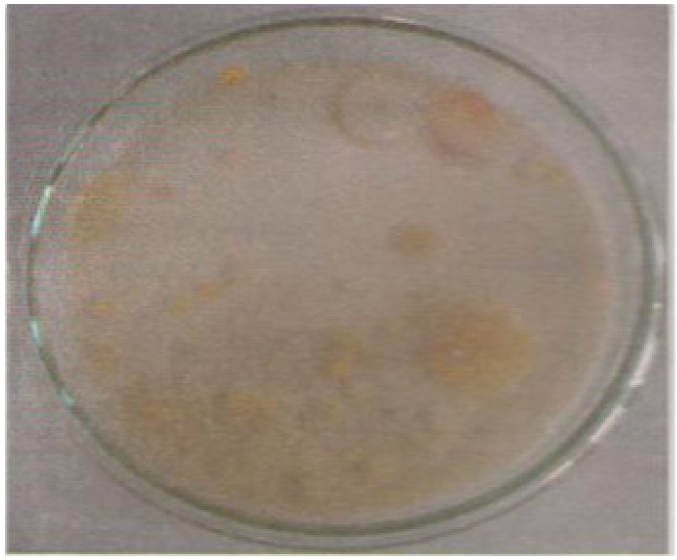

Figure 1. Isolated colonies on nutrient agar plates.

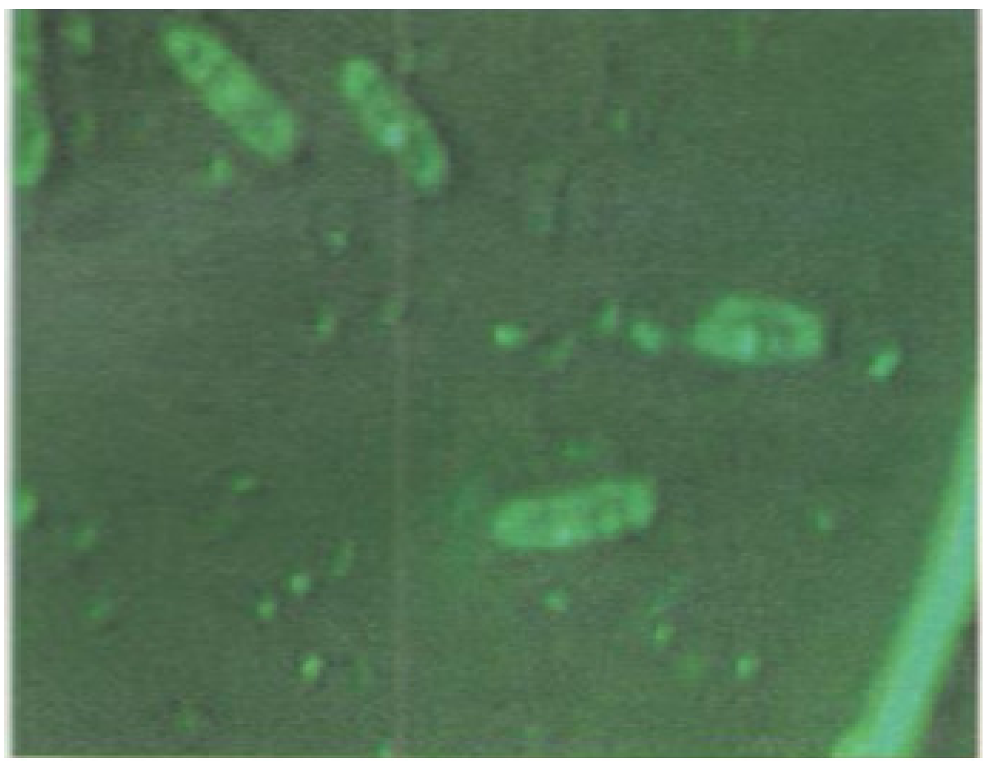

Figure 2. Phase contrast view of isolate.

biochemical tests are listed in the Table 1.

Degradation of dye

The colour degradation was observed overnight and the loss of colour was monitored over the period of time (Figures 3 and 4). The estimated cost of the equipment for the treatment process is given in Table 2.

DISCUSSION

The aim of this work was to biologically degrade the

Table 1. Results of the biochemical tests.

S/N	Test	Result
1	Catalase test	Positive
2	Starch hydrolysis	Positive
3	Oxidase test	Negative
4	Motility test	Highly motile
5	Nitrate reduction test	Positive

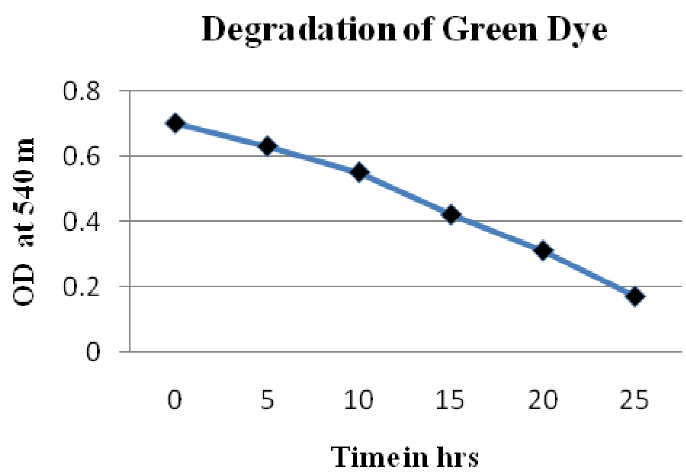

Figure 3. Degradation of green dye.

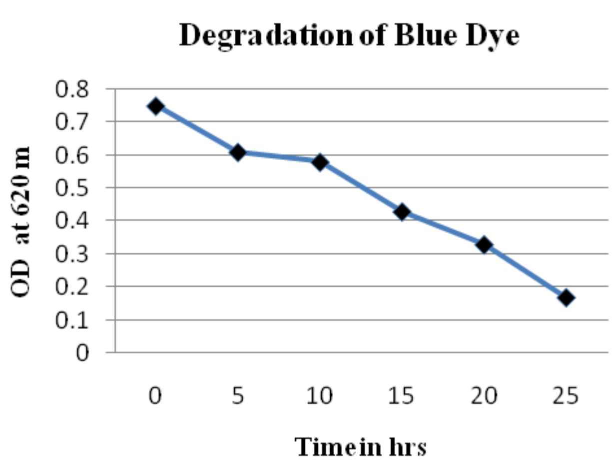

Figure 4. Degradation of blue dye.

dyes, that is, using bacteria that can survive in the conditions imposed by the effluent. The bacterium that was isolated from the effluent was identified to be *P. azoreducens*. Using this bacterium, effective degradation was obtained in 24 h. The main benefit of employing this technique is that the culture has an optimal temperature of 37°C and optimum pH of 7. In addition to this, the inherent advantages of microorganism, like rapid growth, less space requirement, etc makes this an efficient method for treatment of textile industrial effluent. Using trickling filter designed for the earlier mentioned process, the BOD level could be reduced from 600 to 100 mg/l only.

However, the value must be reduced to below 30 mg/l

Table 2. Estimated cost of equipment.

S/N	Cost detail	Cost in lakhs
1	Piping	0.125
2	Packing (river rock)	0.05
3	Compressors/blowers(150 L)	0.80
4	Concrete	0.15
5	Grating (stainless steel)	0.30
	Total	1.425

to make it commercially and environmentally attractive. Hence, in an industrial application, it is recommended to use two of such tricking filters in series.

Conclusion

The process of bringing down the BOD levels of waste below 30 mg/l before discharging into surface water sources has been studied in detail in this work. The present invention indicates that microbial decolourisation could be a viable means in ridding dye waste water. Dye molecule absorption into the cell surface appears to be quick and is often completed in some hours and there is no specific nutrient requirement. This do not seem to be a specific process but direct reactive dyes could all be cleared out of solution using the same approach. It can be conclude from this study that the blue and green colour reactive dyes are completely degraded using the biological treatment.

Evidence from this study suggests that biological colour removal of textile wastewater is sufficient to meet the requirements. Furthermore, the carbon and nitrogen concentration within the waste water may also be biologically treated and reduced. The findings of this research correspond well with results of similar studies found in the literature.

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