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Microbial degradation of textile industry effluent

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ABSTRACT

In the present study bacterial species isolated from textile industry effluent were evaluated for their decolourization and degradation abilities. The textile waste has a high number of organic as well as inorganic pollutants which would be harmful to aquatic flora and faunas well as cause health problems if the industrial effluent is directly discharged into water bodies. Seven microbial strains were isolated and from them two strains identified as *Pseudomonas fluorescens* and *Bacillus cereus* were evaluated for their capability to degrade different dyes. Further the various condition for maximum dye degradation were analysed and *Pseudomonas fluorescens* was seen to give 95-98 % dye degradation under aerobic and agitated conditions at neutral pH.

Introduction

Biodegradation (Chatterjee, et al 2008) is defined as the process by which microorganisms rapidly degrade hazardous organic contaminants to environmentally safe levels in soils, sediments, subsurface materials, and groundwater. The microbes may obtain both energy and carbon through the metabolism of organic contaminants. (Singh and Singh, 2010)

The rate and extent of biodegradation are governed by many environmental factors, including contaminant and cell biomass concentrations, temperature, pH, moisture, supply of nutrients, adequacy of carbon and energy sources, soil structure, the presence of toxins such as heavy metals, availability of contaminants to microorganisms (i.e., contact, contaminant solubility and hydrophobicity, and desorption from solids), time for acclimation, and availability of electron acceptors. Aerobic biodegradation occurs in the presence of oxygen, whereas alternate electron acceptors, including nitrate, sulphate, trivalent iron (Fe^{3-}), and carbon dioxide, are utilized under anaerobic conditions.

Noida is an industrial city in the National Capital Region which houses a great no of textile and textile dying industry. Presence of these industry lead to the problem of effluent treatment which is a major problem in a well planned city like Noida. Effluent discharge from textile and dyestuff industries to neighbouring water bodies can cause significant health concerns. Different waste water management techniques and infrastructure have been shown to give results in these industries but their lack of implementation has been largely due to high cost, low efficiency and inapplicability to a wide variety of dyes. Thus, the ability of microorganisms to carry out dye decolorization is now seen as a cost-effective method for removing these pollutants from the environment.

Materials and method

The sample collected for the study included dye containing waste water from denim industries located in Noida. Basal Mineral Media (BMM) was prepared incorporated with the dye and 0.1 g/l of peptone. The plates were inoculated with the bacterial isolates. The plates were incubated at 37˚C for 5 days and observed for the decolourization of dye.

The broth was inoculated with the bacterial isolates and incubated at the following conditions.

- Aerobic and anaerobic conditions
- Agitated and static conditions
- At different Temperatures
- At different pH

To analyse dye concentration, 2ml of each sample was taken every 24hrs; it was centrifuged at 4000rpm for 30 minutes and absorbance of supernatants were determined at 620nm.

For In Vivo decolourization of industrial effluent : The dye water at the industrial site was collected in a cemented pit and was supplemented with 100mg/l of peptone and inoculated with the bacterial isolates. Incubation was carried out under aerobic and static conditions at pH 7 and at 37˚ C. To analyse dye concentration, 2ml of each sample was taken every 24hrs; it was centrifuged at 4000rpm for 30 mins and absorbance of supernatants were determined at 620nm.

Results

The sample collected and used to isolate bacteria showed the presence of two prominent species A and B. Upon staining, cultural studies and biochemical analysis, the two strains were identified as *Pseudomonas fluorescens* and *Bacillus cereus*.

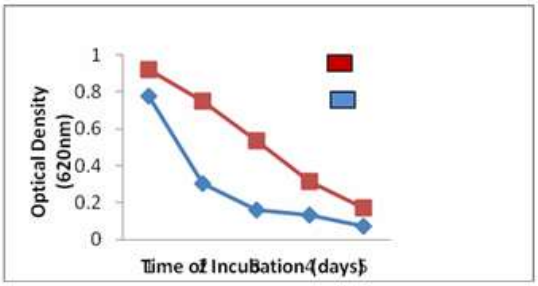

Figure 1: Graph showing biodegradation of different dyes by *Pseudomonas florescens* and *Bacillus cereus* under aerobic

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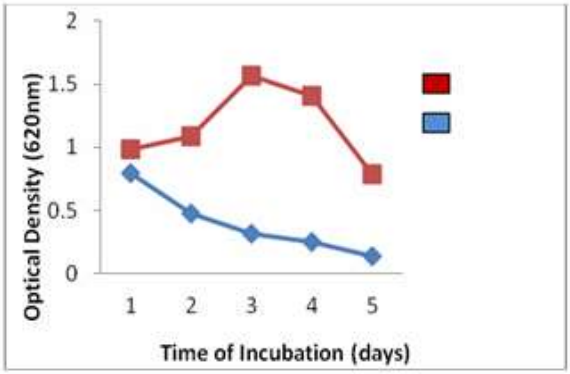

Figure 2: Graph showing biodegradation of different dyes by *Pseudomonas florescens* and *Bacillus cereus* under anaerobic conditions

The absorbance readings were recorded and shown in figure 1to 6. Graphs were plotted between the time of incubation (days) vs OD and % Decolorization by both the bacteria under different conditions were shown in the form of histograms.

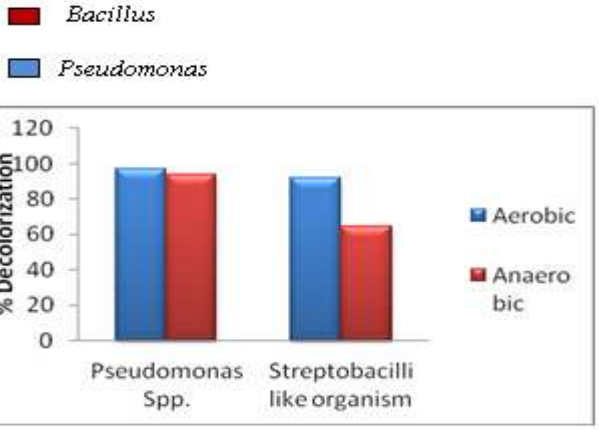

Figure 4: Comparison of dye decolorization *Pseudomonas florescens* and *Bacillus cereus* under aerobic and anaerobic conditions

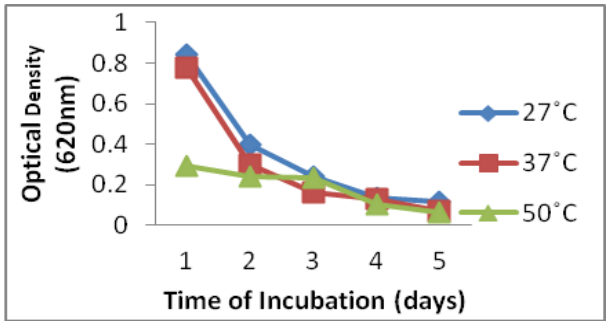

Figure 5 : Biodegradation of dyes by *Pseudomonas florescens* under different temperature conditions in aerobic conditions

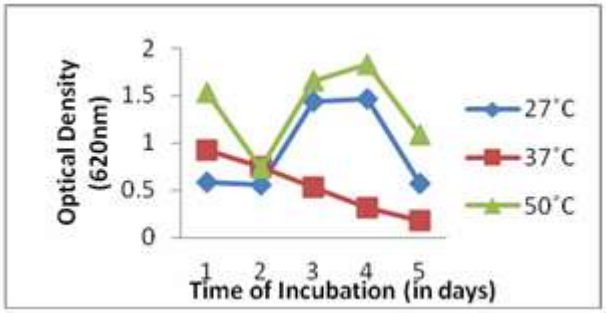

Figure 6 : Biodegradation of dyes by *Bacillus cereus* under three different temperature conditions in aerobic conditions

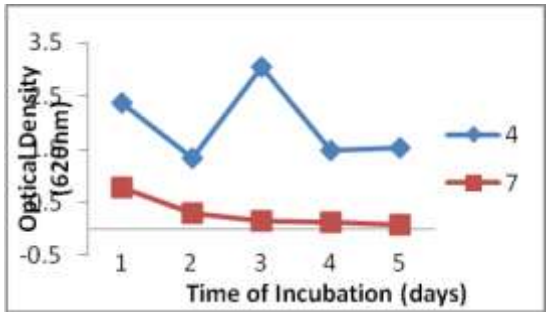

Figure 7: Biodegradation of Dyes by *Pseudomonas florescens* under different pH

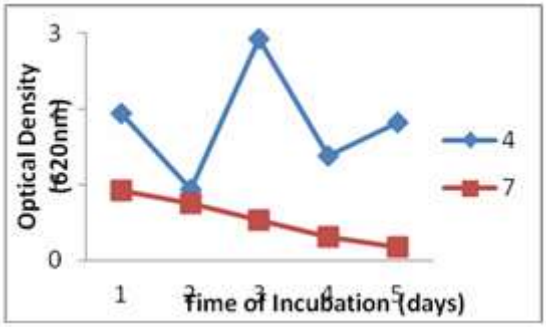

Figure 8: Biodegradation of Dyes by *Bacillus cereus* under different pH

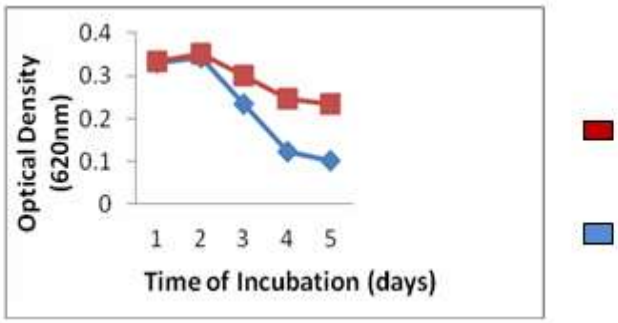

Figure 9: Biodegradation of Dye water at industrial site by *Pseudomonas florescens* and *Bacillus cereus* under Aerobic and static conditions at pH 7 and at 37˚C

Discussion

Decolorization of dyes by microorganisms may involve the adsorption or degradation of the complex pollutants thus, resulting into non-toxic end products. The bacteria were characterized by different biochemical and microbiological tests. One of them was identified as *Pseudomonas florescens* while the other was shown to be *Bacillus cereus*. Invitro biodegradation tests were conducted for both the bacterial isolates using the same concentration (20mg/l) of different dyes. Peptone was added as an additional nitrogen source to enhance the growth of bacteria and to regenerate NADH, which acts as an electron donor for reducing the dye (R.G. Saratale *et al*, 2010). The tubes were incubated under different conditions. After 5 days of incubation, the decolorization of dyes by *Pseudomonas florescens* under aerobic, anaerobic and agitated conditions was found to be 96.85%, 93.79% and 97.39% respectively while the % decolorization by *Bacillus cereus* was 92.21%, 64.61% and 95.54% under the same conditions respectively. The values for decolorization efficiency by *Pseudomonas florescens* at three different temperature conditions (27˚C, 37˚C and 50˚C) were 94.78%, 96.85% and 96.98% respectively. The corresponding values for *Bacillus cereus* were 74.44%, 92.21% and 51.14% respectively. When the decolorization experiment was performed at pH 4, 7 and 8.5, the % decolorization obtained was

47.59%, 96.85% and 55.68% for *Pseudomonas florescens.* Similarly, for *Bacillus cereus*, the decolorization efficiency was 37.72%, 92.21% and 71.59% under the same conditions.

Under aerobic conditions, quite high decolorization efficiency was achieved by both the bacterial strains indicating that the presence of oxygen is necessary for the oxidative enzymes to function in dye decolorization. Dye degradation under anaerobic conditions in case of *Pseudomonas florescens* was comparable to that under aerobic conditions as *Pseudomonas* is a facultative microorganism and hence, can equally tolerate both aerobic and anaerobic conditions (Mustafa Isik *et al.,* 2003). The highest decolorization rate was witnessed in agitated conditions with both the bacterial isolates. This observation may be explained by an increase in the dissolved oxygen content and result in more efficient contact between the dye and biomass (Prachi Kaushik *et al.*, 2009).

With *Pseudomonas florescens* among the three different temperature conditions, the highest decolorization efficiency was seen at 50˚C. This may be possible with certain whole cell bacterial preparations where azoreductase enzyme is relatively thermostable and can remain active upto 60˚C over short periods of time (R.G. Saratale *et al.*, 2010). *Bacillus cereus* showed very low degradation at this temperature which may be due to loss of cell vitality or azo reductase denaturation.

The rate of decolorization by *Pseudomonas florescens* and *Bacillus cereus* at 37˚C was quite high as it is their optimum temperature for growth. Unlike *Pseudomonas florescens*, *Bacillus cereus* showed only partial degradation at 27˚C which may be attributed to reduced growth rate and inactivity of the degradation enzymes.

Both bacteria showed maximum degradation at neutral pH, which is their optimum for cell growth. The effect of pH is related to the transport of dye molecules across cell membrane which is the rate limiting step of decolorization (R.G. Saratale *et al.*, 2010).

The same microorganisms were tested for their biodegradation ability invivo by using the highly contaminated waste water discharged from dyeing industry. It was found that change of pH had no effect on the colour of the waste water implying that the decolorization of dye occurred due to its degradation solely by the microorganisms and not because of any chemical change of pH. Hence, *Pseudomonas florescens* degraded the dye in both invitro and invivo conditions to a greater extent.

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