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Biobleaching of Textile Dye Effluent Using Mixed Culture through an Immobilized Packed Bed Bio Reactor (IPBBR)

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Abstract

A bacterial consortium was raised to treat the textile dying effluent. The mixed culture for biobleaching was isolated from the sludge and dye effluent contaminated soil from ETP houses. Among the several isolated representatives' genera, *pseudomonas pudita* and *Bacillus subtillus* were found to be the potential strains with synergetic mode of biobleaching. 80-90% of decolorization along with 2-3 fold decrease in BOD and COD was observed using the bacterial consortium. This study exemplified the treatment feasibility of bacterial consortium over an immobilized packed bed as a biobleaching agent for treating textile dye effluents.

Keywords: Textile dye, Immobilization, Packed bed, BOD, COD, TDS, TSS

1. Introduction

Major pollutants in waste water from food processing, cosmetics, paper, dye manufacturing, Printing and Textile are color left by dyes (D.K.M. Markanday et al., 1999). Among these, textile industries consumes large volumes of water and chemicals for wet processing of Textiles (P.Nigam etal., 2001). The waste from the dying operations in the Textile industries may contain dyes of various intense colors, such as dyes having the functional groups of alkene, aromatic, C-N bond, S-O bond of red color. Some are made by inorganic molecules such as Al-O, Si-O, K-O, N=N bond which responsible for color development in the waste water (Balasubramanian et al.,1987). In this case, the Reactive B dye is considered for the treatment process. The discharge of dye bearing waste waters in to natural stream or on land has created significant concern as the dye impart toxicity and impedes light penetration and thus upsets the biological activity and also the ground water due to the soil leaching (Ray et al., 1986). Irrigation with raw dying factory effluent at different concentrations drastically reduced the germination, and vigor index of crops like Rice, cowpea and maize,

and nitrogen fixation in green gram. But the diluted effluent improved the groundnut germination and increased the chlorophyll, carbohydrate and protein contents and the biologically treated effluent enhance the yield and quality of many cereals and pulses. This effluent when passed through by ash can be safely used for afforestation (Ramachandran., 1994). There are more than 100,000 commercially available dyes. With over 7 x 10^5 ton of dyes are produced annually (Meyar et al., 1981; Zollinger et al., 1987). The presence of very low concentrations of dyes in effluent highly visible and undesirable (Nigam et al., 2000). Intake of such determined water results in many physiological and pathological effects and the reports of the effect of congo red dye gave a decrease in erythrocyte counts and hemoglobin content in human (subramaniyan et al., 1999). Also dyes can cause for allergic dermatitis, Skin irritation, cancer and mutation (Namasivayam et al., 1996) and carcinogens and toxicity of azo dyes especially benzidine based dyes are well known because of their mutagenicity and carcinogenicity. Thus colors in the waste water have to be removed before it is discharged in to a water body or on land. Some conventional methods like coagulation and flocculation (Panswed & wongoxaisuwam et al., 1986), reverse osmosis (Cohen, 1978), and activated carbon adsorption (venkat rao et al., 1987) and some nonconventional methods like Adsorption, Particularity with low cost materials such as industrial wastes (Ramakrishna etal., 1997), Clays (Jaung et al., 1997), Plant portions (Liversidge et al., 1997; Lebek etal., 1996) and polymeric gels (karzdog et al., 1997), wood charcoal (E.balssubramanian et al., 1999) and also biosorption by using low cost adsorption like Elchhonia root and shoot, Orange peel (C.Namasivayam et al., 1996), saw dust & baggase (D.K.Markendey et al., 1999), wood (poots et al., 1978), Biogas waste slurry (Yamina et al., 1992a; 1992b), rice hulls (Nawer et al., 1989), banana pith (kanchana; 1992, 1993) and waste coir pith (Kathirvelu et al., 1994) are examined. These conventional and nonconventional effects do not show significant effectiveness or economic advantage and also taken long time and consumes more water. Azo dyes degradation occurred through an oxygen insensitive *azoreductase* which catalyzed the reductive cleavage of azo groups using NAD(P)H as an electron donor (Zimmerman et al., 1982). Various anaerobic bacteria have been reported (Meyer 1981) to degrade Azo dyes by reducing the Azo linkage and forming colourless and toxic aromatic amines. The bacterial decolorization is normally faster, but it may require a mixed bacterial community to degrade dyes completely (Haug et al., 1991). The decolorization effect is examined by using the bacterial consortium of *pseudomonas pudita* and *Bacillus subtillus* for biobleaching of textile dye effluent. The decolorization is done through an immobilized packing of bacterial consortium and hence the process is an eco friendly one.

2. Material and methods

2.1 Raising the bacterial consortium

The sludge and dye effluents contaminated soil were collected aseptically and stored under refrigerated condition. For raising bacterial consortium they were enriched with mineral salt medium. The enriched inoculum was checked for its decolorization ability on the dye effluent. Later they were used as inoculum for immobilization.

2.2 Media formulation

(Table 1)

2.3 Immobilization

Immobilization, the restriction of bacterial activity in confined space was prepared as a bed of column. The advantage is immobilized bed induces high retention time there by increases the efficiency of decolorization. The contaminant regulation i.e. escape of microorganisms in the downstream is reduced.

2.4 The Experimental procedure

A piece of "polyurethane foam" was cut and dropped in to the prepared mineral media. Then it was inoculated with bacterial consortium and kept for 24 hrs. After the period it was observed the bacterial growth on the layer of foam. The persistence of the bacteria was also satisfactory. Thus this polyurethane foam was put up as the packing material.

3. Immobilized packed bed bio reactor (IPBBR)

3.1 Construction and operation

The IPBB was incorporated with polyurethane foam packing mounted over a suitable support. The bioreactor is of aerobic, upward flow operation. Air was sterilized by passing through a laminar flow chamber**.**

3.2 Reactor startup and Cell immobilization

Initially the Bioreactor was autoclaved twice at 121^0c for 15min with an overnight interval. After autoclaving, the bacteria suspension was inoculated aseptically. The entire consortium were grown and attached to the surface of Polyurethane foam within 2 days. The growth medium in the bioreactor was replaced with processing medium, after the initial growth and immobilization phase.

4. Results and discussion

Both initial and final parameters of the effluent of before and after the experiments are tabulated in Tables 2 and 3.

4.1 Results

This textile dye effluent after treated through this immobilized packed bed bio reactor has shown 80 – 90 % decolorization and a considerable decrease in COD and BOD altogether.

4.2 Discussion

The degradation of aromatic substance can be achieved under different redox conditions. Under Nitrate reducing conditions, Nitrate is used as potential electron acceptor. It seems that toluene is the most easily degraded compound under this reducing environment. Microbial transformation of aromatic substance is mainly due to aerobic processes. Aerobic organisms alter the resonance energy by hydroxylating the benzene ring with the direct use of the molecular oxygen by mono or di oxygeneses and so, facilitate the subsequent ring cleavage by other di oxygeneses. Oxygen is required as terminal electron acceptor during microbial respirations and also for insertion into aromatic cycles.

5. Oxygeneses

These are the key enzymes in aerobic degradation of aromatic compounds. They may be classified into two groups. Mono oxygeneses introduce one atom of oxygen or molecular oxygen into substrate, whereas dioxygeneses introduce two oxygen atoms into one molecule of substrate. Reaction catalyzed by oxygeneses can be reported by

5.1 Mono Oxygeneses

$$R - H + O_2 + NAD(P)H + H^+ \downarrow$$

$$R - OH + H_2O + NAD(P)^+$$

5.2 Di Oxygeneses

$$R + O_2 + NAD(P)H + H^+ \downarrow$$

$$R(OH)_2 + NAD(P)^+$$

Where, R and R – H are the substrate and NAD(P)H is an external co factor, source of electrons.

Catabolism of aromatic substances generally involves multicomponent iron containing oxygeneses. These enzymatic system ensure three main reactions

- The oxidation of NAD(P)H
- The transfer of electrons to molecular oxygen
- The terminal oxygenation of the substrate

Three different multicomponent oxygeneses are found in bacteria. Cytochrome P – 450 mono oxygeneses, methane oxygenases and related systems and multicomponent mono and di oxygeneses system, which contain non – iron sulphur cluster. These types of multicomponent oxygeneses differ mainly in the nature of iron containing group on the terminal oxygeneses component, which binds the molecular oxygen. It is either Fe in cytochrome P – 450 systems or a bi nuclear (Fe – O – Fe). Iron center in methane mono oxygenase or simply Fe^{2+} in oxygeneses containing iron sulfur (2Fe – 2S) cluster.

5.3 Formation of biofilm over inert materials

In search of a good packing material for immobilization, various materials have been tried out. These includes raschig – porcelain rings, nylon scrubber, glass beads, polyurethane foam etc. since immobilization requires an inert material along with a good area of contact, " polyurethane foam" is found to meet the requirements and hence taken up as packing material. Focus is mainly made on the design of a cost effective bio reactor. The required parameters have been met along with safety precautions and with high efficiency of the immobilized bed, the bio reactor was designed. The design was made keeping in mind the eco friendly disposal of textile dye effluents.

6. Conclusion

The decolorization of the textile dye effluents was made easy with the help of immobilized packed bed bioreactor (IPBB).

Though the traditional methods are available, biobleaching was selected for two major reasons:

1) Cost effective process

2) Eco friendly process

The control of pollutants was achieved in a great fashion through immobilization. The highlight of the immobilized bed is its reuse. It was stable towards reuse and can be used for both batch and semi batch process.

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Table 1. Mineral salt medium

Material	Composition
(NH4)2SO4	1 g/L
K2HPO4	2 g/L
KH2PO4	1 g/L
FeSO4.6H2O	0.001 g/L
MgCl2.7H2O	0.3 g/L

Table 2. Initial parameters of the effluent

Parameters	Values
Total Solids	9200 mg/L
Total Dissolved Solids	2800 mg/L
Total Suspended Solids	6200 mg/L
COD	3000 mg/L
BOD	2600 mg/L
pH	10.2
Color	Blue

Table 3. Final parameters of the effluent

Parameters	Values
Total Solids	5600 mg/L
Total Dissolved Solids	1200 mg/L
Total Suspended Solids	4400 mg/L
COD	700 mg/L
BOD	60 mg/L
pH	8.1
Color	Pale Yellow

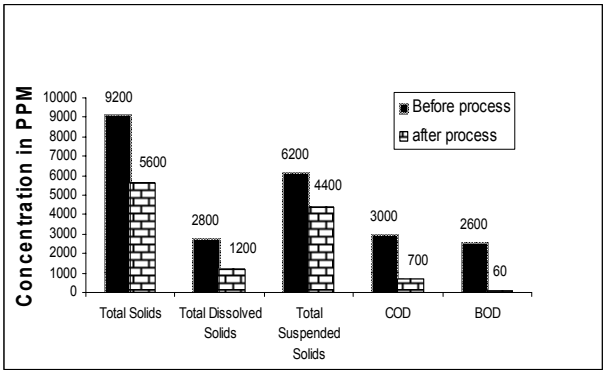

Figure 1. Bacterial Consortium effect of decolorization on Textile dye effluent