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Decolourization of Reactive Yellow by Using *Nocardiasps* in an Upflow Aerobic Submerged Fixed Bedbio-Film Reactor

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Abstract : In this communication, acommercial grade C.I. Reactive Yellow-138:1 dye in an aqueous solution was treated in an Aerobic Submerged Fixed Bed Bio-film reactor (ASFBBR)by continuous run. The Microorganisms used to treat this dye is dye degrading Marine Actinomycetes called *Nocardiasps*. Broken Granite Pieces (Gravel) are used as the support material for the growth of the microorganisms and the reactor was operatedat 24 h Hydraulic Retention Times (HRT). Present study revealed that maximum dye decolourizationwere observed at 24 h HRTare 96%, 74% and 53% efficiencies for dye concentrations50, 55 and 60 mg/Lrespectively.
Keywords:C.I.Reactive Yellow-138:1, Gravel, ASFBBR, HRT, Decolourization

Introduction

Color removal, in particular, has recently became of major scientific interest, as indicated by the multitude of related research reports. Ability of microorganisms to carry out dye decolourization has received much attention. Microbial decolourization and degradation of dyes is seen as a cost-effective method for removing these pollutants from the environment[1].

Actinomycetes strains have been reported with a capability to decolorize reactive dyes, including anthraquinone, phthalocyanine and azo, through adsorption of dyes to the cellular bio-masswithout any degradation[2].

Actinomycetes, particularly Streptomyces species, are known to produce extracellular peroxidases. These have been shown to catalyze hydroxylation, oxidation and dealkylation reactions against various xenobiotic compounds.

A variety of microorganisms used including bacteria such as Escherichia coli, Bacillus cereus, Sphaerotilusnatans, Bacillus coagulans, Bacillus subtilis and Pseudomonas pseudomallei are capable in decolorizing a wide range of dyes through aerobic, anaerobic and sequential anaerobic–aerobic treatment processes[3]. However, researchers are emerging to identify new bacteria that can be used as alternate to decolorize of dye from textile wastewater.

Aerobic Submerged Fixed Bed Bio-film reactor (ASFBBR) is a column filled with various types of solid media for the treatment of carbonaceous organic matter in the wastewater. The aerobic microorganisms

adhere to the media and are not sloughed of the reactor[4]. As such very long mean cell residence time can be achieved even at very short HRT, which is essential for an efficient treatment[5]. Applications ofASFBBR have shown that the process is capable of efficient treatment of many wastewaters at high organic and hydraulic loading rates[6]. The aim of the present study is to investigate the effect of dye concentration on the performance of ASFBBR using *Nocardiasps*, when used for treating textile dye wastewater using lab-scale.

Materials and Methods

Medium:

The microorganism used in this study was identified as *Nocardiasps*based on the bio-chemical properties and production of enzymes. The marine samples were collected and screened for dye degrading actinomycetes[7].

Supporting Media:

Fraction of aggregates, Gravelpassing through 25 mm and retained on 20 mm sieve size were used as supporting material for bio-film growth in ASFBBR. The gravel were soaked in 0.1N HCl for two days and again washed thoroughly with water before use.

Color Measurement:

The dye concentrations were measured with a Thermo UV/VIS spectrophotometer (Model: Evolution 201) at regular intervals during the decolourization process. The concentration of reactive dye was detected spectrophotometrically by reading the culture supernatant. The percent decolourization was determined at 405 nm by using formula,

$$D=\left[\frac{A_0 - A_1}{A_0}\right] X100$$

D = Decolourization
A_0 = Initial Absorption
A_1 = Final Absorption

Experimental Setup

A simple model of ASFBBR was installed in the laboratory. The influent tank connected to the bottom of the reactor. The ASFBBR model was made of a perplex glass tube with provisions of inlet and outlet arrangements. Entire length of the reactor was packed, with the exception of the bottom most part 5 cm and top 5 cm. The bottom space served as a distribution of dye wastewater and aeration and effluent collection chamber, while the top portion of the column providing free board.The wastewater was introduced at the bottom of the reactor and the outlet flow was collected at the top of the reactor. The ASFBBR was housed at a controlled room temperature. Table 1 shows salient features of packing material and dimensions of reactor and Figure 1 represent the experimental setup of Gravel media ASFBBR.

Table 1.Salient Features of the ASFBBR Model

S. No	Features	Values
1	Length of the reactor (cm)	60
2	Diameter of the reactor(cm)	9
3	Total reactor volume (lit)	3.42
4	Total effective volume(lit)	2.5
5	Submerged volume (lit)	2.606
6	Bed porosity (%)	0.515
8	Type of Media used	Gravel
7	Gravelin numbers (No.s)	239
9	Shape of media	Irregular
10	Size of media (mm)	20-25

Process Startup

The reactor was filled with media to required volumes. To startup the reactor, for 750 ml of textile dye solution (50 mg/L concentration), 250 mL of nutrient broth (Peptone- 5 gm/L, NaCl-5 gm/L, Beef Extract-10gm/L) along with *Nocardiasps* bacteria was inoculated to promote the formation of bio-mass. After 3days, nutrient was added to the reactor daily in a fed-batch mode process. This was continued till there was development of a good bio-film for period of further 7 days. This was essential for the effective start up of the system for aerobic bacteria to develop at a faster rate. The development of a thin bio-film layer was observed after 7 days of preparatory period. A clear slime adhesion was noticed on the surface of the media.

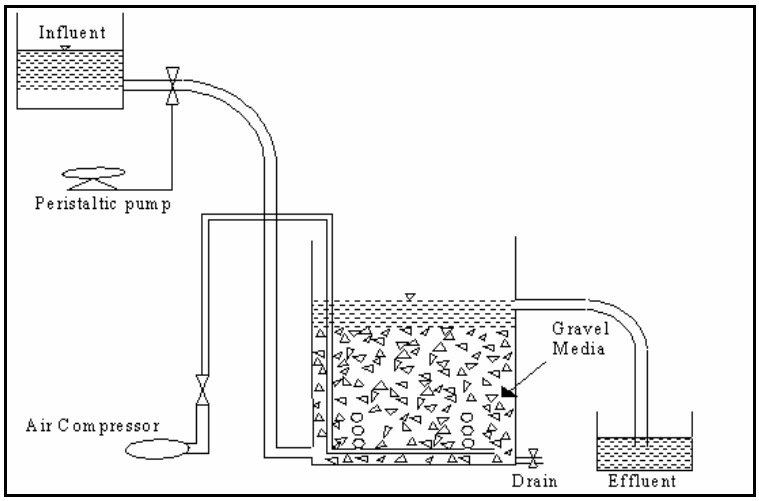

Figure 1: Experimental setup of ASFBBR

Reactor Operation

The reactor after preparatory period of 7 days, next 7 days textile dye wastewater at dye concentration 50mg/L was fed into the reactor for acclimatization through peristaltic pump to maintain continuous regime. Steady state was observed after 3 days of acclimatization period. For experimental work dye concentration was varied gradually from about 50-55 and 60 mg/L and is operated at 24 h HRT. Each step-up change is allowed after steady-state removal efficiency was achieved.

Process Monitoring

The experimental setup, Gravel media of ASFBBR model was monitored for a period of more than 30 days for evaluation of decolourization efficiency. The parameters of influent and effluent were analyzed daily. The steady- state conditions were maintained for a period to enable collection of data for performance evaluation.

Results and Discussions

The ASFBBR was operated in continuous regime throughout the study. The results, Variations in color removal efficiencies at varying dye concentration for 24 h HRT of this part of the study are presented in Figure 2.

In the present investigation, color removal for C.I.Reactive Yellow-138:1ranged from 96% to 53% at different dye concentration for 24 h HRT and is presented in Figure 2. The dye responded favorably with 96% removal at dye concentration of 50 mg/L; 74% removal at dye concentration of 55 mg/L; and moderate removal of 53% at dye concentration of 60 mg/L. The results showed that, the decolourization efficiency is more in the dye concentration 50 mg/L when compared to 55mg/L and 60 mg/L at 24 h HRT.

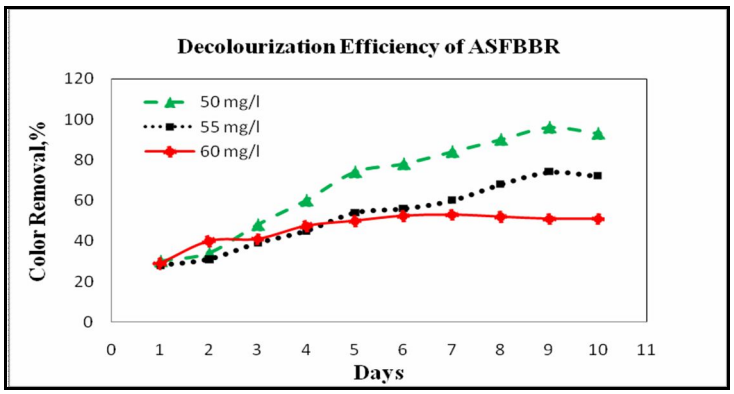

Figure 2.Variations in Color Removal at varying Dye Concentration for 24 h HRT

Removal Mechanisms

From the above discussion and observations, the mechanism of dye color removal by *Nocardiasps* were attributed due to the following reasons:

- Bio-sorption, sorption of textile dye color onto *Nocardiasps* biomass.
- Bio-association between the dye and specifically adapted bacterial cells and subsequent reduction/ decolourization.

Conclusions

1. It has been shown that Gravel media of ASFBBR operating high dye concentration wastewater can successfully treated.
2. The performance of ASFBBR at dye concentration 50 mg/L showed excellent color removal efficiency of 96% when compared with 55 mg/L and 60 mg/L. This proved that dyes with low concentrations were easily removed.
3. As the set up dye concentration were decreased, color got increased from 53-96% due to bio-sorption and bio-association mechanisms. Good results were obtained for dye concentration 50 mg/L for 24 h HRT.
4. Performance studies on laboratory scale ASFBBR using *Nocardiasps* for decolourization of textile dye effluents shown good results and hence reactive textile dye effluents could be successfully treated by ASFBBR using *Nocardiasps*.

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