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EVALUATION OF MEDIA PERFORMANCE IN DECOLOURIZATION OF REACTIVE YELLOW DYE USING *NOCARDIA SPS* IN AN UPFLOW AEROBIC SUBMERGED FIXED BED BIO-FILM REACTOR

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ABSTRACT

In this manuscript, a commercial grade C.I.ReactiveYellow-138:1 dye in an aqueous solution was treated and performances of media were studied in an Aerobic Submerged Fixed Bed Bio-film reactor (ASFBBR) by continuous run. The Biofilm used to treat this dye is dye-degrading Marine Actinomycetes called *Nocardia sps*. In this work, Broken Granite Pieces (Gravel) and HDPE Corrugated Pall Rings (P-Rings) are used as the support media for the growth of the microorganisms and the reactors were operated at 24 h Hydraulic Retention Time (HRT) along with different dye concentrations of 50, 55 and 60 mg/L. Present study revealed that maximum dye decolourization was observed for gravel media with dye concentrations of 50 mg/L at 24 h HRT. Therefore, this demonstrates local available Gravel media shows better performance in the treatment of decolourization as compared to commercial media P-Rings.

KEYWORDS: C.I. Reactive Yellow-138:1, Gravel, P-Rings, ASFBBR, Decolourization

INTRODUCTION

Color removal, in particular, has recently became of major scientific interest, as indicated by the multitude of related research reports [1]. 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 [2].

In recent years, a wide range of studies have raising a enormous attention on biological methods with some microorganisms such as fungi, bacteria and algae [3] are highly capable to biodegrade and biosorb dyes wastewater. The application of microorganisms for dye wastewater removal offer considerable advantages such as the process is relatively low cost, environmental friendly, produce less secondary sludge and the end products of complete mineralization are not toxic [4]. Numerous research works has been conducted and proven the potential of microorganisms such as Cunninghamella elegans [5], Aspergillus niger [6], Bacillus cereus [7], Chlorella sp. [8] and also Citrobacter sp. [9] on dye wastewater removal. The adaptability and the activity of each microorganism are the most significant factors that influence the effectiveness of microbial decolourization [10].

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 [11]. 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 [12]. As such very long mean cell residence time can be achieved even at very short HRT, which is essential for an efficient treatment [13]. Applications of ASFBBR have shown that the process is capable of efficient treatment of many wastewaters at high organic and hydraulic loading rates [14]. The aim of the present study is to investigate the effect of dye concentration and media performances in ASFBBRs using Nocardia sps, when used for treating textile dye wastewater using lab-scale.

MATERIALS AND METHODS

Synthetic Dye

A commercial grade C.I.ReactiveYellow-138:1 dye was brought from suppliers and used for this research work.

Bio-FilmMedia

The Bio-film media used in this study was identified as *Nocardia sps* based on the bio-chemical properties and production of enzymes. The marine samples were collected and screened for dye degrading actinomycetes [15].

Supporting Media

Angular shape Gravel passing through 25 mm and retained on 20 mm sieve size were used as supporting material for bio-film growth in the reactor. The gravel were soaked in 0.1N HCl for two days and again washed thoroughly with water before use[1] and installed in reactor these were installed in $ASFBBR_1$.

Commercial media P-Rings of size 1.5cm thick and 3.0cm dia having a shape of corrugated modular blocks were collected from suppliers and these were installed in $ASFBBR_2$.

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 in %

A_0 = Initial Absorption

A_1 = Final Absorption

EXPERIMENTAL SETUP

Two lab-scale reactors $ASFBBR_1$ & $ASFBBR_2$ were installed and packed with two different media of Gravel and

P-Rings respectively. The ASFBBR models were 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 ASFBBRs were housed at a controlled room temperature at 30^{o}C ±2. Salient features of the reactors were tabulated in Table 1 and Figure 1 indicates the flow diagram of experimental setup of ASFBBR.

PROCESS STARTUP

The reactors were filled with media to required volumes. To startup the reactors, 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 *Nocardia sps* 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[1]. A clear slime adhesion was noticed on the surface of the media.

Table 1: Salient Features of the Reactors $ASFBBR_1$ & $ASFBBR_2$

S. No	FEATURES	$ASFBBR_1$	$ASFBBR_2$
1	Media used	Gravel	P-Rings
2	Length of the Reactor, cm	61	61
3	Diameter of the reactor, cm	9	9
4	Total Reactor Volume, Lit	3.88	3.88
5	Media Submerged volume, lit	2.51	2.51
6	Total effective Volume, lit	2.50	2.10

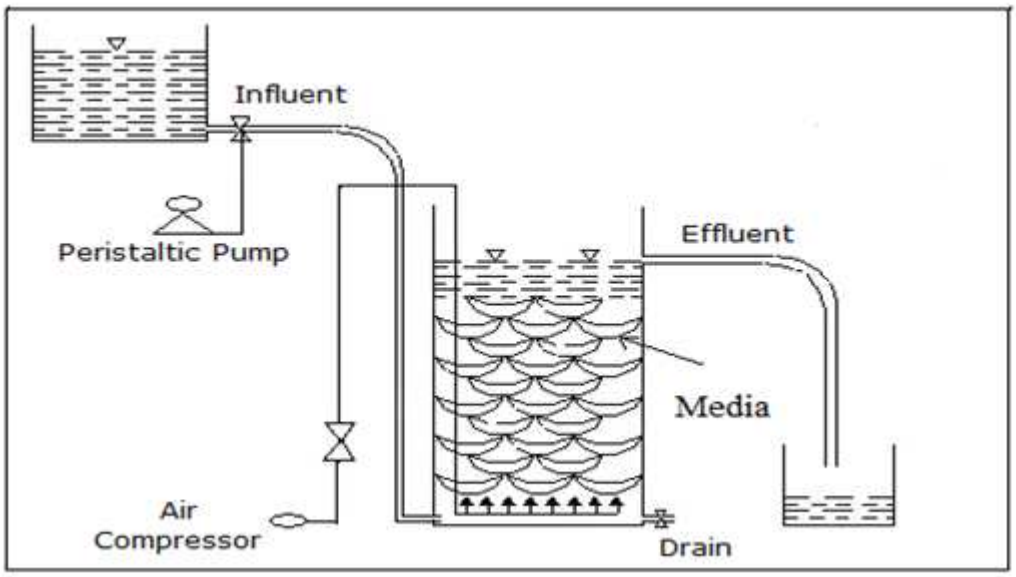

Figure 1: Experimental Setup of ASFBBR

REACTOR OPERATION

For both the reactors ($ASFBBR_1$ & $ASFBBR_2$) 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 and P-Rings 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 ASFBBRs were operated in continuous regime throughout the study. The results, Variations in color removal efficiencies at varying dye concentration for 24 h HRT were presented in Table 2.

In $ASFBBR_1$ at 24 h HRT, the C.I. Reactive Yellow-138:1 dye responded favorably with 96% removal at dye concentration of 50 mg/L (shown in Table 2 & Figure 2); 74% removal at dye concentration of 55 mg/L; and moderate removal of 54.6% 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.

In the other Reactor, $ASFBBR_2$ at 24 h HRT, the C.I. Reactive Yellow-138:1 dye responded favorably with 92% removal at dye concentration of 50 mg/L (shown in Table 2 & Figure 3); 71% removal at dye concentration of 55 mg/L; and moderate removal of 53% at dye concentration of 60 mg/L.

Table 2: Performances of Reactors at 24 h HRT for Varying Dye Concentrations

	Declourization at 24 h HRT, %					
	$ASFBBR_1$			$ASFBBR_2$		
	Dye Concentrations, mg/L			Dye Concentrations, mg/L		
Days	50	55	60	50	55	60
1	30.00	31.00	29.00	38.00	25.00	30.00
2	34.00	39.00	40.00	40.00	41.00	36.00
3	48.00	45.00	41.00	55.00	34.00	38.30
4	60.00	54.00	47.50	57.00	53.00	43.00
5	74.00	56.00	50.00	81.00	60.00	45.00
6	78.00	60.00	52.50	87.00	65.00	50.00
7	90.00	74.00	54.60	90.00	71.00	53.00
8	96.00	74.00	54.60	92.00	71.00	53.00
9	96.00	74.00	54.60	92.00	71.00	53.00

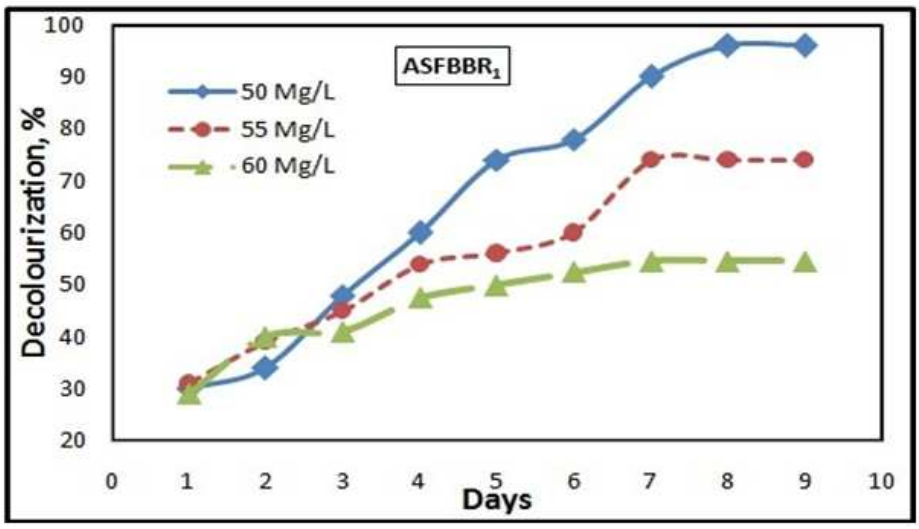

Figure 2: Performance of $ASFBBR_1$

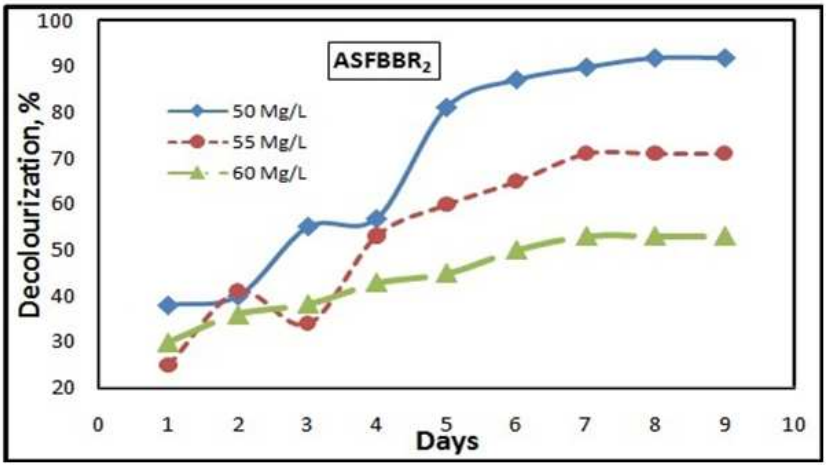

Figure 3: Performance of $ASFBBR_2$

The results showed that, the decolourization efficiency is more in the dye concentration 50 mg/L for both the rectors when compared to 55 mg/L and 60 mg/L at 24 h HRT and also this results revealed that the Gravel media shows better performance when compared to P-Rings in all the variations of dye concentrations. This may be attributed to sloughing biomass in case of $ASFBBR_2$ with P-Rings as media and more biomass cling onto rough surface of Gravel media rector $ASFBBR_1$. This demonstrates usefulness of locally available Gravel as a media for ASFBBRs for effective reactive dye color removal.

CONCLUSIONS

- Study demonstrated that ASFBBRs can be employed for successful decolourization of C.I. ReactiveYellow-138:1 dye using Nocardia sps.
- The performance of ASFBBRs at dye concentration 50 mg/L showed excellent colour removal efficiencies when compared to higher dye concentrations of 55 mg/L and 60 mg/L.
- Results obtained with Gavel as media performed better in decolourization than the P-Rings and hence low cost and locally available Gavel can be used for decolourization treatment.

- Performance studies on laboratory scale ASFBBRs using Nocardia sps for decolourization of textile dye effluents shown good results and hence reactive textile dye effluents could be successfully treated by ASFBBR using Nocardia sps.

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