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# Food Processing Industrial Effluent Treatment Using FBBR

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***Abstract: -*** The present study involves the removal of Biological Oxygen Demand (BOD) and Chemical Oxygen Demand (COD) from food processing industrial effluents with a laboratory scale model of Fluidized Bed Bioreactor (FBBR) using three different bed materials viz., MBBR Plastic media, Pumice stones and high density Foam material. The effluent from Ice making industry is taken as stock solution for conducting the study. The experiment is conducted for over 2 to 3 weeks at daily intervals, till the reactor gets stabilized and a maximum and uniform rate of percent removal of BOD and COD is obtained. The experimental data is analyzed and the results are presented in suitable formats. From the Bio-kinetic study involving reaction rate kinetics and microbial growth kinetics, it is observed that, the bio-kinetic reactions taking place in the reactor conform to First order rate of reactions and the Foam pieces proved to be a good alternative material when compared with that of the Commercially available MBBR plastic media and Pumice stones.

***Keywords: -*** *BOD, COD, FBBR, Growth Kinetics, Reaction kinetics*

## I. INTRODUCTION

The effluents from Food processing industry are highly variable in characteristics, depending on the specific types of food processing operations (e.g., fruit, vegetable, oils, dairy, meat, and fish etc.) showing varying levels of physiochemical parameters. In food processing industrial effluents, the COD and BOD values are often closely matched to each other due to easily biodegradable organic compounds of the effluent. Among the many wastewater treatment systems, Fluidized Bed Bioreactor (FBBR) is reported to outperform other reactor configuration such as the activated sludge system and packed bed bioreactors, where the wastewater flows upward through a bed at the sufficient velocity to fluidize the bioreactor [1].

The designs of biological wastewater treatment processes utilize a good number of empirical as well as rational parameters based on biological kinetic equations. Using these equations, the reactor volume, substrate utilization, biomass growth, and the effluent quality can be calculated [2]. Bio-kinetic coefficients used in the design of Bio-reactors include specific growth rate ($\mu$), maximum rate of substrate utilization per unit mass of microorganisms (k), half velocity constant ($K_s$), maximum cell yield (Y), and endogenous decay coefficient ($k_d$) [3-9].

## II. EXPERIMENTAL SETUP

An experimental setup with three Acrylic glass columns of 120 cm length and 6.9 cm dia. each arranged parallel to each other, with valves at top and bottom of the columns to regulate the flow through them, is fabricated as shown in Fig.1. The columns at the ends are provided with wire meshes between the flanges so as to prevent the loss of bed material into the pipe. A flow meter is arranged on inlet pipe to measure rate of flow. Compressed air is supplied to the fluidizing columns so as to make sure that the bed gets fluidized. About 15 liters of sample from a local food processing industry (Ice cream making industry from Gajuwaka, Visakhapatnam) is collected every day and diluted to 1:5 concentrations and is used as stock solution for experimentation. A concentrated solution of biomass is prepared with crushed tomatoes mixed with small amount of the wet sludge collected from domestic sewage plant. The ingredients are mixed thoroughly everyday for aerobic growth of microorganisms. The process is continued for a week and the slurry obtained is introduced in to the reactor which is to act as seed for biomass acclimatization on bed particles.

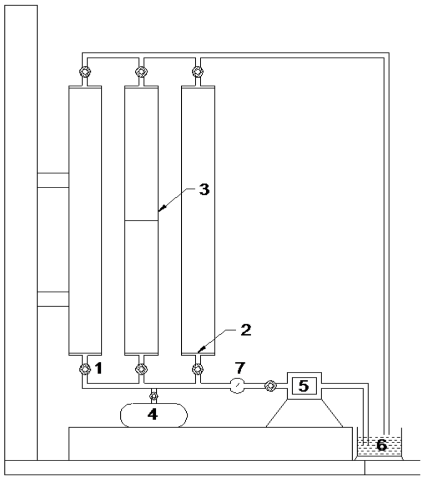


**Fig.1 Experimental Setup of Fluidized Bed Bioreactor**
**1. Valves 2. Stainless Steel Mesh**
**3. Acrylic glass columns of length 120 Cm**
**4. Air compressor 5. 0.5 HP Motor**
**6. stock solution 7. Flow meter**

## III. METHOOLOGY

The acclimatized biomass is transferred to the reactor columns and the columns are filled with water for three days before the start of experiment, and then the experiment is started by pumping the effluent taken from the food processing industry (Ice cream making industry). The initial concentrations of BOD and COD values of the effluent before pumping are determined. The samples from outlet of the experimental columns are collected at intervals of 30min, 60min, 90 min and the respective BOD & COD values are determined. Simultaneously, the rate of flow is measured. The same experiment is carried out with different bed materials. The process is continued till the constant percentage removals of BOD and COD are obtained. The influent and effluent samples are analyzed for BOD & COD values using standard methods. i.e., by D.O. test and standard reflux method respectively.

## IV. RESULTS AND DISCUSSIONS

The maximum percentage removals of BOD and COD from the effluent samples at different operation times using different bed materials are shown in the Table.1 and the percentage removals using Foam pieces as bed material are shown in Fig 2 & 3.

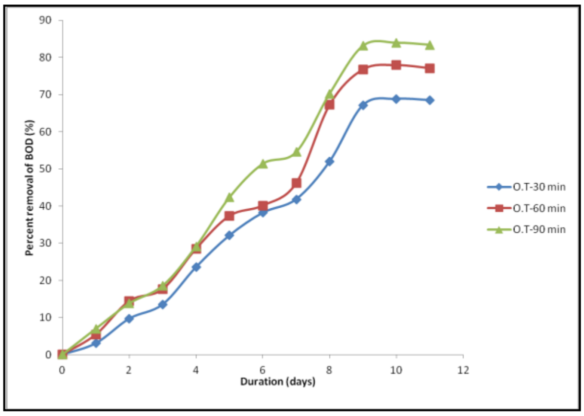


Fig:2 Percentage removal of BOD using Foam pieces

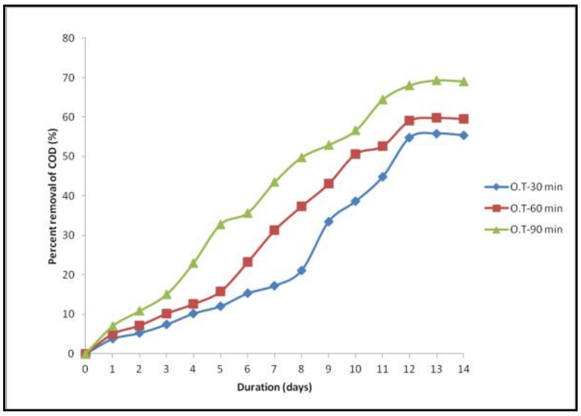


Fig:3 Percentage removal of COD using Foam pieces

Table. 1 The maximum percentage removals of BOD and COD

| S.No | Bed material | Acclimatization/ Experimental duration (days) | Operation time (minutes) | Maximum percentage removal | |
|---|---|---|---|---|---|
| | | | | BOD | COD |
| 1 | MBBR media (Plastic) | 14 | 30 | 57.96 | 55.43 |
| | | 14 | 60 | 64.00 | 59.59 |
| | | 14 | 90 | 73.32 | 69.07 |
| 2 | Pumice stones | 13 | 30 | 63.34 | 61.43 |
| | | 13 | 60 | 73.27 | 69.90 |
| | | 13 | 90 | 78.07 | 75.24 |
| 3 | Foam pieces | 11 | 30 | 68.50 | 65.99 |
| | | 11 | 60 | 77.10 | 72.72 |
| | | 11 | 90 | 83.36 | 79.77 |

Maximum percentage removals are obtained when Foam pieces are used as bed material. Also, the experimental duration/acclimatization period of the reactor is found to be less, with Foam pieces as bed material. It is observed that the maximum percentage removal of BOD is found to be 73.32%, 78.07%, 83.36% for the bed materials Commercially available MBBR media (Plastic), Pumice stones and Foam pieces respectively, at an operation time of 90 minutes. Similarly the maximum percentage removals of COD are found to be 69.07%, 75.24%, 79.77% respectively, for the bed materials in the same order respectively. The acclimatization period is found to be 11, 13, and 14 days against the bed materials Foam pieces, Pumice stones, and Commercially available MBBR media (plastic) respectively. From these results it is observed that, Foam pieces are found to be a good alternative for the Commercially available MBBR media made up of plastic .

For the study on Reaction Rate Coefficients three different reaction rate models are taken into consideration viz., Zero order, First order and Second order reaction. Plots of the integrated forms of the reaction rate expressions are used to determine the reaction rate coefficients 'k'. The reaction rate kinetics of the experimental programme conform to first order reaction rate kinetics. The reaction rate coefficients (k) obtained for the first order kinetics of the experimental programme varied from 0.0515 day$^{-1}$ to 0.1554 day$^{-1}$ as shown in Table.2. These are in agreement with the earlier experimental works [4, 6, 7] and at the same time coefficients are found to be more for the experiment with Foam pieces as bed material.

Table 2 The First Order Reaction Rate Coefficients

| Parameter | Operation time (min) | Reaction Rate coefficients (k), day$^{-1}$ | | |
|---|---|---|---|---|
| | | Bio carriers (MBBR) | Pumice stones | Foam pieces |
| BOD | 30 | 0.066 | 0.077 | 0.1002 |
| | 60 | 0.0786 | 0.0981 | 0.1293 |
| | 90 | 0.0917 | 0.1136 | 0.1554 |
| COD | 30 | 0.0515 | 0.0672 | 0.0943 |
| | 60 | 0.0646 | 0.0845 | 0.1164 |
| | 90 | 0.0867 | 0.1083 | 0.1328 |

For the study on Microbial growth kinetics, the microbial decay coefficients ($k_d$) are obtained from graphs using the specific growth rates (µ) and specific substrate utilization rates (U). It is observed that, the microbial decay coefficient ($k_d$) are found to be increasing for the following order of bed materials. i.e., Pumice stones, MBBR media (plastic), and Foam pieces for different operation times. Maximum microbial decay coefficient '$k_d$' values are obtained when Foam pieces are used as bed material when compared to Pumice stones and MBBR media (plastic). The microbial decay coefficient ($k_d$) values ranged from 0.0012 day$^{-1}$to 0.0062 day$^{-1}$ and are agreement with the earlier experimental works [8].The determination of Microbial decay coefficient '$k_d$' values For the experiment with Foam pieces as bed material and at operation time of 90 min is presented in Table.3.

Table.3 Values of microbial decay coefficients

| S.No. | Bed material | Operation time (minutes) | Microbial Decay Coefficient ($k_d$), $day^{-1}$ |
|---|---|---|---|
| 1 | Bio carriers | 30 | 0.0012 |
| | | 60 | 0.0035 |
| | | 90 | 0.0047 |
| 2 | Pumice stones | 30 | 0.0026 |
| | | 60 | 0.0040 |
| | | 90 | 0.0051 |
| 3 | Foam pieces | 30 | 0.0030 |
| | | 60 | 0.0041 |
| | | 90 | 0.0062 |

## V. CONCLUSIONS

1) The maximum percent removal of BOD and COD are found to be more when Foam pieces are used as bed material.
2) The reaction rate kinetics of the experimental programme conform to first order reaction and the reaction rate coefficients (k) obtained are in agreement with the earlier experimental works.
3) The microbial decay coefficient ($k_d$) are found to be increasing against the following order of bed materials. i.e., MBBR media (plastic), Pumice stones and Foam pieces for different operation times
4) Therefore, Foam pieces can be used as a better alternative against the Commercially available MBBR media (plastic) and Pumice stones for the removal of both BOD and COD in Fluidized bed bio-reactors.
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Note: Author [2] claims the above work as original work and is a part of his doctoral programme.