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Biokinetic Study of Fish Processing Industrial Effluent Treatment in FBBR

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ABSTRACT: *The present study focuses on the removal of Biological Oxygen Demand (BOD) and Chemical Oxygen Demand (COD) from the effluents of Fish processing industry using a laboratory scale model of Fluidized Bed Bioreactor(FBBR) using MBBR media (plastic), Pumice stones and Foam Pieces of uniform shape and size chosen as three different bed materials. An arrangement for sending compressed air is provided at the bottom of the columns. The effluent from Fish processing unit is taken as stock solution for conducting the study. The experiment is conducted over a period of 3 weeks, till the reactor gets stabilized and a maximum rate of percent removal of BOD and COD are obtained. The experimental data is analyzed and the results are presented in suitable formats. From the 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 better for the removal of BOD and COD, out of the three bed materials chosen for the study.*
Keywords: *Biological Oxygen Demand (BOD), Chemical Oxygen Demand (COD), Fluidized Bed Bio Reactors (FBBR), Microbial Growth Kinetics, Reaction rate kinetics.*

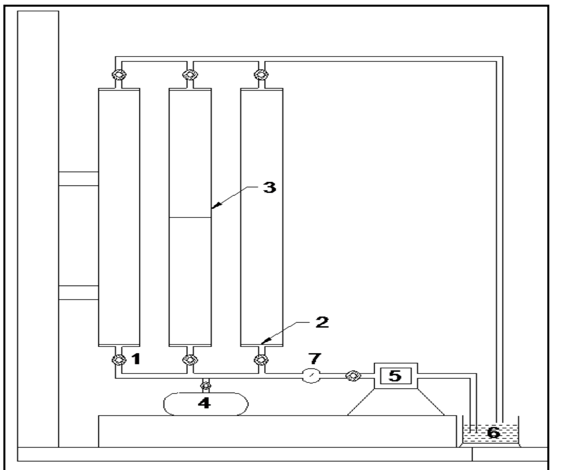
I. INTRODUCTION

Out of many sources contributing wastes, food processing industries play a major role polluting the natural waters. Wastewater treatment involving physical, chemical and biological unit processes is carried out in vessels or tanks commonly known as reactors. Reactors that work by growing cells are known as Bio-Reactors. Fluidized Bed Bio Reactors (FBBR) are relatively advantageous over the other types of wastewater treatment processes and can be effectively used in the treatment of food processing wastes [1]. The present work is focused on the removal of BOD and COD from the effluents generated in the Fish processing industry. Many works on FBBR have reported good removal of organic wastes [2, 3] and many empirical as well as rational parameters based on biological kinetic equations can be used in the design of biological wastewater treatment processes [4]. The Bio-kinetic coefficients that are used in the design of bio-reactors make use of the parameters like specific growth rate (μ), 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) etc., [5]

II. EXPERIMENTAL SETUP

The experimental setup consists of three Acrylic glass columns of 120 cm length and 6.9 cm dia. with valves at top and bottom of the columns to regulate the flow through them as shown in Fig.1. A mesh is provided between the flanges so as to prevent the loss of bed material into the pipe. A flow meter is arranged on the inlet pipe to measure rate of flow. Compressed air is supplied to the fluidizing column so as to make sure that the bed gets fluidized.

About 15 liters of sample from the local fisheries (Visakhapatnam) is collected each day and diluted to 1:5 concentrations and is used as stock solution for experimentation. A concentrated solution of Bio-mass is prepared by using crushed tomatoes mixed with the wet sludge collected from domestic sewage plant, under aerobic conditions. The process is continued for a week and the slurry obtained at the end is introduced into the experimental columns which acted as seed for biomass acclimatization on bed particles in the columns.



1. Vlave 2.Stainless Steel Mesh
3. Acrylic Glass Columns 120 cm long
4.Air Compressor 5. 0.5 HP Motor
6. Stock Solution 7.Flow meter

Fig.1 Experimental Setup

III. METHODOLOGY

The experimental columns are filled with the acclimatized biomass and water for three days, and then the experiment is started by pumping the effluent taken from the fish processing industry. The BOD and COD values of the effluent prior to pumping are determined in standard methods. 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. Reaction rate coefficients are determined using the experimental results, in the method of integration. The method of integration involves the substitution of the measured data of the amount of reactant remaining at various times into the integrated form of the rate expression. The expressions used to determine the reaction rate coefficients are as follows.

Zero Order Reaction:

$r_c = dc/dt = k$

Integrated form is

$C_{eff} = C_i-(k*t)$ --------- (Eq.1)

First Order Reaction:

$r_c = dc/dt = k_c$

Integrated form is

$C_{eff} = C_i*e^{(-k*t)}$ --------- (Eq.2)

Second Order Reaction:

$r_c = dc/dt = k_c^2$

Integrated form is

$C_{eff}=(C_i/(1-k*Ci*t))$ --------- (Eq.3)

where

C_i = influent concentration (mg/L)

C_{eff} = effluent concentration (mg/L)

t = Duration (days)

The other expressions used in the present study are as follows

$U =(\Delta F/\Delta t)/X_m$ --------- (Eq.4)

$1/ \theta c = Y.U - k_d$ --------- (Eq.5)

$\mu = (\Delta X/\Delta t)/X_m$ --------- (Eq.6)

$C_{eff} = C_i - X (1+k_d \theta_c) /Y$ --------- (Eq.7)

Where

C_{eff} = concentration of the effluent, mg/l

C_i = concentration of the influent, mg/l

X = microbial mass concentration

k_d = micro organism decay coefficient

θ_c = mean cell residence time

$\Delta F/\Delta t$ = amount of food utilized per unit time

µ = specific growth rate
X_m = mass of the active micro-organisms in the reactor
Y = Maximum cell yield
U = substrate utilization rate

IV. RESULTS AND DISCUSSIONS

The percentage removals of BOD and COD using different bed material viz. commercially available MBBR (plastic) media, Pumice stones and Foam Pieces are shown in the following figures 2 to 7 w.r.t. Different operational time periods.

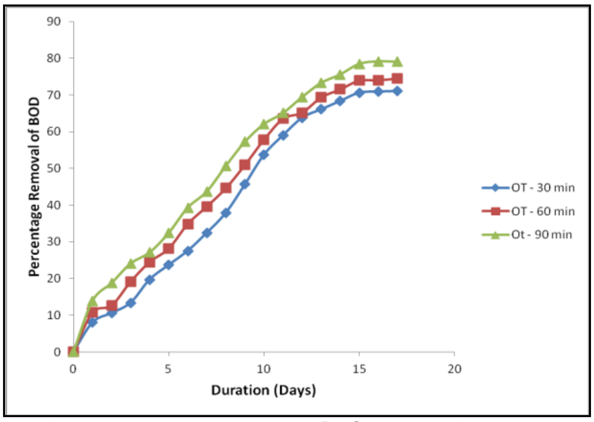


Fig:2 Percentage removal of BOD using MBBR Media(Plastic)

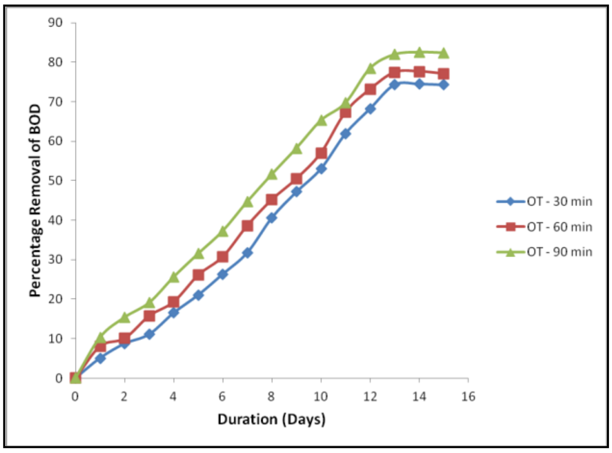


Fig:3 Percentage removal of BOD using Pumice Stones

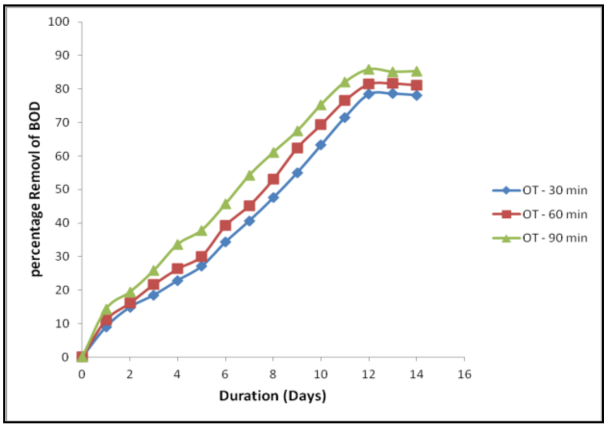


Fig:4 Percentage removal of BOD using Foam Pieces

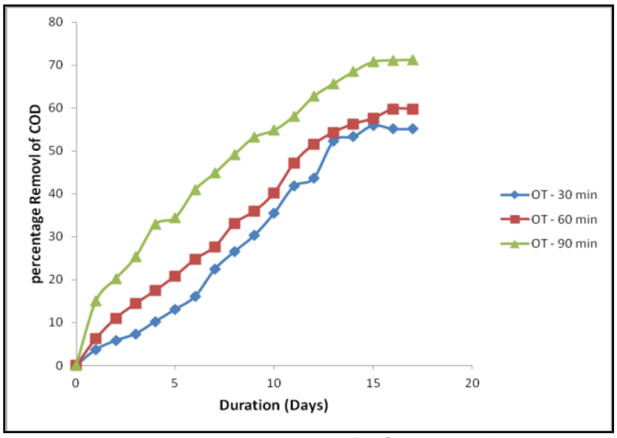


Fig:5 Percentage removal of COD using MBBR Media(Plastic)

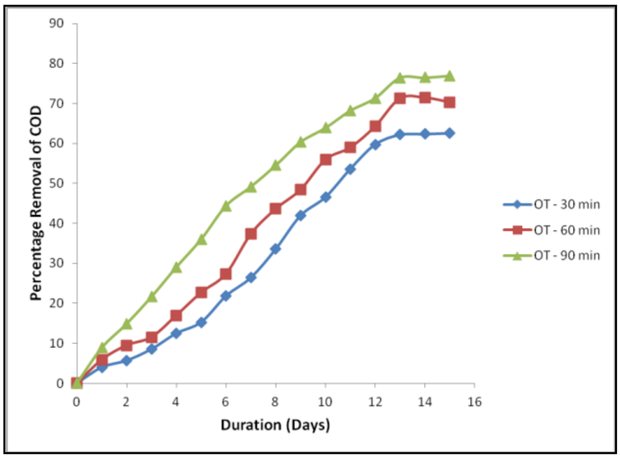


Fig:6 Percentage removal of COD using Pumice stones

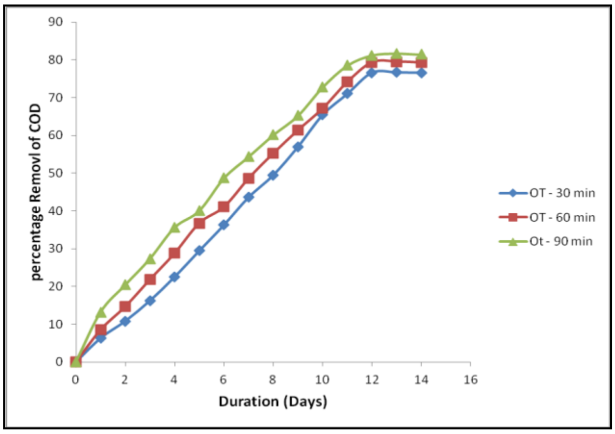


Fig:7 Percentage removal of COD using Foam Pieces

From the results of the study it is observed that, maximum percentage removals are obtained in the experiments in which Foam Pieces are used as bed material. The maximum percentage removal of BOD are found to be 85.25%, 82.38%, 79.06% against the bed materials Foam, Pumice stones and Commercially available MBBR media respectively, at an operation time of 90 minutes. Similarly, the maximum percentage removals of COD are found to be 81.42%, 77.98%, 71.25% respectively, against the bed materials in the same order. The experimental duration/the acclimatization period is found to be 14, 15, and 17 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.

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 reaction rate of the experimental programme conducted with three different bed materials ranged from 0.085 day^{-1} to 0.138 day^{-1} and are in agreement with the earlier experimental works [1,6]. At the same time, coefficients are found to be more for the experiment with Foam Pieces as bed material.

From the study of Microbial growth kinetics it is observed that, the microbial decay coefficients (k_d) are found to be increasing in the experiments using the following order of bed materials. i.e., Pumice stones, MBBR media (plastic), and Foam Pieces. Maximum microbial decay coefficient 'k_d' values are obtained when Foam Pieces are used as bed material when compared to Pumice stones and MBBR (plastic) media. The Microbial decay coefficients obtained for the study are well in agreement with earlier works [7].

V. CONCLUSIONS

1) The acclimatization periods of the experimentation with Foam Pieces as bed material is less compared with other bed materials used viz., Commercially available MBBR (plastic) media and pumice stones.
2) The maximum percent removal of BOD and COD are found to be more using Foam Pieces as bed material.
3) The reaction rate kinetics of the experimental programme conform to first order reaction rate kinetics.
4) The microbial decay coefficient (k_d) are found to be decreasing against the following order of usage of bed materials. i.e., Foam Pieces, MBBR (plastic) media, Pumice stones, , and for different operation times and at the end of the acclimatization period.
5) Therefore, it is concluded that, Foam Pieces can be used as a better alternative against the commercially available MBBR media (plastic) for the removal of both BOD and COD in FBBR for treating fish processing industrial effluent.

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