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Table of Contents

Volume 2, Issue 4, August 2008.

Pages

Experimental Scrutinization on Treatment of Industrial Effluents and Models Representing the Kinetics for Aerobic Digestion

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Abstract

An experimental study is undertaken for the treatment of distillery effluent using aerobic reactor. Sewage sludge was used as a seed culture to treat this effluent and the system was operated with different initial concentrations. The microorganisms present in sewage sludge were isolated by agar – plate method and their populations were reported. The reactor performance characteristics i.e., Chemical Oxygen Demand (COD), Total Suspended Solids (TSS) and Total Dissolved Solids (TDS), pH were analyzed for different concentrations of influent. The effects of initial substrate concentration on various characteristics with respect to time were reported. The performance of the three models namely, the First Order, Diffusional and Singh models in representing the kinetic data of the present work were analyzed. The results indicate that the First Order and Diffusional models are best suited for an aerobic digestion.

Keywords: Aerobic Reactor, Agar-plate method, Seed culture, Singh and Diffusional model and TSS.

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1. INTRODUCTION

Distillery industries are the agro-based industries with high organic and inorganic contents which are high strength wastes and difficult to dispose. Due to the recent advancements in biotechnology, aerobic reactor is widely used as a tertiary treatment for the treatment of high strength distillery effluent. Preliminary studies have been carried out on the treatment of distillery effluents using a laboratory scale Aerobic Reactor.

Aerobic processes are biological treatment processes that occur in the presence of oxygen. The aerobic environment in the reactor is achieved by the use of diffused or mechanical aeration, which maintain the mixed liquor in a completely mixed regime. Aerobic digestion is an alternative method of treating the organic sludge's produced from various treatment operations. According to Metcalf and Eddy [1], there are two variations in the aerobic digestion process namely conventional and pure oxygen[2]. In the conventional aerobic digestion[3], the wastewater is aerated for an extended period of time in an open, unheated tank using conventional air diffusers or surface aeration equipment.[4]

With these in the background, the objectives of the study are

i) Isolation of microorganism present in the sewage sludge, which is used as a seed culture in the Aerobic Reactor.
ii) Experimentation in the continuous degradation of distillery effluent, using an Aerobic Reactor under different conditions.
iii) Kinetic modelling for continuous degradation.

2. MATERIALS AND METHOODS

In the Aerobic Reactor air was passed from the bottom by using an air diffuser of approximately 2.0 to 2.5 mm in diameter. The Aerobic reactor was used for the treatment of distillery effluent in an effectively, by using the sewage sludge as an aerobic seed culture.

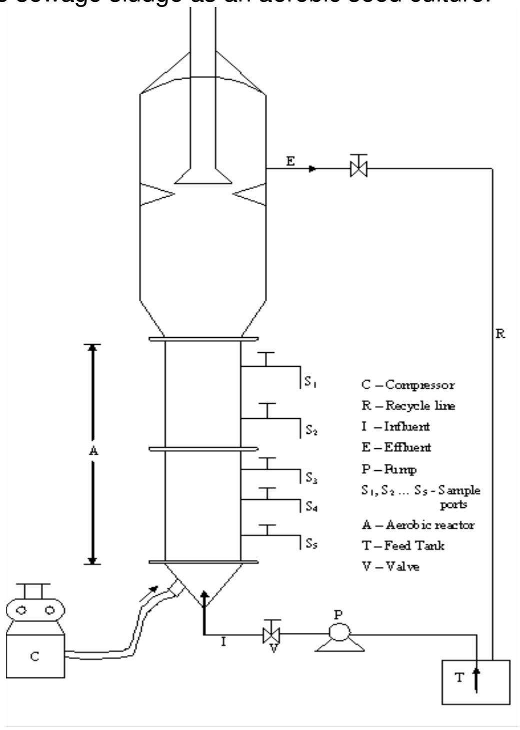

FIGURE 1 Schematic diagram of aerobic reactor

Fig. 1 shows the schematic representation of aerobic reactor. The aerobic reactor was constructed with acrylic pipe, with a height of 1.2 m, 0.1 m in diameter and a working volume of 10.02 litres. Above the reactor zone, an accessory decanting unit was installed with an inner diameter of 0.16 m and 0.6 m height. Five sample ports were located along the height of the reactor. A closed tank was used to pump the feed into the column. The outlet was provided at a height of 1.74 m from the bottom of the column. A provision was made to return the effluent from the column to the feed tank through a recycle line.

The micro-organisms present in the sewage sludge were isolated by Agar plate method. The distillery effluent of different concentrations was fed to the aerobic reactor at the rate of 2.57 x 10^{-4} m^3/s. The sewage sludge of 10 gm/l of sample was added to the effluent and mixed well.The compressed air was passed to the reactor in the bottom portion using an air diffuser of approximately 2 to 2.5 mm in diameter. The velocity of the air was maintained at 2.3 m/s. The initial value of COD, TSS, TDS, and pH of the samples were noted in table 1. The reactor was put into continuous operation for 24 hours. The experimental parameters determined namely COD, TSS, TDS, and pH were estimated in accordance with the standard methods of American Public Health Association(APHA) [5].

3. RESULTS AND DISCUSSION

3.1 Isolation of Microorganism present in the sewage water

The micro-organism present in the sewage sludge was isolated by Agar – plate method. It shows the presence of bacteria, fungi and actinomycetes of 12.5 x 10^7, 30.6 x 10^4 and 1.3 x 10^3 colonies / ml respectively. The comparison of various organisms reveals that the counts of Bacteria are more.

3.2 Effect of Initial substrate concentration on experimental parameters

The results show that the substrate concentration decreases continuously with time and reaches a final value when degradation stopped. The plot between COD, TSS, TDS, pH and time of operation are shown in Fig. 2-5 at different influent concentrations.

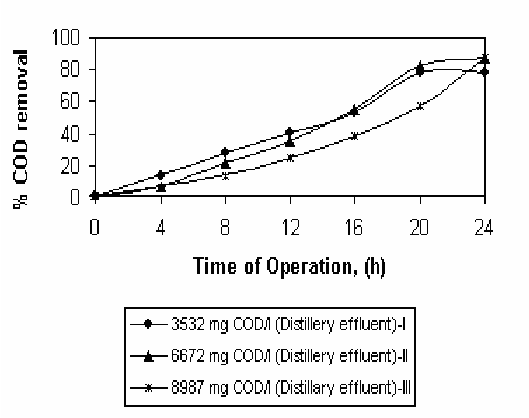

FIGURE 2 Effect of initial substrate concentration on % COD removal

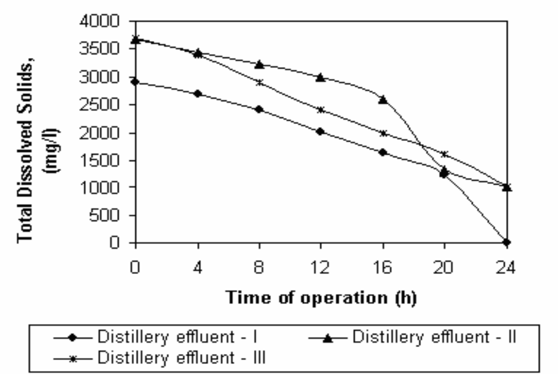

FIGURE 3 Total Dissolved Solids Vs Time of Operation

TABLE 1 Initial substrate concentration and % removal of COD, TSS and TDS

Effluent	Initial concentration of COD	% COD removal	Initial concentration of TSS	% TSS removal	Initial concentration of TDS	% TDS removal
Distillery effluent - I	3532 mgCOD /ml	78%	2900 mg/ml	72.6%	1597 mg/ml	56.2%
Distillery effluent – I	6672 mgCOD /ml	87.6%	3670 Mg /ml	65.8%	2080 mg /ml	48.9%
Distillery effluent - I	8987 mgCOD /ml	87.7%	3700 mg /ml	72.9%	2800 mg /ml	67.2%

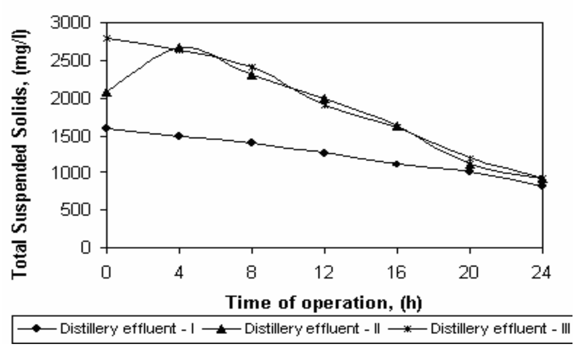

FIGURE 4 Total Suspended Solids Vs Time of Operation

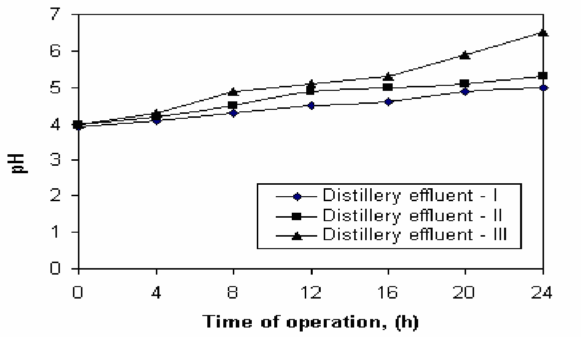

FIGURE 5 pH Vs Time of Operation

The percentage removal of COD, TSS and TDS are given in Table 1. It is observed from the figure that the % COD removal has increased with the time of operation, for all initial concentrations and was varying from 13 to 87%, 30 to 88% and 35 to 94% for distillery effluent. Since the major part of the removal is observed to occur during the 8 hours of operation for the runs 1 and 2, the monitoring of parameters was carried out for closer operational times from the third run onwards. The monitoring was carried out after every 4 hours of operation. Hsu *et al.* [6] and Charles et.al, [7] reported that the effluent concentrations were found to decrease with increase in time of operation during the start-up of the reactor.

3.3 Continuous Degradation kinetics

The kinetics of aerobic digestion, based on the experimental data, three models namely, the first order, diffusional and Singh models were chosen.

3.3.1 The First Order Model

The first order model is

$$-dc_s/ dt = K_f C_S \qquad (1)$$

On integration between known limits, gives

$$\ln C_S/C_{S0} = -K_f\ t \qquad (2)$$

C_{so} = initial substrate concentration, mg COD
t = fermentation time, h, K_f = first order rate constant, h^{-1}

The experimental data in represented in Fig. 6-8 and the first order rate constant, K_f was calculated from the slope of the straight line by the least square (LSQ) fit. The detailed results including the determination coefficient (R^2) are presented in Fig. 6-8. As the initial concentration of substrate increases, the rate constant K_f decreases and this can be described to a growing importance of the recalcitrant fraction in reducing the diffusivity of the biodegradable substance. This is in confirmation with the results of Converti et al., [3]. The satisfactory values of R^2 compliment the ability of the first order model in describing the kinetics of the present work. The determination coefficient (R^2) is defined as the ratio of explained variance to the total variance.

$$R^2 = [\ \sum (X_i - \bar{X})\ (Yi - \bar{Y})^2 / n\sigma_X\sigma_Y]^2$$

Where, X is the mean of x; σ_x is the Standard Deviation (SD) of x
Y is the mean of y and σ_y is the SD of y

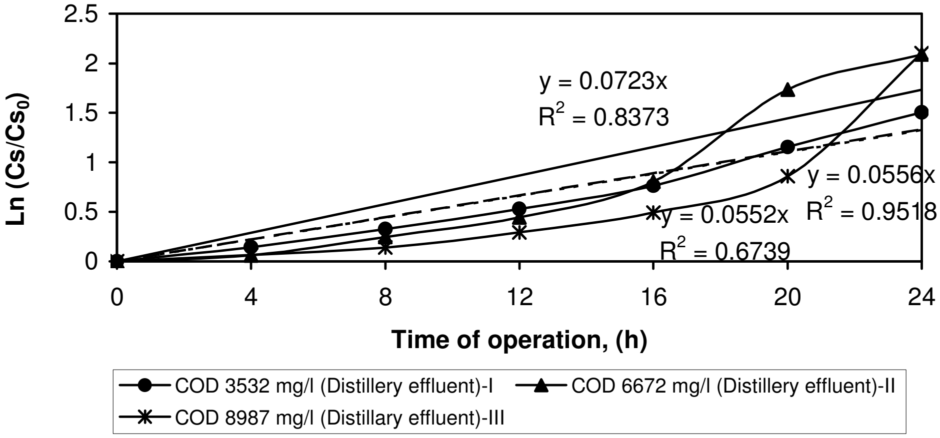

FIGURE 6 First order model in continuous degradation kinetics

3.3.2 The Diffusional Model

The diffusional model is

$$-\ dC_s/ dt = K_d\ (C_s)^{0.5} \qquad (3)$$

When integrated between the known limits, yields

$$(C_s - C_{so})^{0.5} = -\ K_d^{\ t/2} \qquad (4)$$

From the experimental data, the diffusional model rate constant K_d was determined through the LSQ fitting. The diffusional model seems to provide a satisfactory description of the process. The diffusive phenomenon describes its consistent with the actual situation for the process under consideration. Satisfactory fit of the experimental data results as demonstrated by the higher R^2 values as shown in Fig.7.

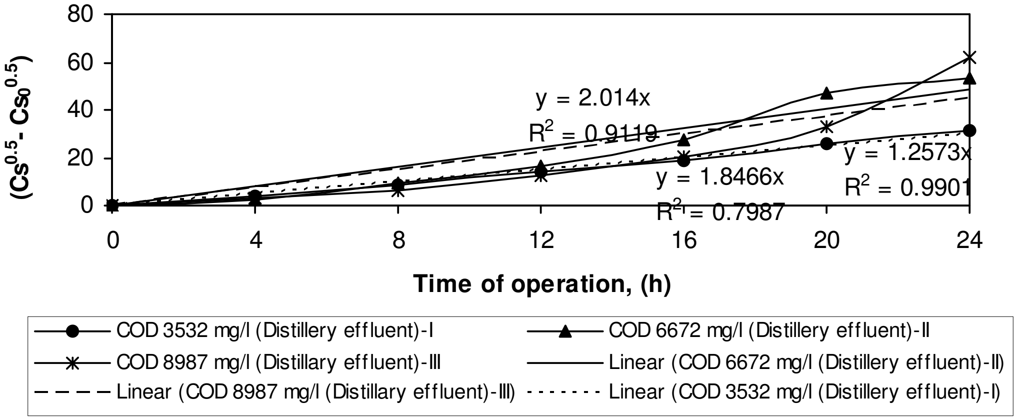

FIGURE 7 Diffusional model in continuous degradation kinetics

3.3.3 The Singh Model

The Singh model is

$$- dCs/dt = K_S C_S/(1+t) \qquad (5)$$

On integration between proper limits, the Singh model is

$$\ln C_S/C_{SO} = - K_S \ln(1+t) \qquad (6)$$

Where K_s is the rate constant of the Singh model and C_s, C_{so} & t have the usual meaning. The integrated form of the Singh model is presented in Fig. 8. The values of K_s and R^2 are given in Fig. 6-8. Though the kinetic constant K_s decreases with increasing initial substrate Concentration, unsatisfactory values of R^2 raises doubts on the ability of the Singh Model.

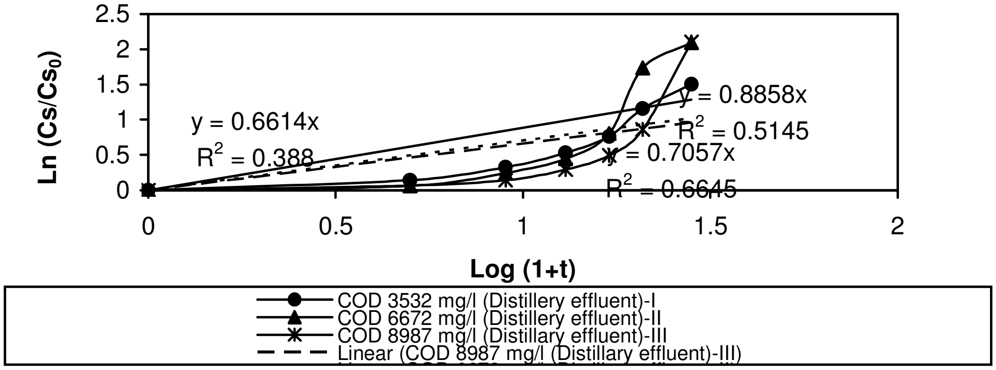

FIGURE 8 Singh model in Continuous degradation kinetics

CONCLUSION and FUTURE WORK

The effects of initial substrate concentration on % COD removal were investigated in an Aerobic Reactor. The results indicate that as time increases, the % COD removal increases. For the first time, sewage sludge was used as a seed culture to treat relatively small concentrations of influent concentration. The maximum COD removal was found to be 78%, 87.76% and 87.77% at a concentration of 3532, 6672 and 8987 mg COD/l of distillery effluent respectively. The percentage COD removal has increased with time of operation for all initial concentration.

The capability of the three models namely, the first order, diffusional and Singh model, representing the continuous kinetic data of the present work were reported. The results indicate that the first order and diffusional models are best suited to describe the aerobic digestion of the distillery wastewater, while Singh model is inadequate. The results of the isolation of organisms present in the sewage sludge were found to be 12.5 x 10^7, 30.6 x 10^4, and 11.3 x 10^3 colonies / ml of Bacteria, Fungi and Actinomycetes, respectively.

REFERENCES

1. American Public Health Association, *“Standard Methods for the Estimation of Water and Wastewater”*, 18th Edition (Edited By Greenberg A.E., Connors J.J. and Jenkins D.), Washington D.C,1992.

2. Charles Nara and Stringer, P.R, “*Pure Oxygen Technologies in Waste Water and Environment Control”*, 174-178, 1993.

3. Coverti, A., Borghi, D.M. And Ferraido, G, “*Influence Of Organic Loading Rate On The Anaerobic Treatment Of High Strength Semi Synthetic Waste Water In A Biological Fluidized Bed*” Chem. Engg.J.52:21-28, 1993.

4. Hsu.Y. and Shich.W.K, “*Start Up Of Anaerobic Fluidized Neutral with Acetic Acid as the Substrate Biotechnology*”, Bioengineering. 41:347-353,1993

5.Leslie Grady, C.P., & Henry C. Limmarcel Dekker, “*Biological wastewater Treatment Theory & Applications”*, Inc. Newyork & Basel, PP.690-691,1980.

6. Metcalf and Eddy, Inc. “*Wastewater Engineering Treatment, Disposal, and Use*”
Third Edition, McGraw Hill, New York,1995.

7. Parlostathis.S.G and Giraldo. E., “*Kinetics of Anaerobic Treatment”* Water Science and Technology, 24.No.8, 35-59, 1991.

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