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MUNICIPAL WASTEWATER TREATMENT AND KINETIC STUDIES USING IMMOBILIZED FIXED BED ANAEROBIC DIGESTER

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ABSTRACT: This study was designed to evaluate the performance of a cylindrical immobilized fixed Bed. Anaerobic digester in treating diluted municipal waste water. A series of three independent batch experiments was performed for a total operation time of 28 days. The system of anaerobic digestion showed stability conditions, with no noticeable scum or foaming problems. The anaerobic treatment of diluted municipal waste water is done using immobilized fixed bed anaerobic batch reactor. The source of waste generation is a mixed sludge collected from dock yard. The present study, thus initiated a need based experimental work on anaerobic digester incorporated with immobilized poly urethane foam system. The kinetic parameters are also estimated using experimental data. Empirical relations were developed for the characteristics like BOD, COD, SCOD, TDS and TSS using modeling equations.

Key words: kinetic parameters, COD (chemical oxygen demand), SCOD, BOD (biological oxygen demand), TDS (total dissolved solids), TSS (total suspended solids).

INTRODUCTION

The production of organic wastes can be thought of as an integral part of a developed society. These organic wastes are generated from agriculture, food processing domestic wastes, etc. One of the burning problems faced by the world today is the management of Wastes from all sources, which endangers the existence of human life. The wastes may be either liquid or solid. In India, the daily per capita solid generation ranges from 100 g in small towns to 500 g in large towns. The management of the solid wastes has become a great concern in recent years, as they are hazardous to human beings as well as cause extensive damage to the environment when left as such. Rapid growth of population and urbanization has aggravated this problem. There are different methods of disposing these wastes like open dumping, sanitary landfill, incineration, pyrolysis, etc. But these methods are not efficient because open dumps are the breeding grounds for flies, rats, etc. causing public health problems. Whereas incineration and pyrolysis lead to air pollution and the initial investment is also high. Apart from this, the energy crisis is another problem faced by the world today. Hence, to meet these requirements, the processes of waste treatment and recycling are adopted. To relieve citizens from the nuisance of organic waste by scientific treatment by a cost-effective, quick, and non-polluting method or by recycling, the best possible option is the biological conversion of solid wastes that contains higher percentage of organic matter by anaerobic treatment as this process results in the recovery of useful energy in the form of biogas, thus reducing fossil fuel and green house gas sources [1]. Biological processes based upon Immobilized fixed bed anaerobic Batch Reactor is effective for organic carbon removal in domestic and industrial wastewater.

The main advantages are easy operation, low cost, handling hydraulic fluctuation as well as organic load without any significant variation in removal efficiency. Thus, the aim of this study was to evaluate the use of anaerobic digester (fixed film fixed bed) in the treatment of a sewage effluent and to study the kinetics of other parameters .The Municipal waste is collected from the municipal water treatment plant near dock yard. Nearly 300-400m^3 of waste water comes to this treatment plant per day. A graphical Model was also developed to predict total COD level in municipal wastewater, providing an important design parameter for implementation of fixed-film anaerobic digestion systems [2]. The high strength industrial waste stream can be treated in such anaerobic system for system efficiency of 80-90% COD reduction. The incorporation of immobilized microbial support systems in the reactors to have attached-growth systems of microorganisms will enable anaerobic systems to perform well with much more process stability

MATERIALS AND METHODS

The experimental setup consists of Immobilized Fixed Bed Anaerobic Digester (IFBAD) Anaerobic digester having effective reactor volume of 2.0 lit. The experimental model is of 1.5 lit effective volumes Immobilized IFBAD is fed by diluted municipal wastewater. Biomass sludge was activated by aerating the organisms which was fed in to anaerobic digester and the harvesting was carried up to 28 days[3]. Mixed vegetable waste is used as a nutrient for the development of micro organisms. Samples were collected from a local market and macerated using a domestic food blender so that the wastes had been reduced to the smallest possible sizes(125-250µm) and stored in a refrigerator at 4°C.1 gram of mixed vegetable waste (on wet basis) is added per 1 liter of the waste water to be treated[7]. The type of samples collected were Brinjal, cabbage, carrot, potato, pumpkin, tomato in their rotten form. Each of these vegetables is added in equal quantities and grinded. The reactor was observed to attain the steady state conditions after four weeks with an average COD removal of 80% to 90%.After the Inoculum development step, the influent was fed by the upper part of the immobilized FBAD at six different theoretical hydraulic retention times (HRT) in a decreasing order of 6, 5, 4, 3, 2 and 1 days, which corresponded to average organic volumetric loading rates (Bv) of 26,36,40,74,152,201,226 mg/L of COD[2] .The experiment was run for five batches. The operating conditions are interpreted for the parameters of organic loading rate (Bv, mg/L); COD, BOD and SCOD (filtered COD). Also the parameters like TDS and TSS for every operating batch were observed. Values are averages of 3 determinations taken over 3 weeks after the steady-state conditions had been reached [1]. The differences between the observed values were less than 3% in all cases. The features and characteristics of influent used are shown in Table 1 which lists the average values and standard deviations of the separate analysis carried out.

RESULTS AND DISCUSSIONS:

Kinetic Model: The success of any biological treatment plant lies in the kinetics of the process as they determine the dimensions of the unit operation and dictates the control parameters and operating values. The experimental observations and their kinetic interpretation are used to evaluate the substrate utilization (COD removal) kinetics of the anaerobic process of treatment having attached growth system [10]. The removal of COD is envisaged for the maximum percentage, with necessary operating variables of influent COD, SCOD, TDS, TSS, and HRT. The loading rate of organics on the biological system, the composition of biological systems and the active status of the biological systems are correlated to explain the process of COD removal or in terms of (substrate) utilization [11]. Better the utilization of organics by the biological system for their energy requirement (during which they also stabilize most of the unstabilized waste constituents) better the COD removal. According to the results obtained by regression analysis, logarithmic type functions appear to describe the effect of *B*v on the fractional removal efficiency [4].

Table 1: A table representing the influent characteristics of dairy waste water.

Influent characteristics	Values (mg/L)
COD	304
TS	1688
TDS	1393
TSS	295
BOD	81
pH	7.6

Table 2: A table showing values of the empirical constants K1 and K2, and the regression coefficients of the parameters that were studied.

Parameters	K1	K2	R^2
COD	0.0044	1.0081	0.9986
SCOD	0.0044	0.9998	0.9990
TDS	0.0016	0.4254	0.9233
TSS	0.0013	0.2813	0.9439
BOD	0.0036	0.8679	0.9698

The general mathematical expression that relates Bv and the fractional removal efficiency is given by the following equation:. Where EF is the fractional removal efficiency at a given value of Bv, K1 is a dimensionless empirical constant and K2 is another empirical constant equivalent to the EF value obtained when Bv is equal to unity and, therefore, ln (1/Bv) is equal to zero[6]. The values for the empirical constants K1 and K2 obtained in the experiment and the correlation factors are summarized in Table 2. Equation (1) is only valid within the experimental range of BV studied (226-26 mg/LCOD dm^{-3} d^{-1}).The effect of the organic volumetric loading rate on the effluent COD is illustrated in Figure 1. An increase of BV in the range from 26 to 226 mg/LCOD caused virtually a linear increase in the fractional removal efficiency of COD from 10 % to 89%. When BV increased from 26 to around 226 mg/L COD, the effluent COD concentration increased moderately from 26 to 74 mg/L. Hence, the process was capable of assimilating a considerable increase of the organic loading without failure. The following empirical relationship was found between BV and effluent COD:

Likewise, empirical relations were developed for TDS, TSS, BOD parameters whose fractional removal efficiency decreased with the increase of bv .In TDS and TSS, the rate of removal efficiencies proceeded at a slower pace, particularly in case of TDS. Since the organic matter is the main substrate for anaerobes to degrade, no significant removal rates were seen in TDS and TSS .But BOD levels decreased at a satisfactory rate. The fractional removal efficiency equations are obtained as follows:

The plot of loading rate Bv versus the fractional efficiency is made to study the COD and as well independently for other parameters like SCOD, BOD, TDS, TSS. The plots of drawn curves are shown in the Figures. 2, 3, 4 and 5.

CONCLUSION: The elimination of COD increases with the no. of days up 45 mg/L .More than 85% COD removal efficiency was achieved in the reactor with influent COD concentration of 226mg/L. The empirical equations for removal efficiencies of other characteristics were developed. The results from this study proved the Immobilized Fixed Bed Anaerobic Digester flexibility and excellent performance for treating domestic and easily biodegradable wastewater such as municipal wastewater.

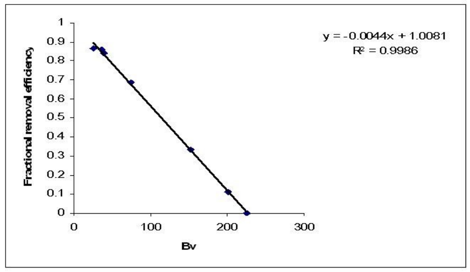

Figure 1: Fractional removal efficiency vs Bv.

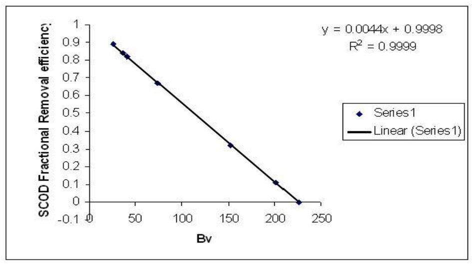

Figure 2: Fractional removal efficiency graph of Bv vs SCOD.

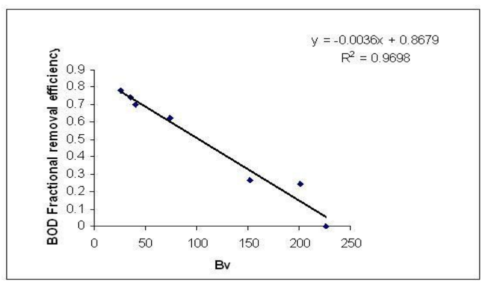

Figure 3: Fractional removal efficiency graph of Bv vs BOD.

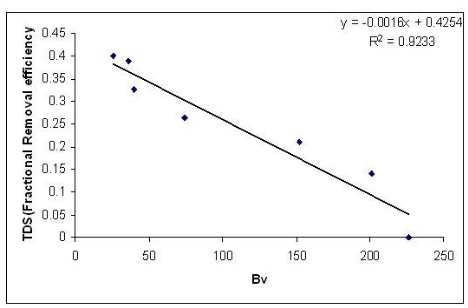

Figure 4: Fractional removal efficiency graph of Bv vs TDS.

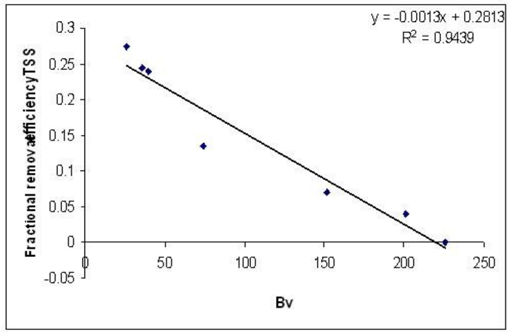

Figure 5: Fractional removal efficiency graph of Bv vs.TSS

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