American-Eurasian Journal of Scientific Research 4 (2): 89-92, 2009
ISSN 1818-6785

A Study on Dairy Wastewater Using Fixed-Film Fixed Bed Anaerobic Diphasic Digester

[1]G. Srinivasan, [2]R. Subramaniam and [3]V. Nehru kumar

[1]Department of Civil and Structural Engineering, Annamalai University, Annamalai Nagar,
[2]Civil and Structural Engineering, Department of Civil and Structural Engineering, Annamalai University, Annamalai Nagar,
[3]Environmental Engineering, Department of Civil and Structural Engineering, Annamalai University, Annamalai Nagar,

Abstract: In any dairy plant, the quantity and characteristics of effluent is depending upon the extent of production activities, pasteurization to several milk products. The anaerobic digesters in the first phase of treatment, which is followed by high rate aerobic treatment remain as the most common effluent treatment scheme for dairy plants. The Indian dairy industries is stated to have the growth at more than 15% and poised to cross the 150 million tones per annum. The requirement for milk and milk products is keep growing in steady pace, making a significant impact on the Indian agriculture domain. The dairy industries require large quantity of water for the purpose of washing of cans, machinery and floor, the liquid waste in a dairy originates from manufacturing process, utilities and service section. The various sources of waste generation from a dairy are spilled milk, spoiled milk, skimmed milk, whey; whey is the most difficult high strength waste product of cheese manufacture. The present study, thus initiated, for evaluating a need based experimental work on anaerobic diphasic digester incorporated with bio film support systems, for treating dairy effluent. The kinetic parameters are also estimated using the experimental data.

Key words: Anaerobic processes · Biofilms · Diphasic digester · FFFB · Microbial support media · COD · OLR · VLR

INTRODUCTION

Water management in the dairy industry is well documented [1], but effluent production and disposal remain a problematic issue for the dairy industry. To enable the dairy industry to contribute to water conservation, an efficient and cost-effective effluent treatment technology has to be developed. To this effect, anaerobic digestion offers a unique treatment option to the dairy industry. Not only does anaerobic digestion reduce the COD of an effluent, but little microbial biomass is produced. The biggest advantage is energy recovery in the form of methane and up to 95% of the organic matter in a waste stream can be converted into biogas [2].Many high-rate digester designs are currently available and some have successfully been used for the treatment of dairy effluents. Lettinga and Hulshoff-Pol [3], reported the use of full-scale upflow anaerobic sludge blanket digesters in use world-wide. The fixed-bed digester is another high-rate digester that has been used for the treatment of dairy effluents [4]. A high-rate combination design, using the upflow anaerobic sludge blanket (UASB) and the fixed-bed digester types, was developed by Guiot and Van den Berg [5]. This design was successfully used to treat landfill leachate [6] and baker's yeast factory effluent. Landfill leachate and yeast effluent both have high COD concentrations and both are difficult to degrade biologically. On the other hand, dairy effluents are fairly easily biodegradable, since they consist mainly of diluted dairy products. Thus, the aim of this study was to evaluate the use of anaerobic diphasic digester (fixed film fixed bed) in the treatment of a synthetic dairy effluent A graphical Model was also developed to predict total COD level in dairy wastewater, providing an important design parameter for implementation of fixed-film anaerobic digestion systems. The diphasic configuration will make acidogenesis and methanogenesis in two independent reactors, which will optimize the process kinetics, control mechanisms, reactor size etc. The high strength industrial waste stream can be treated in such diphasic anaerobic system for system efficiency of 70-80% COD reduction.

Corresponding Author: G. Srinivasan, Sr. Lecturer in Department of Civil and Structural Engineering, Annamalai University, Annamalai nagar

The incorporation of microbial support systems in the reactors to have attached-growth systems of micro organisms will enable diphasic anaerobic systems to perform well with much more process stability.

MATERIALS AND METHODS

The experimental setup consist of a Diphasic Fixed Film Fixed Bed (FFFB) Anaerobic digester having effective reactor volume of 0.03843m^3 (38.00 lit) The physical features and process parameters are listed in (Table 1). The schematic of the experimental set up is shown in Figure 1.

The experiment was initiated using domestic wastewater. The reactor was observed to attain the steady state conditions after 60 days with an average COD removal of 70% to 80 %.

The experimental model is 0.03843 m^3. (38 lit) of effective volume and empirically designed for the ratio of 1:3, for the phased out, independent reactors of acidogensis and methanogeness, which connected in series for performing the diphasic digester.

The acidogenic reactor is envisaged for the BSS of 2.26 m^{2}and methenogenic reactor for 4.65 m^2. The BSS is made off imported plastic, of a specified modular design that has the effective surface area of 7.185 m^{2}per 0.0186 m^3

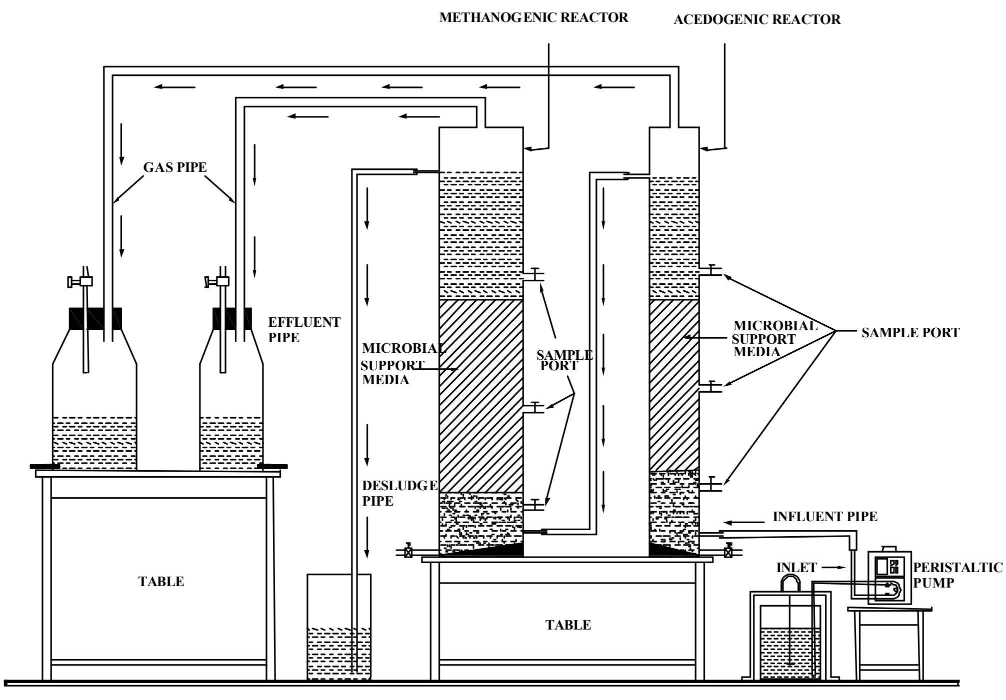

Fig. 1:

Table 1: Physical features and process parameters of experimental model

Reactor type: *Diphasic anaerobic digester*

Pump used: *Peristaltic pump-PP-20 model (Miclin's product)*

SPECIFICATIONS	*ACETOGENIC REACTOR*	*METHANOGENIC REACTOR*
Reactor volume	0.0113 m^3	0.0314 m^3
Reactor diameter	0.12m	0.20m
Reactor height	1m	1m
Height of biomass support media fill	0.4m	0.45m
Influent pipe diameter	0.006m	0.006m
Sample ports [from bottom of the reactor]		
S1	0.17m	0.12m
S2	0.4m	0.4m
S3	0.65m	0.65m
Reactor Volume	0.00452 m^3	0.01413 m^3
Specific area of the fill	500 m^2 /m^3 (16mm)	350 m^2 /m^3 (32mm)

The gas collection and measuring system are provided for both the reactors independently. A composite, integrated dairy unit as a case study M/s Hatsun Agro Products located in Salem, Tamil Nadu INDIA is considered for the study. The streams of synthetic waste for the experiment are prepared on the basis of the observed characterization of the drawn sample.

The experiment was run for different combinations of influent COD (mg/lit) (8000, 8996, 9956, 10976, 11981). and effluent flow rate (m^3/d) (0.006, 0.012, 0.024, 0.036, 0.048). The operating condition are interpreted for the parameters of organic loading rate (OLR, Kg COD/m^2.day) and hydraulic retention time (days) Also, VSS and biogas generation for every operating influent COD and flow rate were observed.

Mathematical 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 diphasic process of treatment having attached growth system. The removal of COD is envisaged for the maximum percentage, with necessary operating variables of influent COD, flow rate, 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 COD (substrate) utilization.

Better the utilization of organics by the biological system for their energy requirement (during which they also stabilize most of the unstablized waste constituents), better will COD removal efficiency, that no the efficiency of the said treatment process. A Model named Dewalle and Chian , provided the differential equations using Fick's law of molecular diffusion,

$$\frac{dF}{dt} = -AD\frac{ds}{dz}$$

This can be applied independently for acidogenic and methanogenic reactors, in series and also considering it as one process (anaerobic fixed film) in two phases. When substrate concentration is > k_S, the expiration above can be stated as:

$$\frac{1}{V}.\frac{dF}{dt} = (K\,A/V)\sqrt{Se}$$

While the substrate concentration is < k_s, the equation can be restated as:

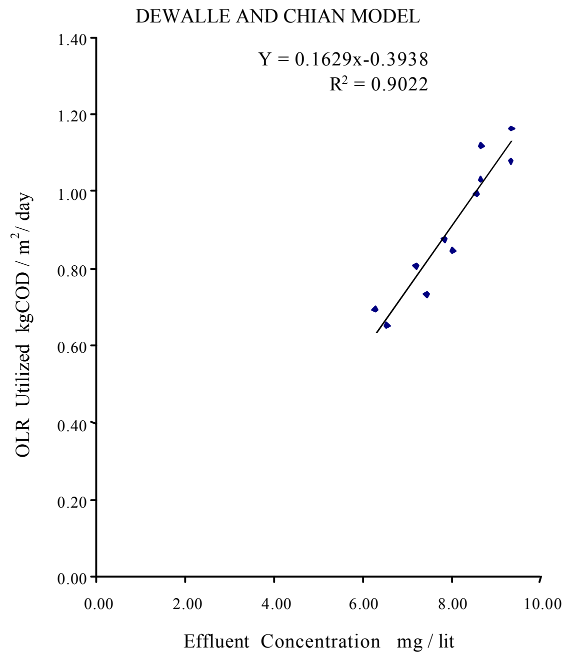

Fig. 2: OLR Vs Effluent Concentration [Acedogenic Reactor]

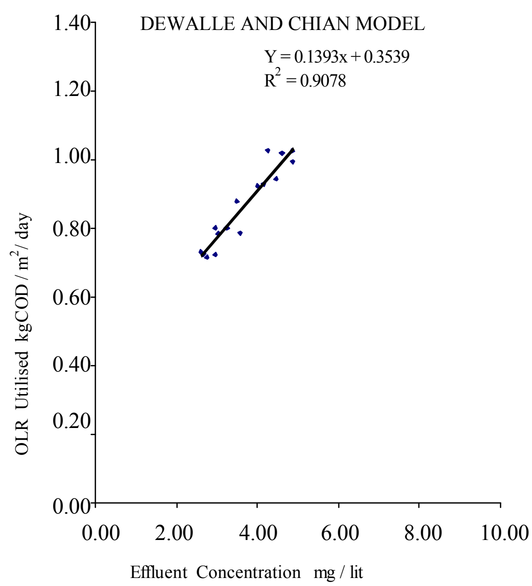

Fig. 3: OLR Vs Effluent Concentration [Methanogenic Reactor]

$$\frac{1}{V}.\frac{dF}{dt} = (K\,A/V)\,Se$$

The plot of loading rate versus the effluent concentration is made to study the substrate utilization (for the diphasic model) and as well independently for acidogenic and methanogenic reactor. The plots of drawn curves are shown in the Fig. 2, 3 and 4.

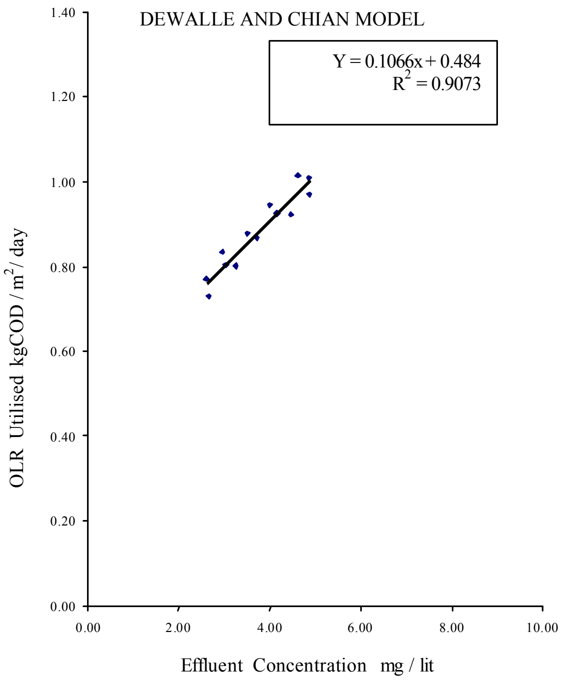

Fig. 4: OLR Vs Effluent Concentration [Diphasic Reactor]

RESULT AND DISCUSSION

Figure 5 shows the Overall reactor performance in the maximum removal of COD as 70.40 % at a flow rate of 0.006 m^3/day for a Overall OLR of 1.265 Kg COD/m^3.day Fig. 6 shows the maximum yield of bio-gas at 0.330 m^3 of gas / kg COD removed at an average influent COD as11981 mg /lit for a OLR of 14.812 Kg COD/m^3.day.

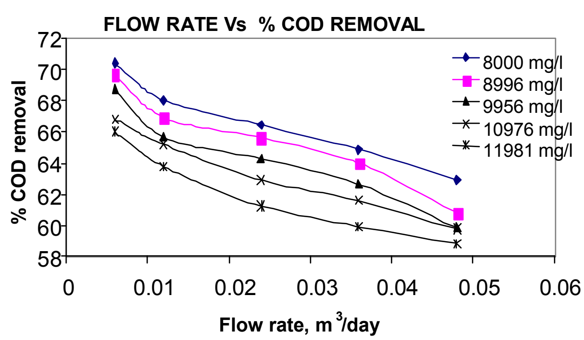

Fig. 5: Shows the Overall reactor performance in the maximum removal of COD as 70.40 % at a flow rate of 0.006 m^3/day for a Overall OLR of 1.265 Kg COD/m^3. day

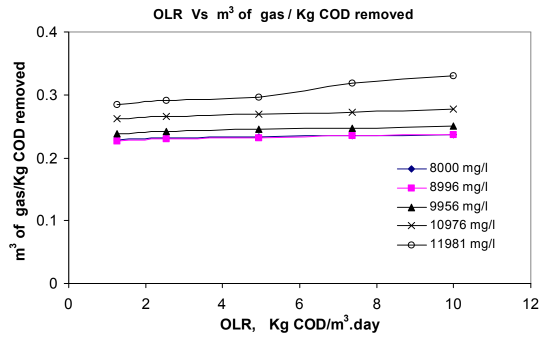

Fig 6: Shows the maximum yield of bio-gas at 0.330 m^3 of gas/kg COD removed at an average influent COD as11981 mg /lit for a OLR of 14.812 Kg COD/m^3. day

CONCLUSION

The Modified Diphasic digester is found to treat dairy waste water for a maximum COD removal of 70.40% and 0.330 m^3 of gas production / kg COD removed. Hence Diphasic digester can be used for removing COD up to 75% and the rest can be removed in the down stream aerobic systems, more effectively and economically.

ACKNOLEDGEMENT

The authors gratefully acknowledge the authorities of Annamalai University for providing laboratory facilities.

REFERENCES

1. Berg Van den, L. and K.J. Kennedy, 1983. Dairy waste treatment with anaerobic stationary fixed film reactors. Water Science Technol., 15: 359-68.
2. Orhon, D., E. Gorgum, F. Germirli and N. Artan, 1993. Biological tretability of dairy wastewaters. Water Reserach, 27(4): 635-633.
3. Michal perle, Shlomo Kimchie and Gedaliah Shelef, 1995. Some biochemical aspects of the anaerobic degradation of Dairy Industries. Water Research, 29(6): 1549-1554.
4. Burak Demirel, Orhan Yenigum and T. Turgut, 2005. Ohay-Anaerobic treatment of dairy wastewater: A review- process Biochemistry, 40: 2583-2595.
5. Cordoba, P.R., R.F. Sanchez and F. Sineriz, 1984. Treatment of dairy industry wastewater with an anaerobic filter. Biotechnol Lett., 6(11): 753-758.
6. Strydom, J.P., J.F. Mostert and T.J. Britzl, 1995. Anaerobic treatment of a synthetic dairy effluent using a hybrid digester- Water SA, Vol. 21 No. 2 April.