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EFFECT OF ORGANIC LOADING RATE FOR TREATING DISTILLERY EFFLUENT IN DIPHASIC ANAEROBIC DIGESTER

B. Asha and V. Nehru Kumar
Deptt. of Civil Engineering, Annamalai University, Annamalainagar-608 002, T.N., India

ABSTRACT

Diphasic anaerobic digesters have inherent advantages of exclusive process controls on the growth of microorganisms independently in acidogenic and methonogenic phases. A laboratory model of 15.0 liter effective volume with 2.5 liter of acidogenic reactor and 13.5 liter of methonogenic reactor was used to characterize the treatability of distillery wastewater. The model was run for varying concentrations of COD and influent rates to study the effect of organic loading rate in reducing the COD into harmless end products. The COD removal efficiency was found to vary from 17.67 to 26.19 % for varying organic loading rate (OLR) from 41.06 to 2.903 kg COD/m^3/d for acidogenic reactor and 58.28 to 77.42% for varying OLR from 6.317 to 0.396 kg COD/m^3/d for methanogenic reactor. The overall maximum COD removal was observed for 82.30% at an OLR of 2.903 kg COD/m^3/d.

INTRODUCTION

The diphasic anaerobic processes are the most appropriate for the high-strength distillery wastewater because of its widely reported advantages such as the possibility of maintaining optimal environmental conditions for the acid and methane forming organisms, alternation of imbalances between organic acid production and consumption, stable performance, and high biogas yield (Cohen et al. 1980). Pohland & Ghosh (1971) proposed separation of the two main groups of microorganisms physically into serial reactors to make use of differences in their growth kinetics. An advantage of diphasic digesters is that their operating conditions may be selectively determined in order to maximize not only acid but also methane forming bacterial growth.

The introduction of an acidogenic phase should enable optimization of the conditions required for many of the complex organic compounds present in the wastewater to be converted into short chain volatile fatty acids (VFA) and other simple compounds. This, in turn, buffers the slow-growing methanogens, predominantly present in methanogenic reactor, from possible toxins or inhibitors and ensures a uniform feed stock for the methanogens. Massey & Pohland (1978) suggested that the process could be applied to complicated as well as simple substrates, and equation were derived describing the growth of bacteria during substrate utilization in the dual-phase treatment system. Ince (1998) achieved good separation of acid and methane phases with low and high methane yields in the first and second phases. Solera et al. (2002) observed the variations in auto fluorescent methanogens and non-methanogenic bacteria at differing rates of hydraulic retention time (HRT) and organic loading rate (OLR).

The phased anaerobic treatment process is gaining momentum in industrial wastewater treatment plants. The wastewater-specific design of diphasic process is invariably important for desired performance of the treatment plant. The present study used a diphasic anaerobic digester model for treating distillery effluent.

MATERIALS AND METHODS

A diphasic, two-reactor configuration has been used to investigate treatability in terms of COD reduction in acidogenesis and methanogensis independently and collectively under different streams of distillery spent wash. The phased digesters are defined in the recommended ratio of volume of 1:5 viz., acidogenic reactor (AR) verses methanogenic reactor (MR). Both the experimental reactors were made up of Plexiglass and had working volumes of 2.5 and 13.5 liters. The two reactors were hermetically sealed to avoid any air entrapment. The acidogenic reactor is fed with diluted distillery spent wash from the influent tank by means of a peristaltic pump. The methanogenic reactor is respectively and continuously fed with the acidogenic effluent. The % COD reduction and gas production are continuously measured for both the reactors. The schematics of the experimental setup of diphasic digester is shown in Fig. 1

Wastewater source and its characteristics: The distillery spent wash used in this study was collected from the molasses based distillery industry M/s EID Parry India Ltd, Nellikuppam, Cuddalore district, Tamil Nadu. The important characteristics of the distillery spent wash are analyzed and the average values are given in Table 1. All the analysis was carried out in accordance with standard methods (APHA 1992).

Acclimatization and processes stability: The digesters were seeded with anaerobic digesting distillery sludge**,** which was collected from a return sludge line of wastewater treatment plant of M/s

Table 1: Characteristics of distillery-spent wash.

Parameters	Concentration
Colour	Dark brown
pH	4.5
BOD_5, mg/L	54000
COD,mg/L	92000
Total solids, mg/L	72000
Volatile solids, mg/L	54000
Suspended solids, mg/L	3800
Total Nitrogen, mg/L	1600
Total phosphate, mg/L	800
Sodium as Na, mg/L	2200
Potassium, mg/L	8000
Calcium, mg/L	2200
Sulphate, mg/L	2400

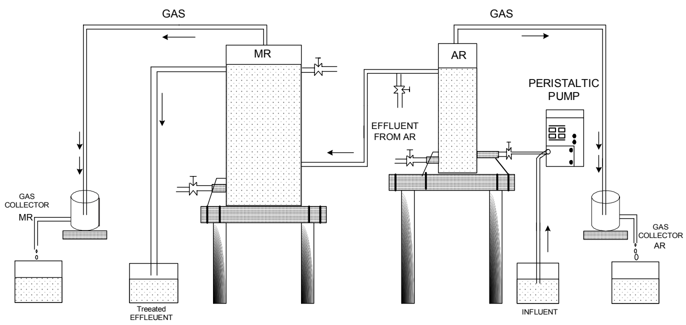

Fig. 1 Experimental Setup of the diphasic digester

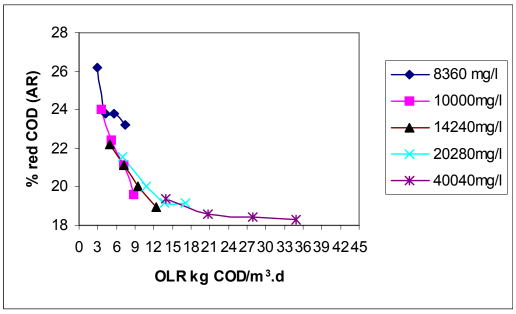

Fig. 2: OLR Vs. % red COD (AR).

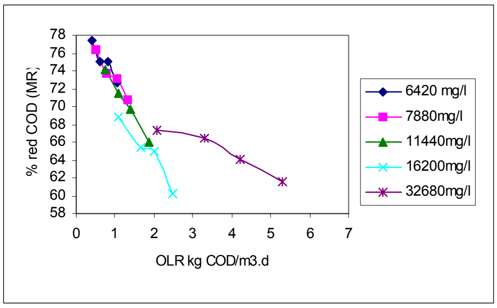

Fig. 3: OLR Vs. % reduction COD (MR).

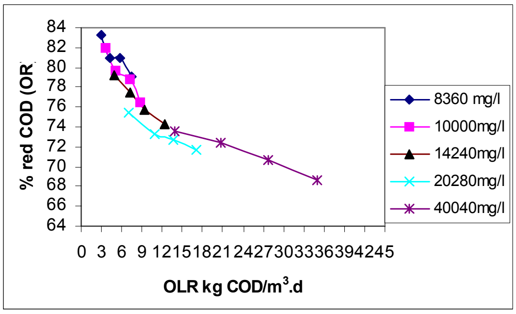

Fig. 4: OLR Vs. % reduction COD (OR).

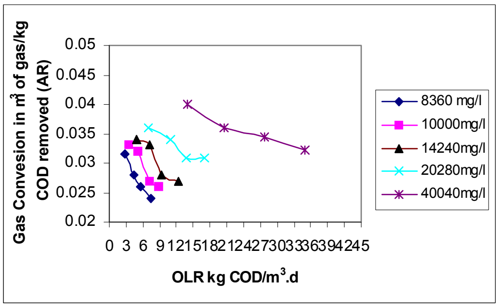

Fig. 5: OLR Vs. gas conversion in m³ of gas/kg COD removed (AR).

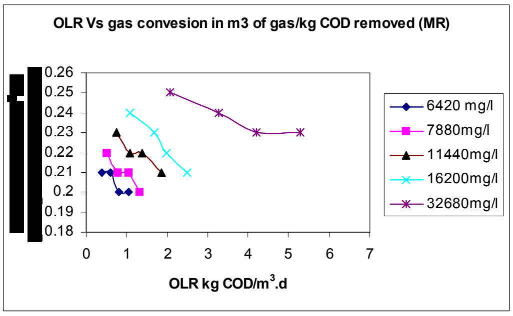

Fig. 6: OLR Vs. gas conversion in m³ of gas/kg COD removed (MR).

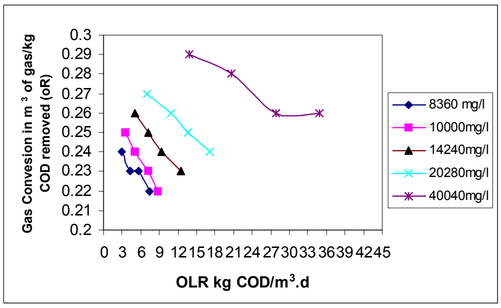

Fig. 7: OLR Vs. gas conversion in m³ of gas/kg COD removed (OR).

EID Parry India Ltd. In continuous-flow systems, acclimatization is a time-dependent process and can be influenced by the type of seed used, the characteristics of feed, and the plant operational and environmental conditions (Ghosh et al. 1975).

The process stability of the model was assessed with uniform COD reduction at 21 to 22% in acidogenic reactor and 62 to 65 % in methanogenic reactor after 27 days from the date of experimental start. Five different COD concentrations (8360, 10000, 14240, 20280 and 40040mg/L) of spent wash, treated for five different HRT (18.52, 12.35, 9.26, 7.41 and 6.17 days) conditions, were investigated, which allowed the maximum COD removal efficiency and significant biogas yield. The HRT was varied from 0.96 to 2.89 days in acidogenic reactor, and correspondingly methanogenic reactor was operated from 5.21 to 15.63 days.

RESULTS AND DISCUSSION

Five different concentrations (COD) of spent wash were investigated, which allowed the maximum COD removal efficiency and significant biogas yield. The applied OLR were 2.903 to 41.06 kg COD/m^3/d for acidogenic reactor and correspondingly methanogenic reactor was operated from 0.396 to 6.317 kg COD/m^3/d. It was found that the COD reduction rate is largely affected by the changes in OLR, reaching its maximum value of 26.19% for acidogenesis at an OLR of 2.903 kg COD/m^3/d and 77.42 % for methanogenesis at an OLR of 0.396 kg COD/m^3/d (Fig. 2 and Fig. 3). The biogas collection from acidogenic reactor was found insignificant while the biogas collection from the methonogenic rector was found to range from 0.19 to 0.25 m^3 of gas/kg COD removed. The respective observations are depicted from the Figs. 4, 5, 6 and 7. The overall COD reduction efficiency of 82.23% was achieved at an OLR of 2.903 kg COD/m^3/d (Fig. 4).

CONCLUSION

The organic loading rates were found to significantly influence the performance of the model. The COD removal efficiency was as low as 59.51% at an OLR of 41.06 kg COD/m^3/d. The maximum COD removal efficiency was 83.23% for an applied OLR of 2.903 kg COD/m^3/d. It can be seen from the curves that the average COD reduction of 75% was observed for the applied overall OLR of 8.502 kg COD/m^3/d. Hence, it can be concluded that diaphasic digester can be applied at an OLR of 8.502 kg COD/m^3/d, for an optimum COD reduction of 75 % for treating distillery wastewater.

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