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Effect of Volatile Fatty Acid for Treating Distillery Effluent in Diphasic Anaerobic Digester

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ABSTRACT

A laboratory model of 15.0 litre effective volume with 2.5litre of acidogenic reactor and 13.5litre of methonogenic reactor was used to evaluate the treatability of distillery wastewater stream. The model was run for varying concentrations of COD and influent rates to study the effect of volatile fatty acids in the acidogenic phase and methanogenic phase. The main objectives of this investigation were to determine the optimum condition for the performance of volatile fatty acids in the diphasic digester. The COD removal efficiency is found to vary from 17.672 to 26.19 % for the acidogenic reactor and 69.69 to 77.42% for the methanogenic reactor. The overall COD removal of the system is observed at an efficiency of 82.30% for the diphasic digester.

Keywords:

Diphasic digester, spent wash, acidogenesis, methanogenesis, COD, OLR, Volatile Fatty Acids.

INTRODUCTION

The diphasic anaerobic processes are the most appropriate for 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 [3]. [9] proposed the separation of the two main groups of microorganisms physically into serial reactors to make use of the differences in their growth kinetics. An advantage of diphasic digester is that their operating conditions may be selectively determined in order to maximize not only acid but also methane forming bacterial growth.

The incorporation of an acidogenic digestion process into a wastewater treatment system is a new and novel idea. Little attention was paid to the acidogenic phase in which many of complex organic compounds present in the wastewater to be converted to Volatile Fatty Acids (VFA) and other simple compounds [4]. 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.

[8] 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 – phased treatment system. [7] achieved good separation of acid and methane phases with low and high methane yields in the first and second phases. [10] observed the variations in auto fluorescent methanogens and non-methanogenic bacteria at differing rates of HRT and 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 .A laboratory model of diphasic digester was evaluated to characterize its performance for treating distillery wastewater.

EXPERIMENTAL SETUP

A diphasic, two-reactor configuration has been used to investigate tradability in terms of COD reduction in acidogenesis and methanogenesis 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 experimental reactors were made of Plexiglas 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 on diphasic digester is shown in Fig. 1

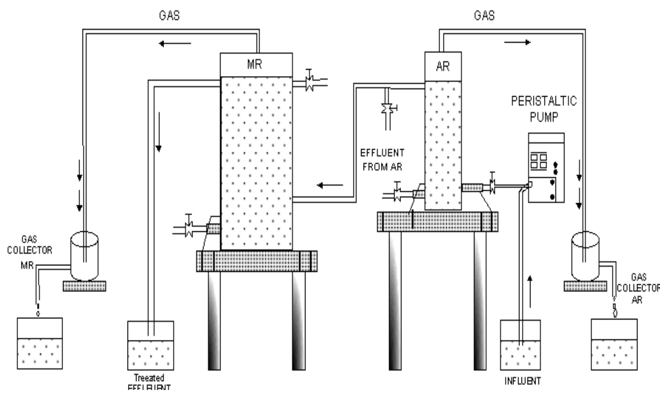

Fig. 1 Schematic diagram of the diphasic digester

EXPERIMENTAL METHODOLOGY

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 samples are analyzed and the average value is presented in Table 1. All analysis was carried out in accordance with Standard methods [11].

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	1800
Sodium as Na,mg/l	2200
Potassium,mg/l	8000
Calcium,mg/l	2200
Sulphate,mg/l	2400

Acclimation 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 EID Parry India Ltd. [5] observed in continuous – flow systems, acclimation is a time – dependent process and it can be influenced by the type of seed, the characteristics of feed and the plant operation and environmental conditions. 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 up. The phenomenon was considered complete when both the increase in VFA production and the decline in pH exhibited signs of stability in acidogenic reactor and in the case of methanogenic reactor, increasing of pH and decreasing of VFA production. The diluted spent wash of varying influent COD concentrations applied over the acidogenic reactor is 8360, 10000, 14240, 20280 and 40040 mg/l. The COD of the supernatant from the acidogenic reactor applied to the methanogenic reactor are 6440, 7880, 11440, 16200 and 32680 mg/l.

RESULT AND DISCUSSION

The high concentrations of VFA (6330 to 10200 mg/l) for the acidogenic reactor and the significant lower concentration of VFA (720 to 1482 mg/l) in the methanogenic reactor, proved that the existence of sufficient buffering capacity in the diphasic digester model in treating distillery spentwash.

The levels of VFA recorded in the acidogenic and methanogenic reactors under different HRT conditions are presented in **Figure 1.1** and **Figure 1.2**. The VFA concentration increased drastically with increase of HRT. The production and conversion of VFA with respect to OLR are drawn in the **Figure 1.3** and **Figure 1.4.**

The acidogenic reactor was operated for a maximum OLR of 41.06 kg $COD/m^3.d$ with a VFA of 8940mg/l and correspondingly the methanogenic reactor for a maximum OLR of 6.317 kg $COD/m^3.d$ with a VFA of 960mg/l. The maximum COD conversion rate of 26.19% was achieved in the acidogenic reactor and 77.42% was achieved in methanogenic reactor. The diphasic digester model is found to offer an overall COD reduction of 82.3% in treating distillery spent wash.The biogas collection from acidogenic reactor is found insignificant. The biogas collection from the methonogenic rector is found to range from 0.19 to 0.25 m^3 of gas/kg COD removed.

The methane production was increased as a result of an increase in the concentration of VFA. The increased level of VFA in AR and decreased level of VFA in MR were never seriously stressed by the pulses. This also agrees with the previous findings [1,2]. [6] suggested that the VFA directly simulated microbial growth in the rumen. In this study also the microbial growth in two ways i.e acidogenesis and methanogesis, which simulate the production and conversion of VFA.

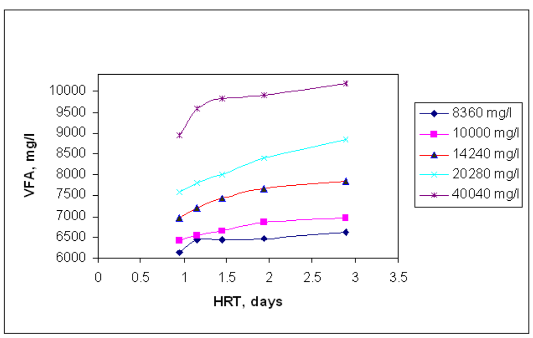

Figure 1.1 HRT Vs VFA (AR)

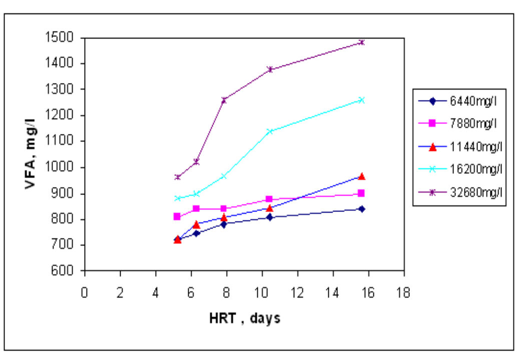

Figure 1.2 HRT Vs VFA (MR)

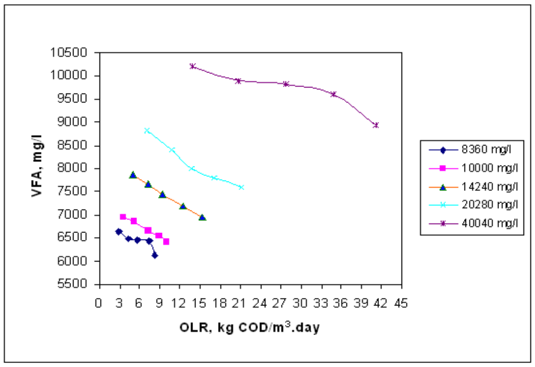

Figure 1.3 OLR Vs VFA (AR)

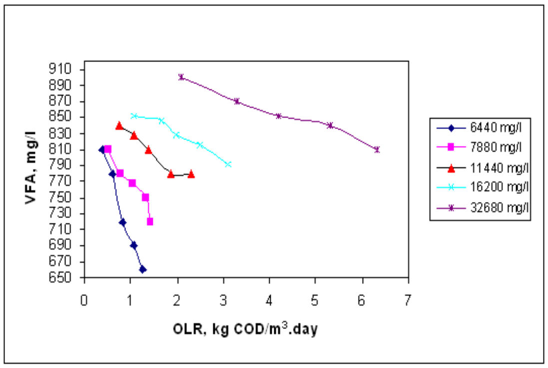

Figure 1.4 OLR Vs VFA (MR)

CONCLUSION

It is found that the COD reduction rate and biogas cnversion is largely affected by the conversion of VFA in the diphasic digester. The increased level of VFA in the acidogenic phase and the decreased leval in the methanogenic phase in the effluent indicates the robust conversion of the substrate into gaseous end products. It can be concluded from the result of the experiment that the effect of volatile fatty acid is found significantly affect to the performance of the diaphasic digester.

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