ASSESSMENT OF BIOGAS PRODUCTION FROM ANAEROBIC DIGESTION OF WINE LEES

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ABSTRACT

The production of wine consists a significant sector of Greek industry with major exports worldwide. From 1000 kg of grapes around 800 L of wine and 50 kg of wines lees are produced. Wine lees are generally acidic with a yellowish color and high values of Chemichal Oxygen Demand (COD). The present paper deals with the anaerobic digestion of wine lees generated from a local winery, with emphasis on COD removal, biogas and methane recovery. A high-rate anaerobic digester (contact process) was operated at five different loading rates, ranging from 2.5 to 10.5 kg COD m^{-3} d^{-1}. The experiments were conducted at 37 °C. The lowest applicable hydraulic retention time was equal to 3.5 d. Under the conditions examined, the digester pH was spontaneously maintained in the range of 6.26-7.13, thus eliminating the use of alkali for pH control. The COD removal efficiencies were found to be 94-99% and the biogas yield was in the order of 0.55 m^3 kg^{-1} COD feed. Percent methane was found to be in a range of 74-79%. Anaerobic treatment of wine lees was proved to be successful enabling energy recovery pollution control for small and medium wineries.

Keywords: Wine lees, methane, COD, anaerobic mesophilic contact reactor.

1. Introduction

The EU is one of the largest wine producers. Producing some 175m hl every year, it accounts for 45% of wine-growing areas, 65% of production, 57% of global consumption and 70% of exports in global terms [1]. The operation of these industries is seasonal since operation time depends on the production of the fruits that they process. That means that the pollutants from those industries will also be seasonal [2].

It is known that the performance of the anaerobic reactors can be induced by the substrate retention time and the degree of contact between influent substrate and living microorganism population. These parameters depend on the mixing conditions in the reactor. With the appropriate mixing, the microorganisms remain suspended, the produced biogas can leave the system and a homogeneous substrate distribution can be achieved [3]. The anaerobic contact reactor is considered to be one of the high-rate anaerobic processes. It is a modification of a CSTR, with recycled biomass. The anaerobic contact reactors treating typical high strength waste water in the food processing industry represent a proven sustainable technology [4].
The objective of the present work was to examine the effect loading rate and hydraulic retention time on the performance and stability of a hybrid mesophilic anaerobic contact reactor.

2. Materials and methods

2.1. Origin of the wine lees

Wine lees were obtained from a winery located in Kalochori, Thessaloniki. The anaerobic granules used as inoculum was collected from an anaerobic digester in Trikala. To prevent blocking of feed tubes, substrate was mixed with tap water. After letting it settle overnight, the influent of the reactor was the supernatant liquid. Characteristics of the wine lees after dilution are presented in Table 1.

Table 1: Characteristics of wine lees after sedimentation used in the experiments (after dilution)

Parameter	Average Value	Unit
TCOD	31.81	Kg m^{-3}
SCOD	27.21	Kg m^{-3}
TSS	1.73	Kg m^{-3}
VSS	1.56	Kg m^{-3}
pH	4.19	-
EC	2.31	mS/cm

2.2. Contact Anaerobic Sludge Bed Reactor (CASPER) configuration and operation conditions

CASPER combines the advantages of an Up flow Anaerobic Sludge Bed Reactor and an anaerobic contact reactor. Some of the most important features of CASPER are the easy operation, the low cost equipment and the simple internal installation for the separation of the biomass.

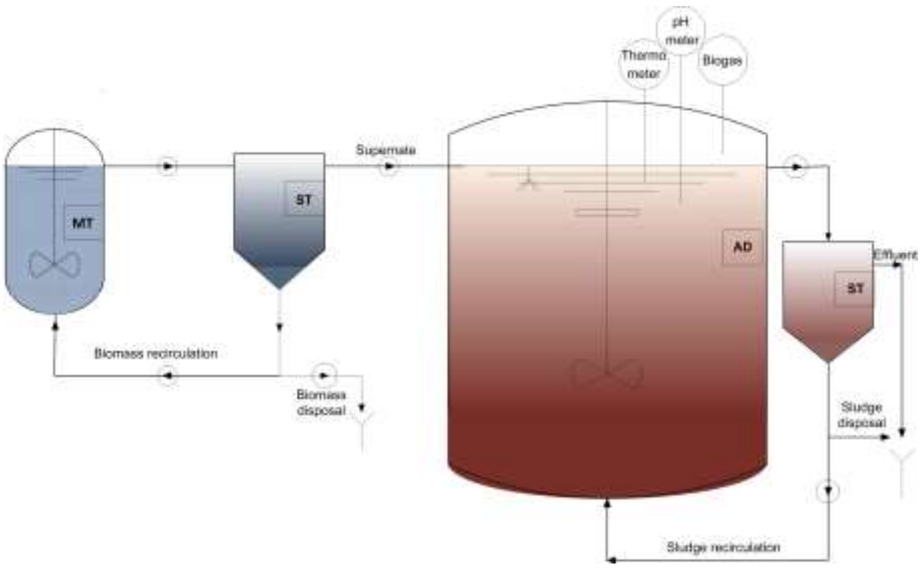

Figure 1: The schematic view of CASPER used in this study. MT: Mixing tank, ST: Sedimentation tank, AD: Anaerobic digester

A continuous digestion of wine lees was carried out in a stirred tank reactor with a total volume of 50L and a working volume of 42L. The reactor was built from double glass cylinder. The mixer, mixer motor, feed tube, and effluent tube, temperature measuring port, biogas collecting port and sampling port were installed on top of the reactor. Effluent samples were drawn from the middle layer of the digester contents using the sampling port located in the middle of the reactor. A water bath was used to maintain the temperature of the digester at 36 ± 0.6 °C. The digester was stirred continuously at a low velocity. The pumps used were controlled manually. The Schematic of CASPER used in this study can be seen in Figure 1.

2.3. Analytical methods

Biogas production, pH and digester temperature were followed on daily basis. Process parameters such as total suspended solids (TSS), volatile suspended solids (VSS), total and soluble chemical oxygen demand (TCOD and SCOD) were measured by periodic sampling, twice a week. The sampling was always performed before feeding. All the analyses were performed in accordance with APHA Standard Methods (2005).

3. Results and discussions

3.1. Process performance at different loading rates

The reactor was operated at different organic loading rates. At each loading rate, the reactor was operated until a steady state was reached. The variations of HRT, OLR and specific biogas production rate in the reactor throughout the whole experimental period are shown in Figure 2. The OLR during the entire process varied within the range of 1.9–11.1kg COD $m^{-3}d^{-1}$in order to investigate its effect on the CASPER's performance.

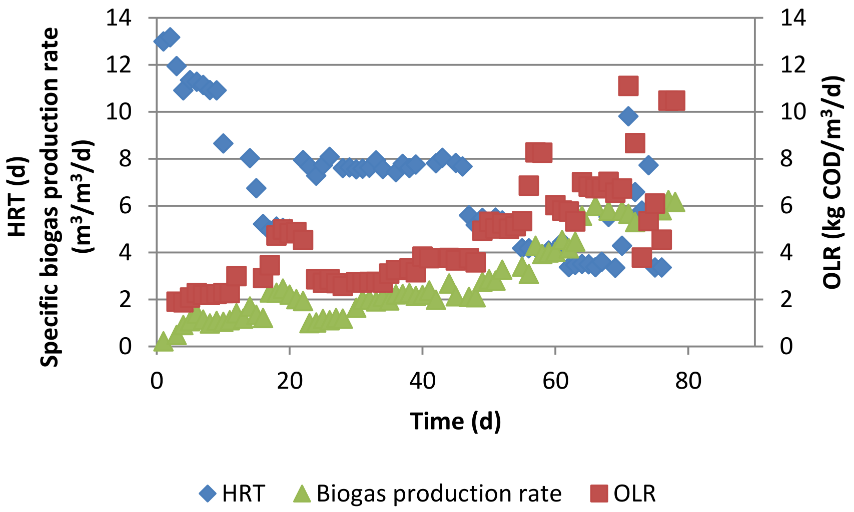

Figure 2: Variation of HRT, OLR and specific biogas production rate in CASPER

The correlation between the applied OLR in the CASPER and the corresponding COD removal rate is shown in Figure 3. The inclination of the trend line corresponds to the respective mean COD removal percent. As it can be seen from Figure 3, the system displayed steady performance with increasing OLRs.

3.2. Biogas production and composition

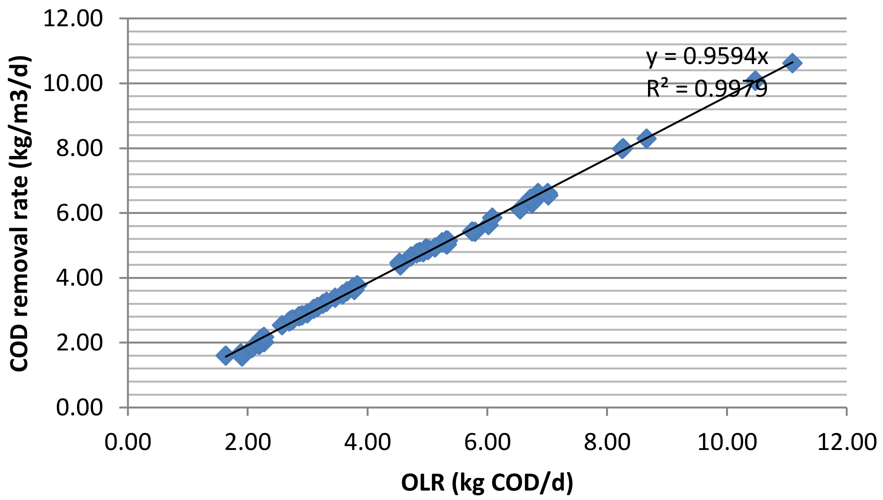

Figure 3. Correlation between OLR and COD removal rate in CASPER. The inclination of the trend line corresponds to the respective COD removal percentage.

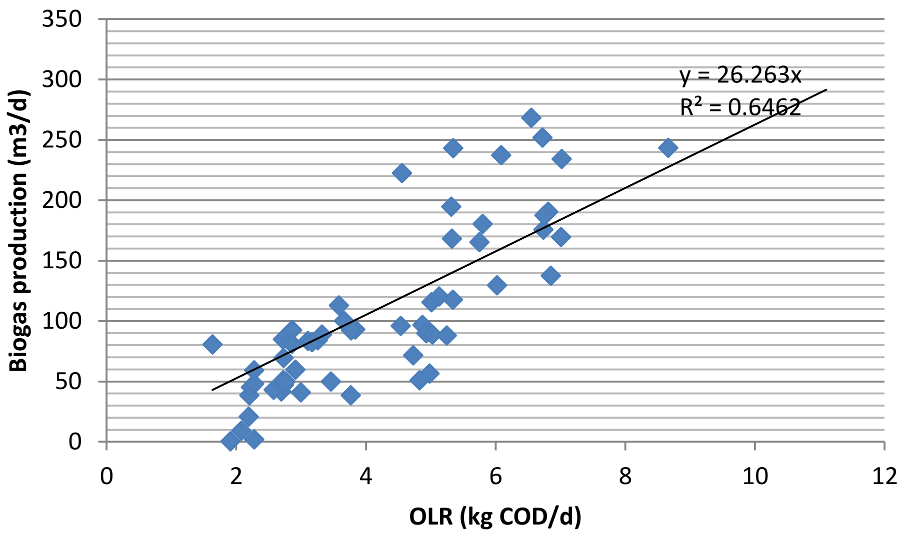

Figure 4: Correlation between OLR and biogas production rate in CASPER.

In Figure 4, the biogas production as a function of OLR is shown. The results clearly indicated that the process was efficient in terms of biogas production and yield at all loading rates, since there is a direct linear correlation between the biogas production and the OLR.

A peak biogas production of 6.23 m^3 biogas per m^3 reactor per day was achieved with an OLR of 10.5 kg COD/m^3 d, with a biodegradation in the range of 96%. With increasing OLR, the methane content of the biogas remained almost the same. Throughout the entire process, methane content in the range of 76.1±3.5% were obtained. The average methane yield was found to be 0.36 m^3 CH_4/kg $COD_{removed}$.

4. Conclusions

Different OLRs and HRTs were evaluated. The influences of organic loading rate on process performance of CASPER treating wine lees were investigated. CASPER provided high COD removal efficiencies, short HRT, high volumetric COD loading rates and high biomass concentration without any washout. The results obtained from the process performance evaluation under steady state conditions showed that the COD removal efficiencies were 94–99%.The results also indicated a good correlation between organic loading rates and total biogas production. Percent methane was found to be in a range of 74-79%. The generated biogas can be utilized for heat or electricity generation thereby meeting the energy demands of the unit.

ACKNOWLEDGMENT

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