Operation of an AnMBR for winery wastewater treatment at low temperature

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INTRODUCTION

The growing concern in the development of new intensive and compact technologies is due to the more and more stringent regulations regarding waste disposal and the aim of reducing energy and space requirements, particularly in industrial facilities as wineries. During vintage, the high organic load of the winery wastewater favours the application of mesophilic anaerobic processes to convert the organic matter into biogas. However, when loads are low in winter season, the anaerobic digestion should be carried out at room temperature. The main goal of this work is to operate an anaerobic membrane bioreactor (AnMBR)fed with synthetic winery wastewater at low temperatures (15ºC and 25ºC) evaluating its methanogenic activity and comparing it with the operation at mesophilic conditions.

MATERIALS AND METHODS

The AnMBR was set-up as a conventional stirred anaerobic digester of 5-L coupled with an external flat-sheet membrane unit (Orelis, Rayflow Module) with 100 cm^2 of membrane area achieving and average flux of 8.7±3.5 LMH operating at 0.3 bar. Influent wastewater was fed from a 10-L tank placed in a coolbox to avoid early degradation. Synthetic wastewater was prepared with diluted white wineandNH_4Cl and K_2HPO_4 were supplied to achieve a chemical oxygen demand to nitrogen and phosphorus ratio (C:N:P) of 800:5:1, as well as, $NaHCO_3$ was added reaching an alkalinity of 900 mg $CaCO_3$ L^{-1}.

RESULTS AND DISCUSSION

The AnMBR was operated during 45 days at 25ºC. The COD removal efficiency was on average 80±9%. Since winery wastewater contained easily biodegradable COD, the removal efficiency decreaseddue to occasional VFA accumulation, being on average 184±105 mgVFA/L. The alkalinity added to the system should be enough to maintain a stable pH when high amount of VFA were accumulated.By keeping a ratio between intermediate and total alkalinity (IA/TA)below 0.3 the stable operation was assured. However, the day 28 (Fig.1a) when VFA increased to 400 mg/L, it increased to 0.4 and the removal efficiency decreased to only 59%.Although the influent COD was constant at 1457±320 mgCOD/L, the flux through the membrane tended to decrease due to the cake layer formed on its surface. Hence, after a cleaning, the flux increased and thus the organic load that promoted the VFA accumulation.

Afterwards, the operational temperature was decreased to 15ºC during 25 days. In Fig. 1b, it is clearly observed a start-up period when the COD removal efficiency was below 40%. After 5 days, COD removal efficiency increased to 67±6% and the ratio IA/TA was kept around 0.20.

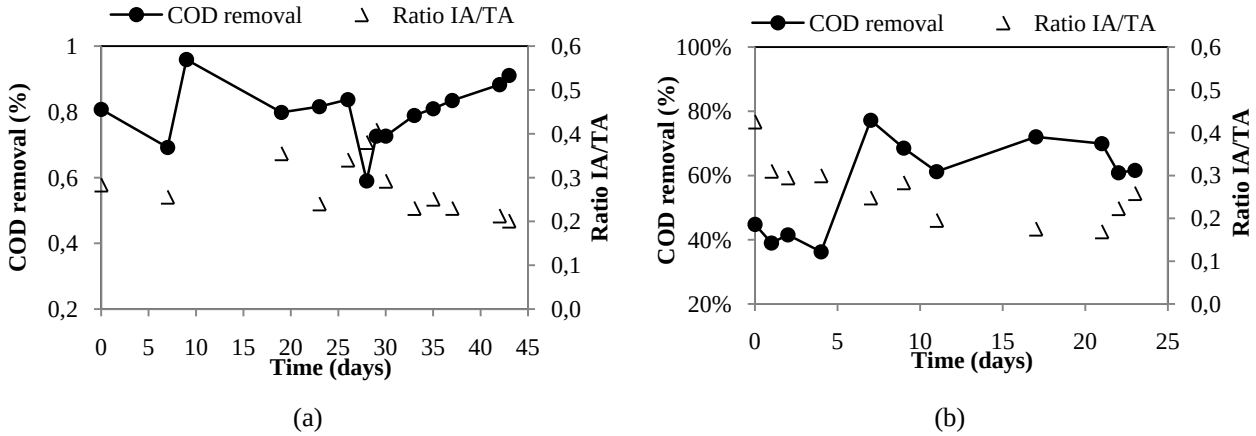

Figure 1. Evolution COD removal efficiency and ratio IA/TA during AnMBR operation at 25ºC (a) and 15ºC (b).

In Table 1, the operational parameters and results obtained in both periods are summarised. Slightly better results in terms of COD removal and biogas production were obtained at 25˚C. At 15˚C, the specific methanogenic activity (SMA) was 0.22 gCH_4-COD/(gVSS d), which was lower compared with the SMA at 25ºC (0.38gCH_4-COD/(gVSS d)). The specific methane production (SMP) was 0.24 and 0.21 for 25˚C and 15˚C, respectively. It should be taken into account that the SMP was not only related with the COD removal but also was affected by the dissolved methane that was retained in the effluent.

Table1. Operational parameters of the AnMBR at low temperature.

Operational parameters		
Temperature	**25ºC**	**15ºC**
pH	7.40 ± 0.27	7.39 ± 0.11
Alkalinity (mg $CaCO_3$/L)	824.94 ± 113.74	906.25 ± 68.97
MLSS (g /L)	1.95 ± 0.17	3.13 ± 0.21
HRT (d)	4.66 ± 1.70	3.94 ± 1.60
COD influent (mg/L)	1457.41 ± 320.25	1029.57 ± 134.97
COD effluent (mg/ L)	288.49 ± 129. 98	438.05 ± 165.61
%COD removal	80 ± 9	67 ± 6
OLR (kg COD/($m^3_{digester}$ d))	0.31 ± 0.13	0.24 ± 0.15
Biogas production		
Pb ($m^3_{biogas}/m^3_{digester}$d)	0.03	0.02
%CH_4 in biogas	83 ± 3	81 ± 2
SMP (m^3CH_4/kgCOD)	0.24 ± 0.10	0.21 ± 0.02
SMA(gCH_4-COD/(gVSS d))	0.38	0.22

It is well known that is preferable to operate an anaerobic digester at high temperatures (i.e. 35˚C or 55˚C). At mesophilic conditions (35˚C) the SMA obtained was 0.56 gCH_4-COD/(gVSS d), and the SMP was 0.35 m^3CH_4/kgCOD with a COD removal over 95%. However, when the wastewater does not contain enough COD to cover heating requirements, the mesophilic digestion would not be feasible.In winter season, the operational temperature would be close to 15˚C and the influent COD concentration would be between 500 and 1000 mgCOD/L. Therefore, the efforts to improve the feasibility of the system would be focused on increasing the treatment capacity at the lowest temperature.

CONCLUSIONS

AnMBR has shown good performance for winery wastewater treatment, removing organic matter concentration with low nutrient requirement. Instabilities caused by oscillations in organic load were coped by keeping a ratio IA/TA below 0.4. The operation at 25˚C resulted in slightly better COD removal and thus biogas production than the operation at 15˚C.Nevertheless, in winter season the operational temperature would be close to 15˚C, temperature at which a COD removal of 67±6% and a SMP of 0.21±0.02 were reached. Further research will be focused on improving the COD removal efficiency at 15˚C in order to meet the discharge requirements as well as increasing biogas production.

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