CONCENTRATION OF MEAT INDUSTRY WASTEWATER BY REVERSE OSMOSIS AND ANAEROBIC DIGESTION OF THE CONCENTRATE

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Introduction

In our work we focused on the concentration of meat industry wastewater by reverse osmosis (RO) prior to treatment by anaerobic digestion (AD). Our primary aim was to optimize the RO process to achieve maximum recovery of organic matter with the highest efficiency of the membrane process and minimize fouling. As a pretreatment, coagulation was tested to investigate if higher fluxes can be maintained during the concentration process. Secondly, AD experiments were conducted on the RO concentrate and appropriate pretreatment methods were sought after to achieve maximum biogas production. To find the best pretreatment method for highest biogas production, the effect of mixing with grease, alkaline and acidic conditions combined with thermal pretreatment were evaluated. AD tests were conducted to test the decomposition ability for the RO concentrate, and the impact of alkaline condition with heat treatment on increasing biogas production. The advantage of pretreatment was evaluated in terms of the rate of anaerobic decomposition into biogas and the length of LAG-phase of digestion.

Materials and methods

Meat industry wastewater

Parameter	Mean value	SD
TS (mgL^{-1})	*3210*	*296*
TOC (mgL^{-1})	*834.1*	*35.3*
Lipid (mgL^{-1})	*115.1*	*21.7*
Protein (mgL^{-1})	*379.4*	*21.2*
pH	*6.13*	*0.23*
Conductivity (μScm^{-1})	*983.2*	*14.2*
Density (kgm^{-3})	*1005.3*	*3.2*
Viscosity (mPas)	*0.877*	*0. 009*

Analytical procedures:

- *TOC: Sievers 900 TOC analyzer* (GE, U.S.)
- Protein assay: Lowry method
- Lipid content: partition-gravimetric method

Design of experiments and modeling

- Modde 8.0 (Umetrics, Sweden)
- CCF design and response surface methodology

Factors:
- *Pressure (p)*
- *Temperature (T)*
- *Recirculation flow rate (Q_{rec})*

Responses
- *Permeate flux (J_{perm})*
- *Total resistances (R_t)*

PCI tubular module

Oxitop C barometric measuring head

RO concentration

- PCI B1 module
- AFC-99 polyamide membrane
- Membrane area of 0.85 m²
- Concentration to VRR=3.75

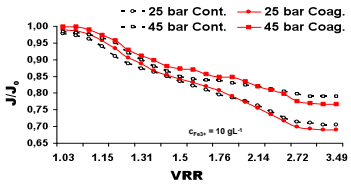
$$VRR = \frac{V_{feed}}{V_{feed} - V_{perm.}}$$

AD tests

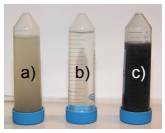
- Mesophilic conditions *(35 ± 0.2°C)*
- Digestion time: 30 days
- Oxitop C barometric measuring heads
- 250 mL continuously stirred reactor

Results

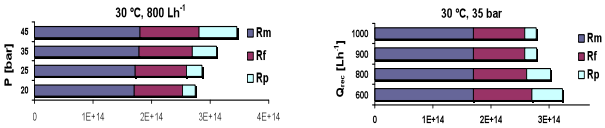
Membrane concentration



Effect of pre-coagulation

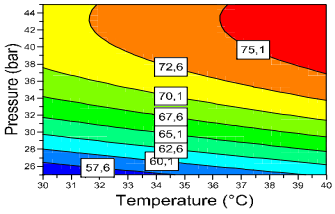


a) Raw wastewater, b) RO permeate, c) RO retentate



Analysis of resitance components

$$R_m = \frac{\Delta p}{\eta_w J_w} \qquad R_f = \frac{\Delta p}{\eta J} - R_m \qquad R_p = \frac{\Delta p}{\eta J} - R_m - R_f$$



Lowest R_t with highest J_p

- T= 38°C
- p= 38.5 bar
- Q_{rec}=920 Lh^{-1}

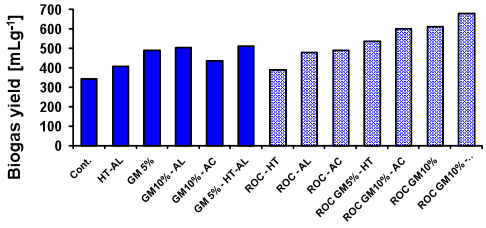
$$J_p = 71.0214 + 8.25p + 0.5659Q_{rec} + 2.711t - 4.989p^2$$

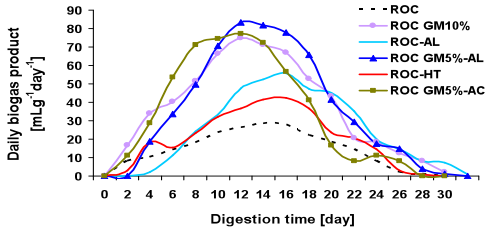
$$R_t = 2.9009\times10^{14} + 2.986\times10^{13}p - 3.659\times10^{12}Q_{rec} - 3.95\times10^{12}t + 3.107\times10^{10}p^2$$

Anaerobic digestion

Pretreatments:

- HT – heat treatment at 70°C for 60 min.
- GM – mixing with grease
- AL – alkaline pretreatment (pH12 for 60 min)
- AC – acidic pretreatment (pH2 for 60 min)





Conclusions

Reverse osmosis (RO) was proven viable for the purification of meat industry wastewater, and concentration of organic matters in one step. The RO operation produced purified water with low organic content and a concentrate suitable for anaerobic digestion (AD). Optimization by response surface methodology showed that the recirculation flow rate, pressure as well as temperature have an impact on the efficiency of the RO process. The efficiency of RO process was highest at 38.5 bar operating pressure with recirculation flow rate of 920 Lh^{-1}. Mixing the RO concentrate with grease increased the specific biogas yield and the specific biogas rate. Alkaline pretreatment combined with heat treatment at 70°C enhanced the biogas production by 70%. This research was conducted as part of the Northern Periphery Programme funded Micro Waste to Energy: Micro energy to rural business (MicrE) project and it was concluded that the method can be used for bioenergy generation in rural, small-sized meat processing companies.

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