INTEGRATION OF ANAEROBIC DIGESTION OF PRE-TREATED SLUDGE WITH A MEMBRANE BASED BIOGAS UPGRADING SYSTEM:

EVALUATION OF PROCESS CONFIGURATION THROUGH PILOT-SCALE OPERATION

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Aim & Objectives

Integration of an anaerobic reactor with a membrane-based biogas upgrading system for the production of a final gas stream of at least 95% CH_4 purity.

Validation of the preliminary experimental results at pilot-scale conditions:

1. Implementation of the most effective method for sewage sludge pre-treatment
2. Integration of a hollow fiber polymeric membrane at the pilot-scale set-up for biomethane production

Pilot unit configuration

Anaerobic Biogas Reactor

Made of stainless steel with a working volume of 600 L.

Equipped with thermal jackets to maintain the operating temperature at 37 ± 2°C.

Periodical reactor feeding using a peristaltic pump.

Membrane-based Upgrading Unit

Two-stage hollow fiber membrane system.

Continuous operation at 11.3 bars using an oil-injected rotary screw gas compressor.

Integrated System

The system operates entirely on automation.

PLC-based long-distance control modules allow for remote monitoring and control of the system.

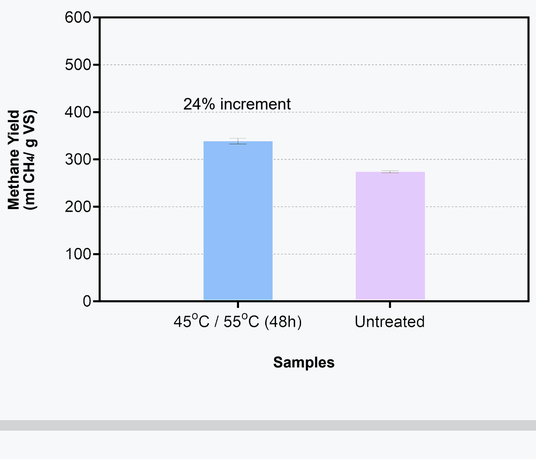
Results

Lab-scale trials

Evaluation of the optimum sludge pre-treatment method

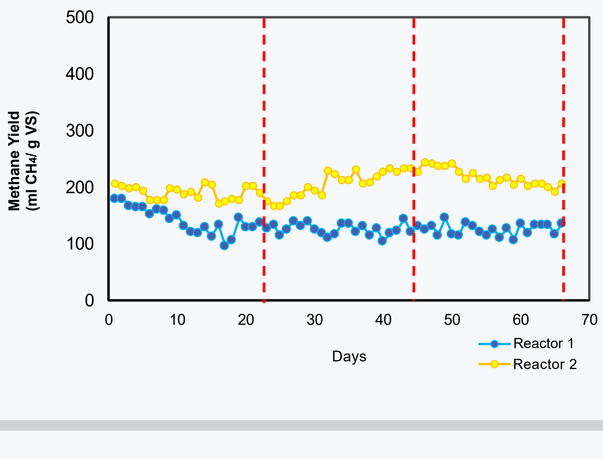
BMP tests

- 14 different methods examined
- Optimum: 45° C for 48h & 55° C for 48h



Continuous stirred reactor operation (CSTR)

- Further evaluation of the optimum pre-treatment method
- Reactor 1: Fed with untreated sludge (control)
- Reactor 2: Fed with pre-treated sludge



Lab-scale trials

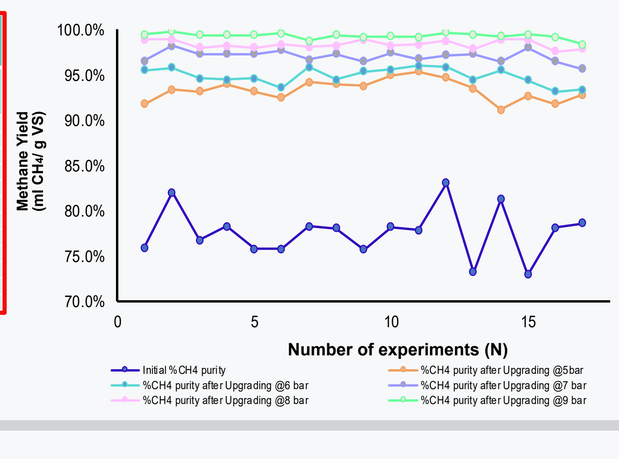
Evaluation of two hollow fiber polymeric membranes: Polysulfone (PSF) & Polyimide (PI)

Determination of the most effective membrane

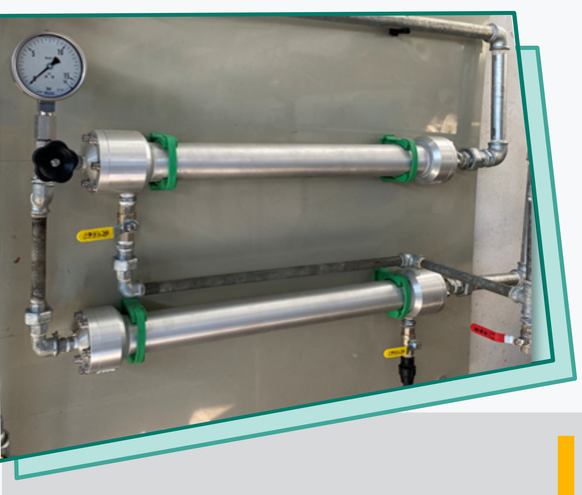
Feed Gas Composition	PSF		PI	
% vol CH_4/CO_2	Feed Flow Rate (mL/min)	Purity CH_4 %	Feed Flow Rate (mL/min)	Purity CH_4 %
55/45				
	2000	98.3	2000	98.83
	2500	95.77	2500	98.94
60/40				
	2500	97.2	2500	98.51
	2500	94.05	2500	94.69
65/35				
	1500	94.72	1500	96.96
	2100	95.46	2100	97.63
70/30				
	1500	94.43	1500	95.77
	1700	95.66	1700	97.78

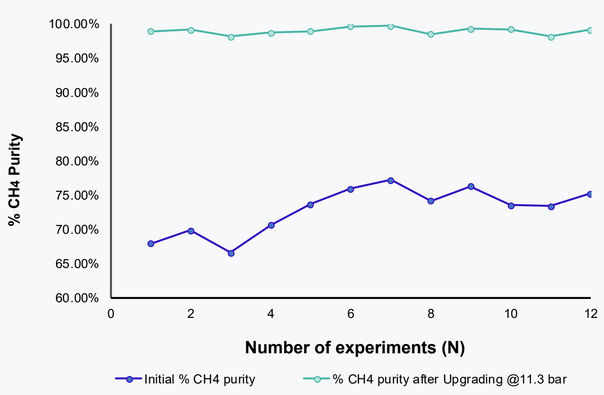
Further evaluation of PI membrane

Feed gas: simulation of real biogas' composition which was produced during the operation of the lab-scale CSTR (Reactor 2)



Integrated Pilot System - Biogas Upgrading





CH_4 purity at retentate side exceeded 95% during pilot unit operation

Innovation

The demonstration of the PI membrane-based biogas upgrading system at a high level of technological maturity for the first time in Greece, lays the foundation for accelerating the commercial exploitation of the results and enhancing the competitiveness of wastewater treatment and biogas production facilities.

The CH_4 produced can be directly utilized as a renewable energy resource for heat and electricity.

Biogas upgrading broadens the AD-delivered biogas' potential as an energy carrier in transportation or as a substitute for natural gas.

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