An innovative low-temperature anaerobic system for high quality biogas production from municipal sewage

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Research fields:

- Aerobic biofilters and granular reactors;
- Wastewater reuse in agriculture;
- Anaerobic digestion of lignocellulosic biomasses;
- Low-temperatura anaerobic processes.

Background

Aerobic process VS Anerobic process

Gain:

- High quality effluent
- Operation at environamental temperature

Drawbacks:

- Sludge production (~ 60% operting costs)
- Energy consumption (~ 50% aeration)

Low-strength wastewater

Gain:

- Biogas production
- Negligible sludge production
- No need for external aeration

Drawbacks:

- Lower effluent quality (suspended solids, nutrients)
- Energy consumption for thermal regulation (≥35°C)

High-strength wastewater

Current limitations to anaerobic processes in temperate climate regions for sewage

Anaerobic processes in **mesophilic** conditions: **30-40 °C**

Sewage temperature range: **10-25 °C**

} **1.16 kWh/m³** for 1 °C rise in temperature

Anaerobic processes in **psychrophilic** conditions:

- **Limited hydrolysis** of particulate organic matter
- Reduction of **methanogenesis rate**
- Higher **liquid viscosity** (< substrate diffusivity)
- Limited generation of biogas bubbles (**low mixing**)

\+ **Low-strength wastewater** = High risk of **biomass washout**

Overcome psychrophilic anerobic process limitations

Increase sludge retention time (SRT):

- Anaerobic membrane reactors (AnMBRs) → Energy - Fouling
- Anaerobic biofilter (AF): porous media
- Anaerobic sequencing batch reactors (ASBRs): increase substrate concentration (transient), variable settling phase and water mixing

Proposed approach

Anaerobic biofilter operating in sequential mode for treating sewage or low-strength wastewater

Plant scheme and operation

Sequential mode operation: filling/drawing; reaction; idle

Working volume: 26 L

HRT: 45 h

Up-flow velocity: 2 m/h

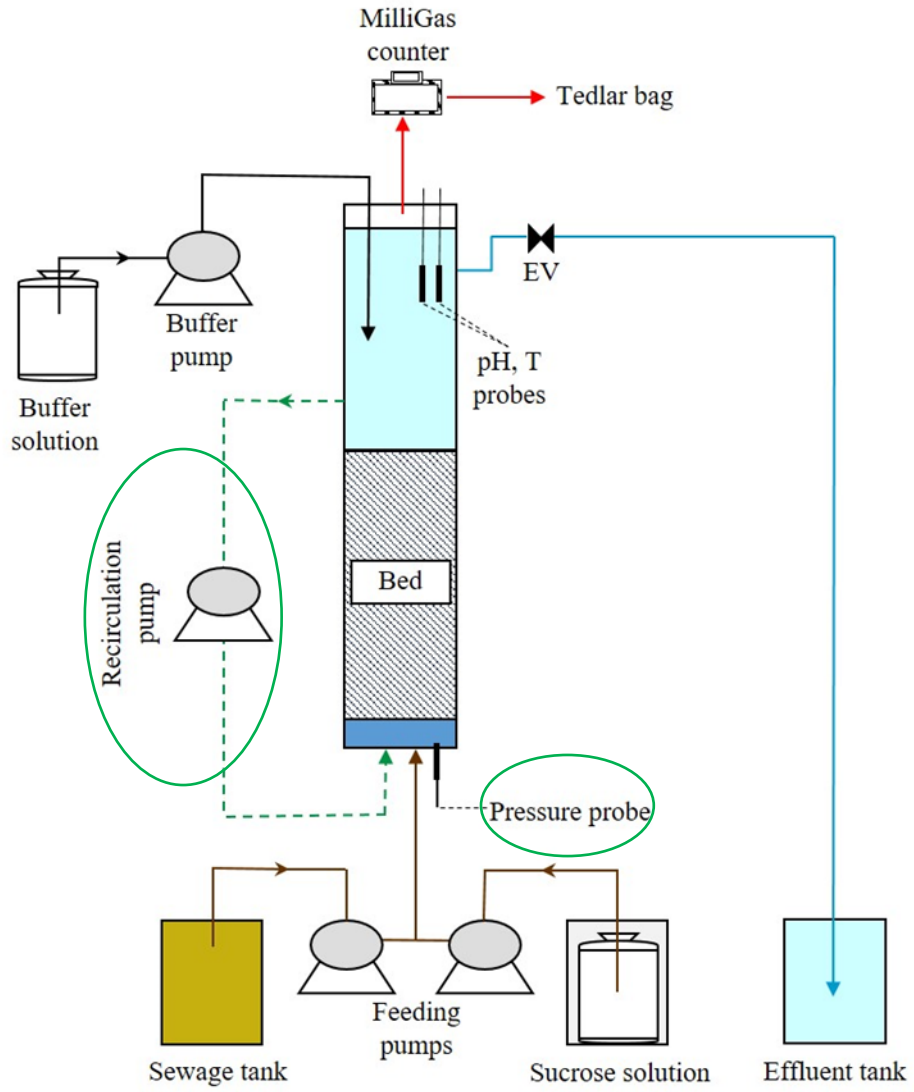
pH: ~ 7

Temperature: environmental condition (14-30°C)

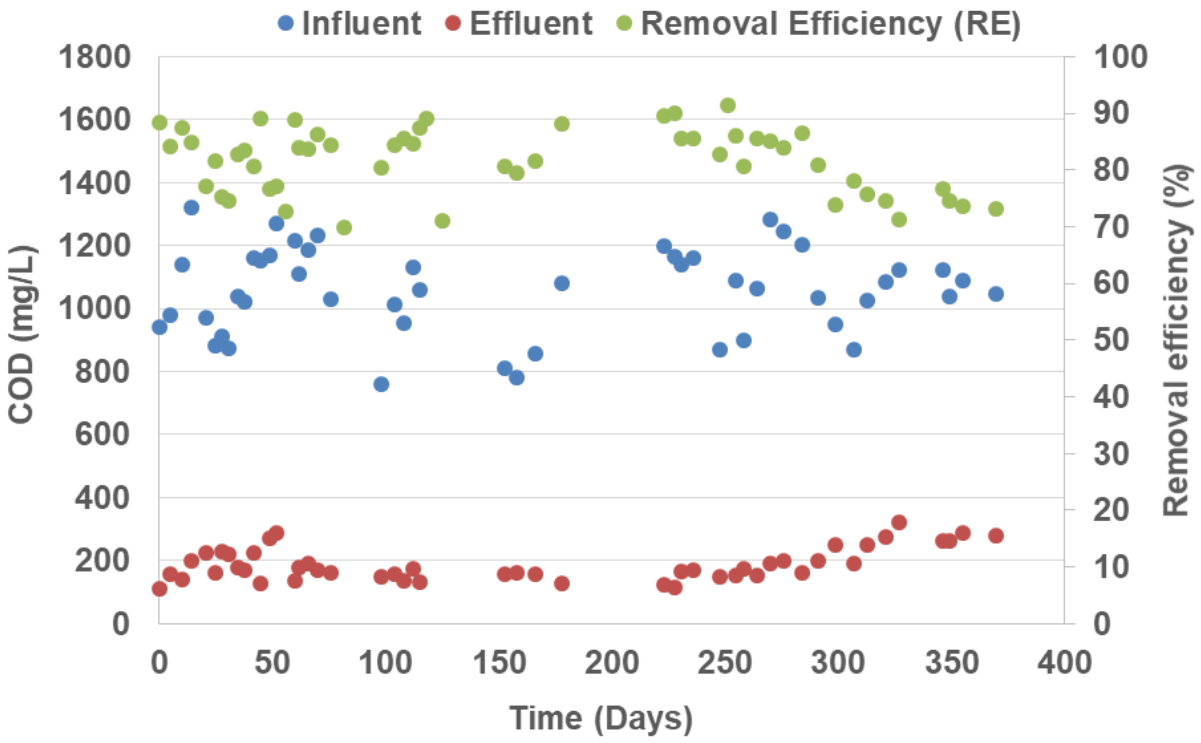
Wastewater composition: sewage + sucrose

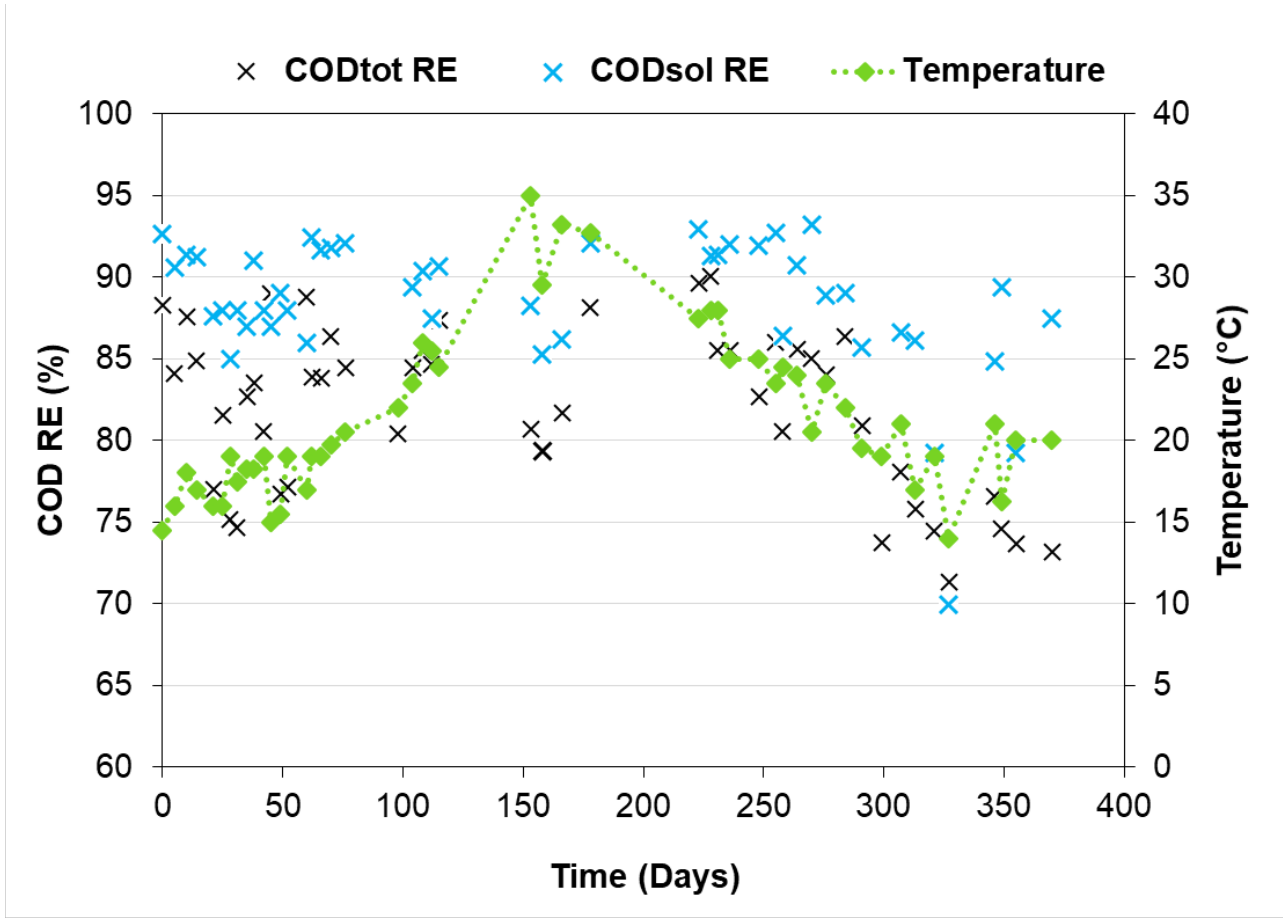
Average OLR: 0.6 kgCOD/m^3·d

COD	TSS	TN	P
1056 ± 137	64 ± 46	27 ± 9	5 ± 2

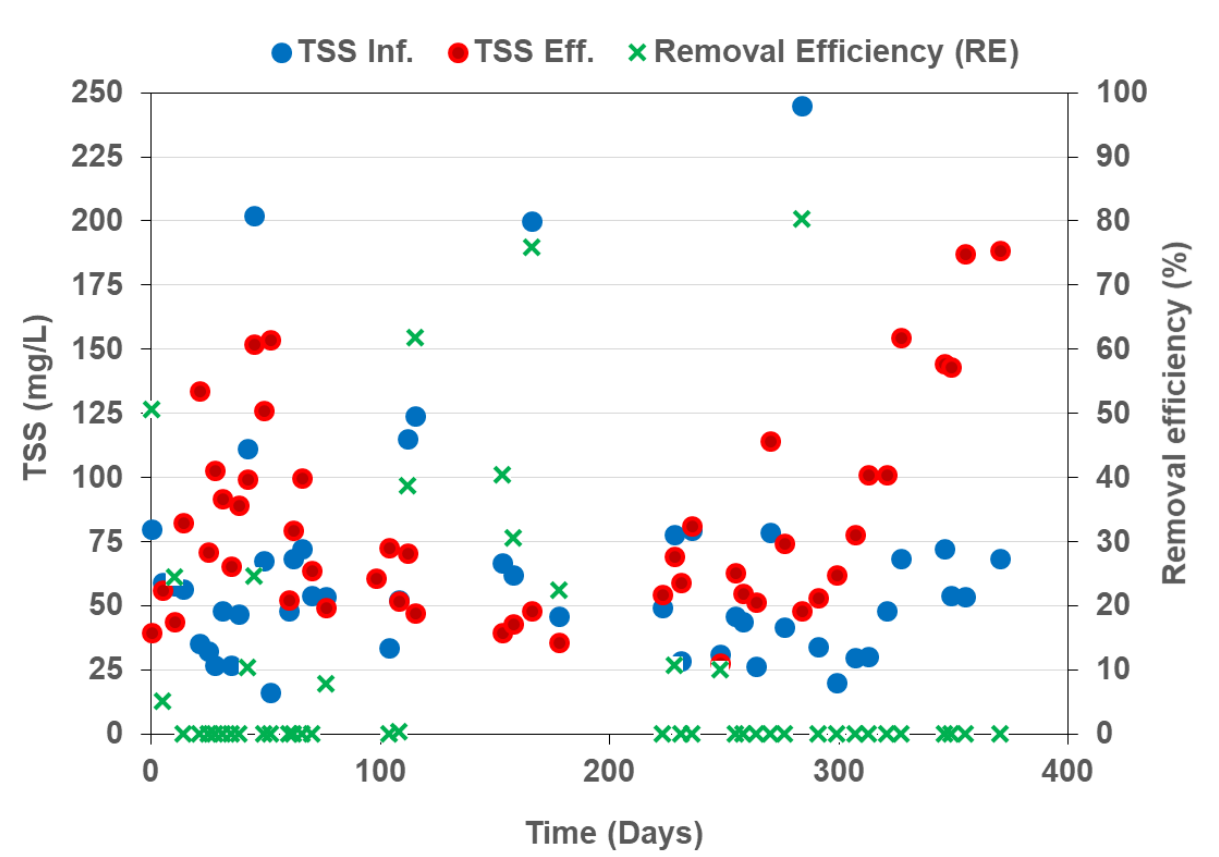


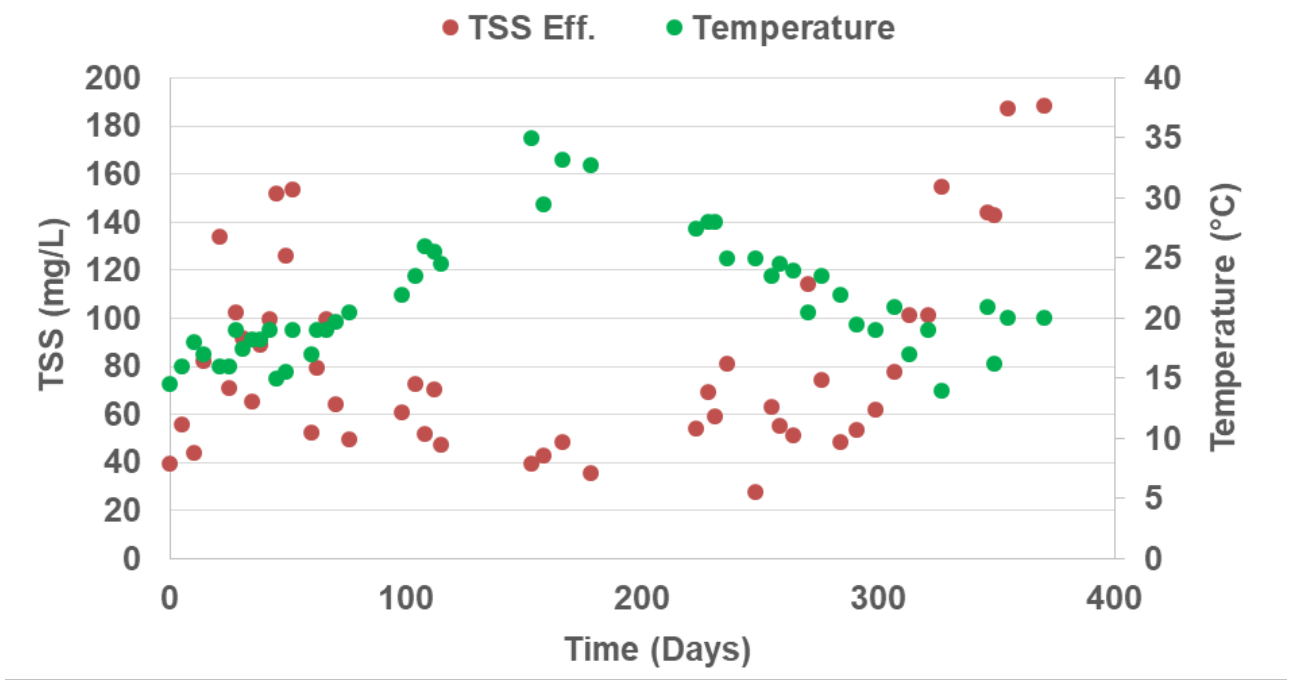
Results: COD


Influent
Effluent
Removal Efficiency (RE)
COD (mg/L)
Removal efficiency (%)
Time (Days)
0
200
400
600
800
1000
1200
1400
1600
1800
0
10
20
30
40
50
60
70
80
90
100
0
50
100
150
200
250
300
350
400


CODtot RE
CODsol RE
Temperature
COD RE (%)
Temperature (°C)
Time (Days)
60
65
70
75
80
85
90
95
100
0
5
10
15
20
25
30
35
40
0
50
100
150
200
250
300
350
400

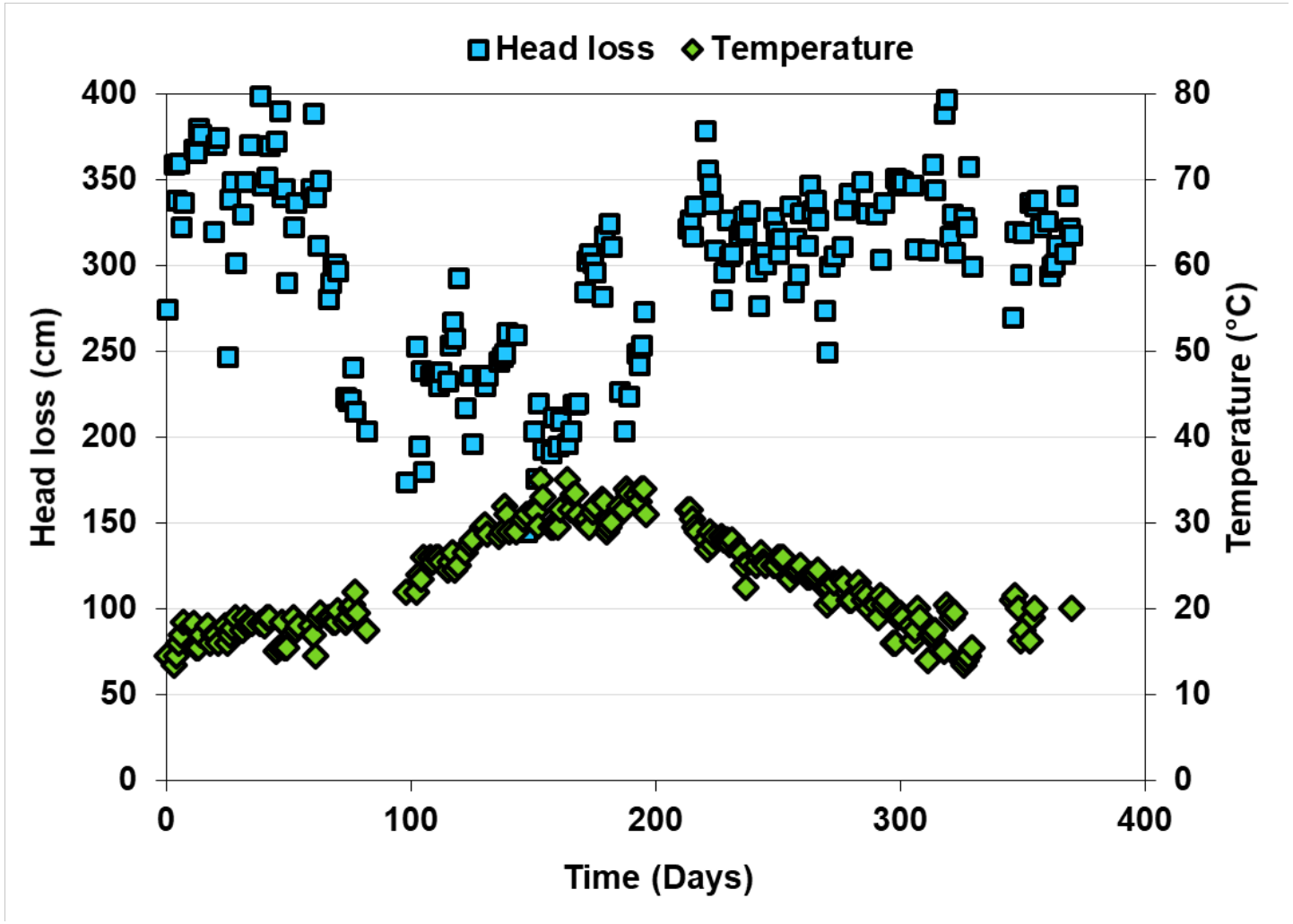
Results: TSS





Sewage and effluent TSS/VSS: 96%

Results: Biofilter porosity vs temperature



Cold seasons: Biomass, TSS, EPS accumulation in the biofilter

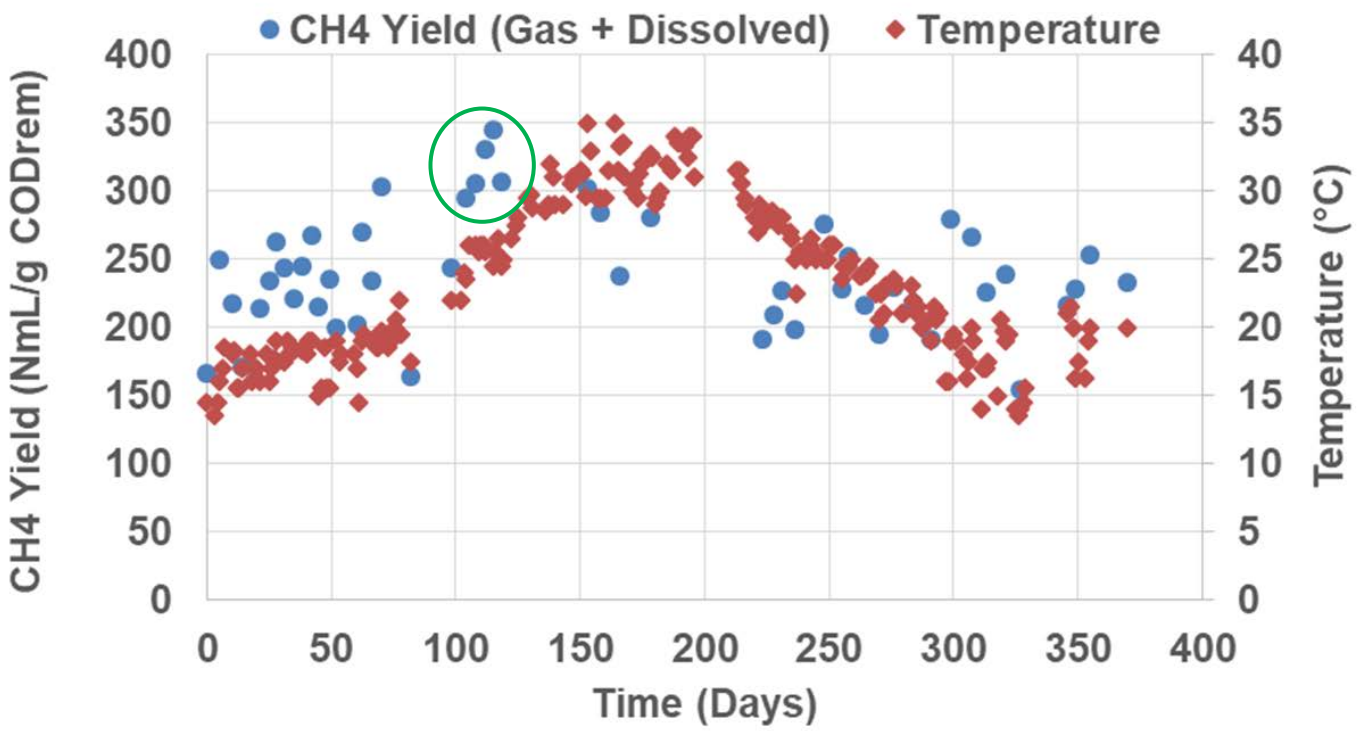
↓

Shear forces increase

↓

Balance head loss increase with biomass release into effluent

Results: Biogas production



Biogas composition (%)	
CH_4	86 ± 5
CO_2	5 ± 2
N_2	5 ± 2
O_2	2 ± 1
H_2	< 0.1
H_2S	< 0.1

Dissolved methane: 32-47 NmL/gCOD_{rem}

Conclusions…

- Seasonal temperature fluctuations did not inhibit microbial activity;
- Biofilter head losses and methane yield suggest accumulation and hydrolysis of particulate organic matter during cold and warm seasons, respectively;
- Due to its self-regulation mechanism, the plant does not require maintenance operations;
- The plant ensured high-quality biogas (86% CH_4) generation from low-strength wastewaters.

THANK YOU FOR THE ATTENTION

ANY QUESTION?

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