Impact of hydraulic retention time and temperature on an anaerobic moving bed biofilm reactor treating brewery wastewater

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High-rate processes for industrial wastewater

Industry needs:

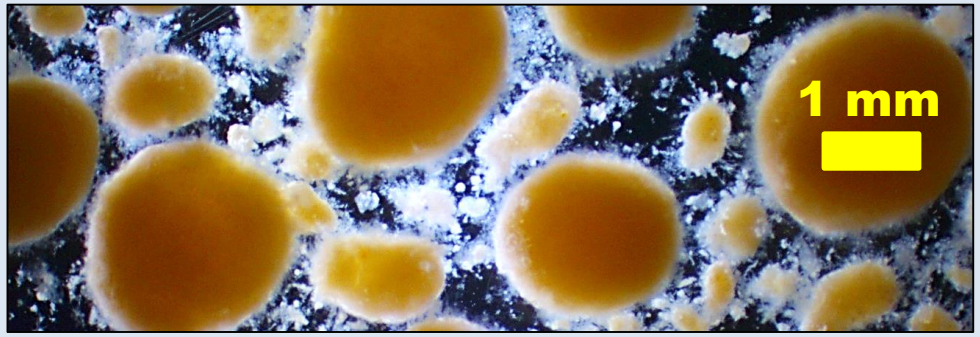
Small footprint

High capacity

Anaerobic digestion requires:

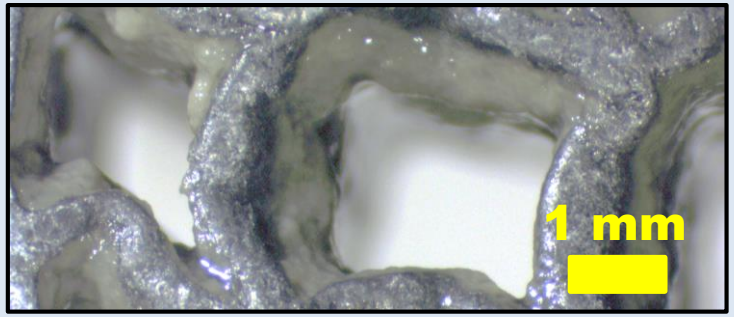
Long SRT

1) High settleable sludge aggregates

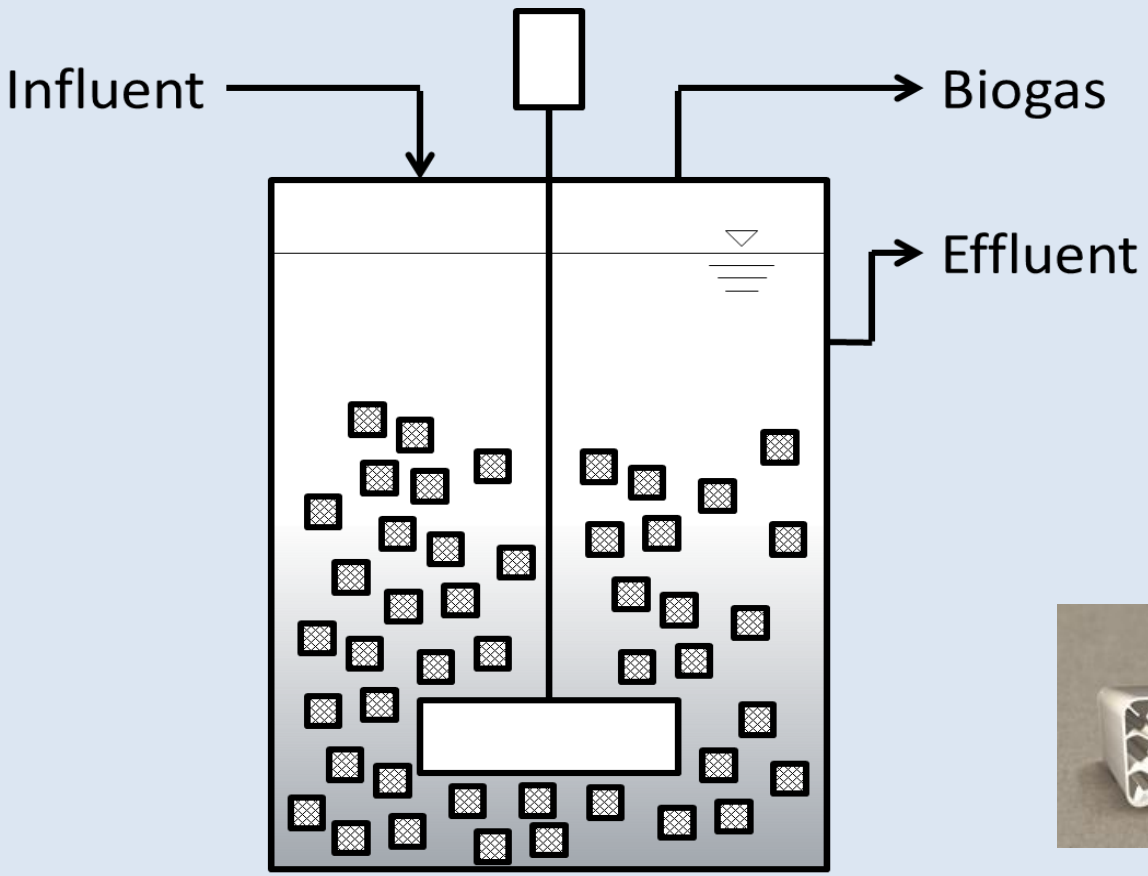


2) Biofilm on high-density carriers

3) Biofilm on packing material



Anaerobic moving bed biofilm reactor



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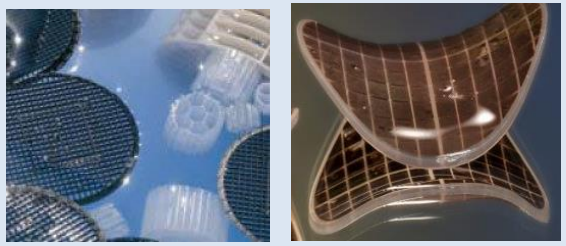


www.veolia.com

Headworks
INTERNATIONAL

www.headworksinternational.com

Umwelttechnologie AG

www.mutag-biochip.com

Objectives

- **Examine performance under:**
  - **Increasing organic loading (4 to 22 kg sCOD/m^3 d)**
  - **Decreasing hydraulic retention time (24 to 6 h)**
  - **A range of temperatures (35 to 15 ^oC)**
- **Performance measures:**
  - **COD removal and surface area loading rates (SALR)**
  - **Gas production/composition**
  - **Suspended/attached solids**
- **Develop design parameters**

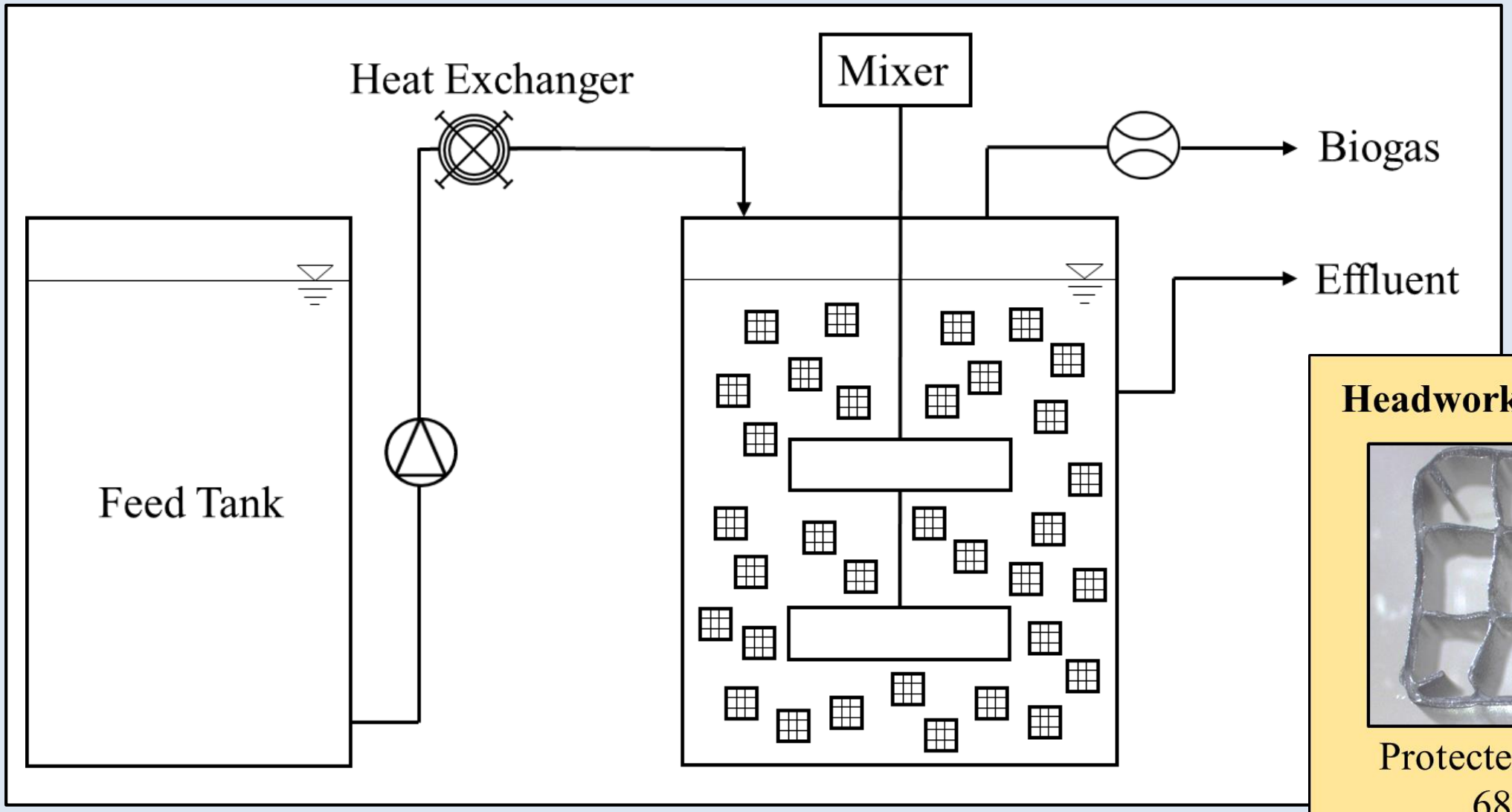
Brewery wastewater

- Rich in organic carbon
- Valuable for biogas production

	Typical brewery wastewater	Fort Garry Brewery	Limit for sewer discharge	
			Winnipeg (Canada) [1]	Veneto (Italy) [2]
BOD_5 (g/L)	**1 – 3.5**	**5**	**0.3**	**0.25**
COD (g/L)	**2 – 6**	**7**	**0.45**	**0.5**
TSS (g/L)	**0.2 – 1**	**0.4**	**0.35**	**0.2**
pH	**4.5 – 12**	**4 – 11**	**5.5 – 9.5**	**5.5 – 9.5**
Temperature	**24 – 30.5**	**N.A.**	**-**	**-**

[1] City of Winnipeg (Canada) bylaw No.92/2010
[2] D. Lgs. 152/06 (Parte Terza, Allegato 5, Tabella 3) for Veneto Province

Setup – Hydraulic retention time (HRT)



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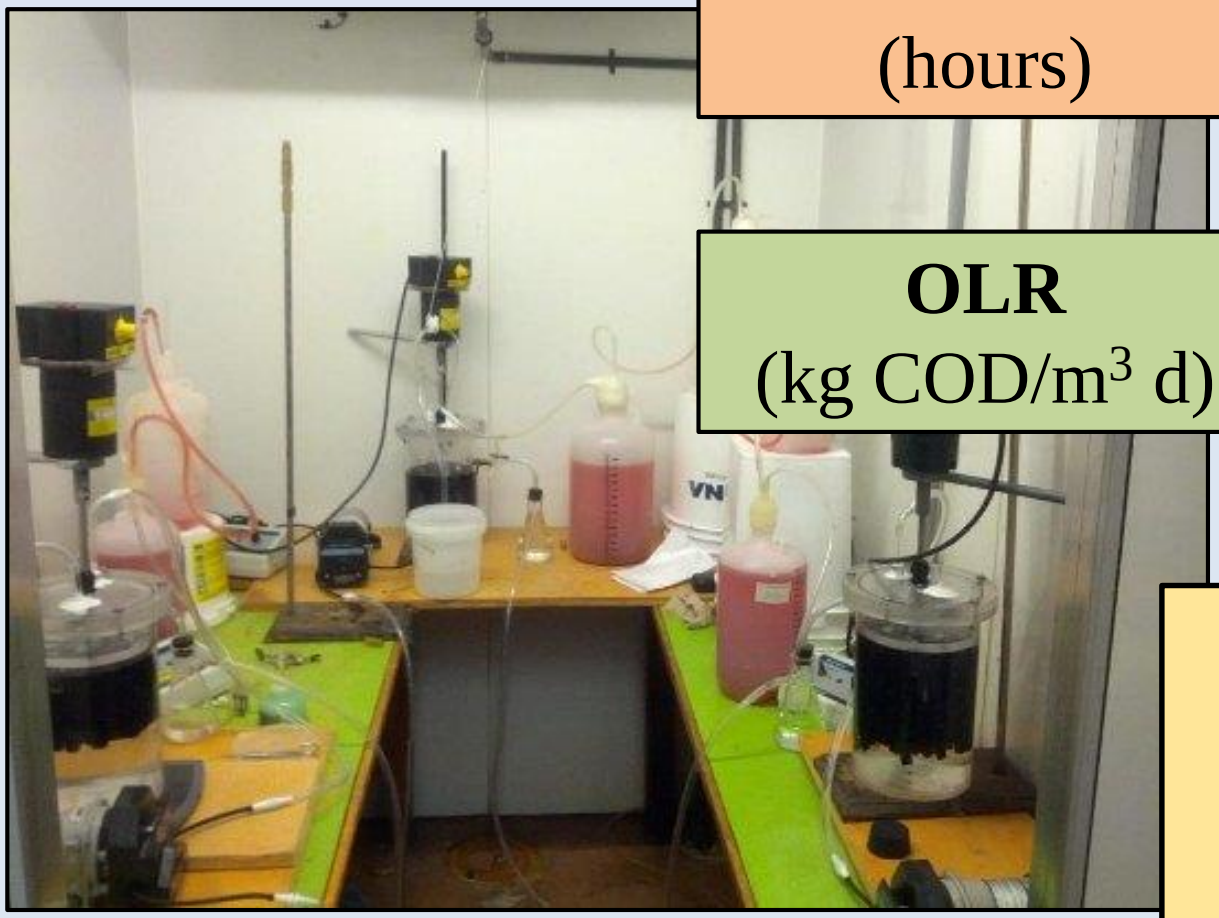
Protected surface area
680 m^2/m^3

Setup – HRT & OLR



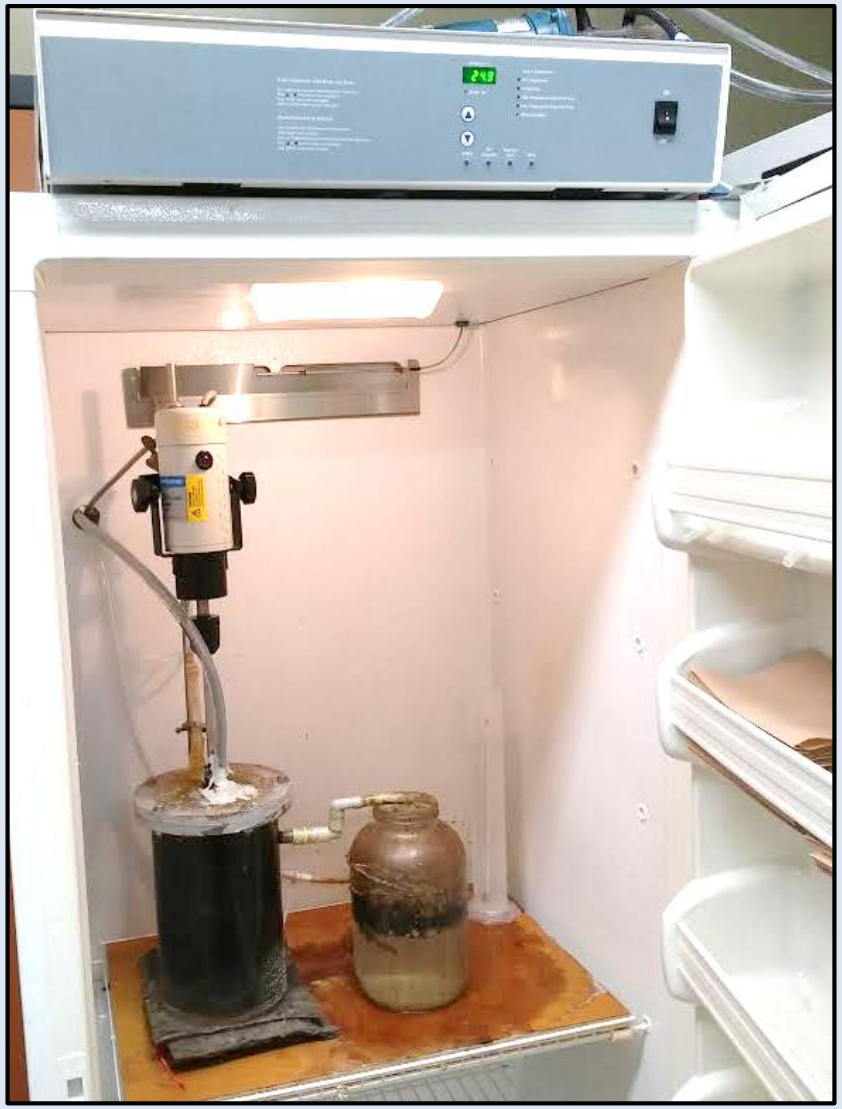
HRT (hours)	24	18	12	10	8	6
OLR (kg COD/m^3 d)	4	5.5	10	14	21	22

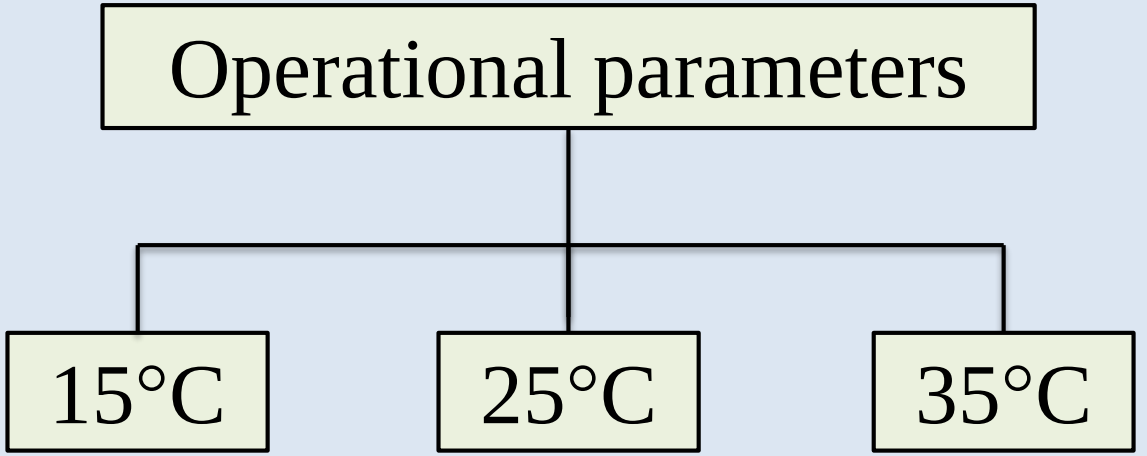
Three reactors (4L):

40 % media fill

1.1 m^2 available surface area

Setup – Temperature (T°C)



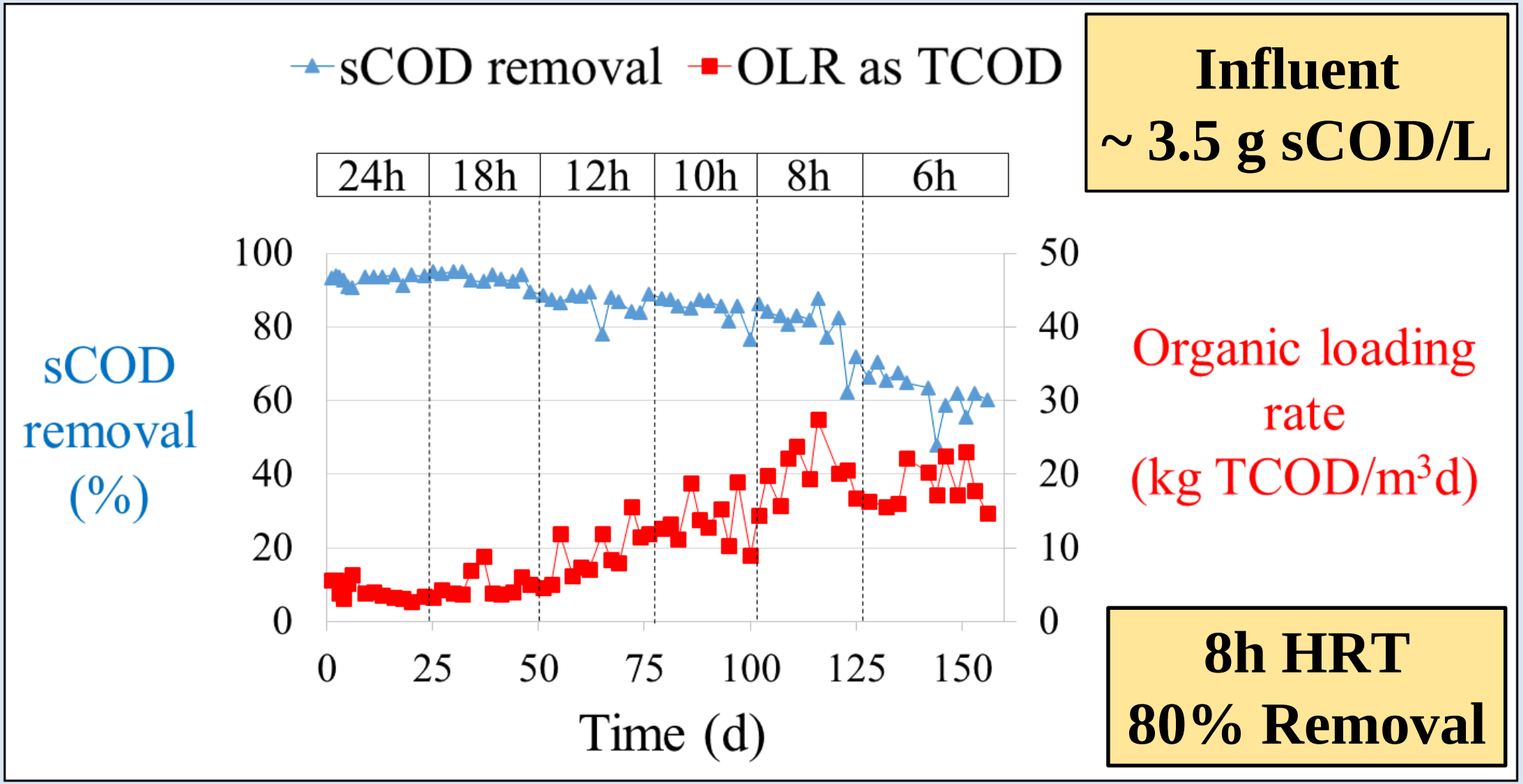


Three reactors (4L):

50 % Media fill

1.4 m² available surface area

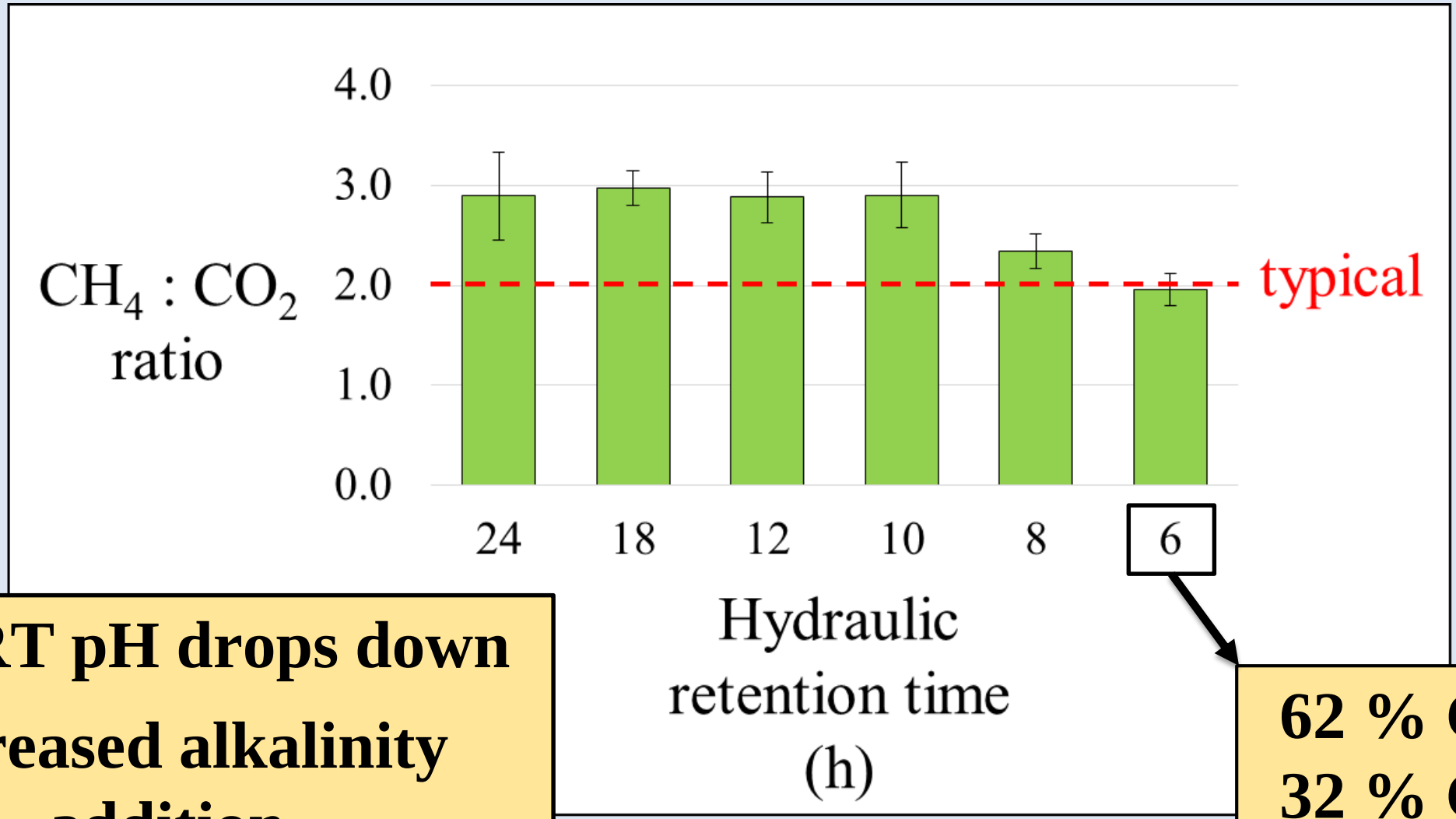
Performance – HRT



Influent
~ 3.5 g sCOD/L

8h HRT
80% Removal

Process efficiency – HRT

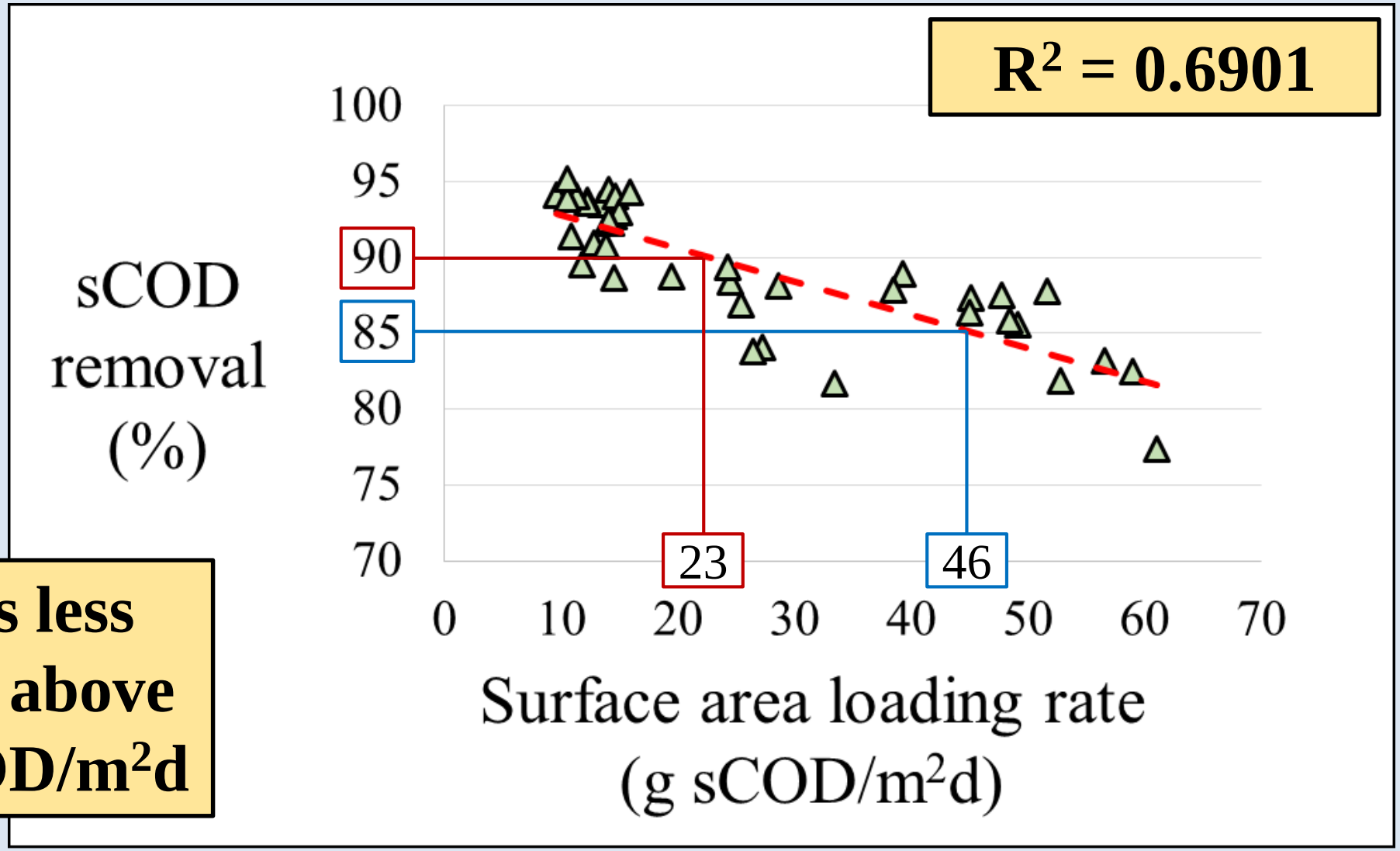


8h HRT pH drops down

Increased alkalinity addition

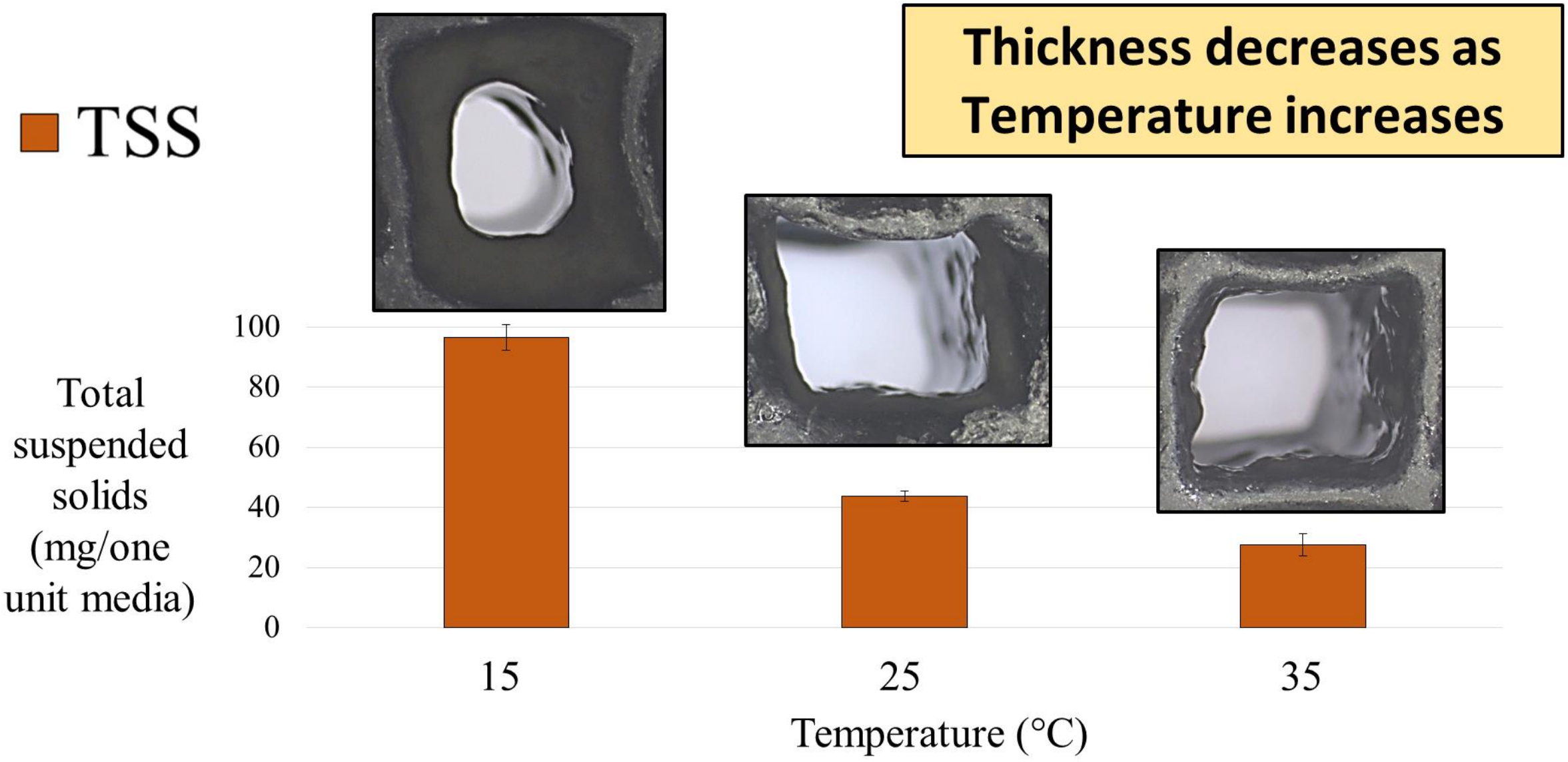
62 % CH_4
32 % CO_2

Engineering significance – HRT



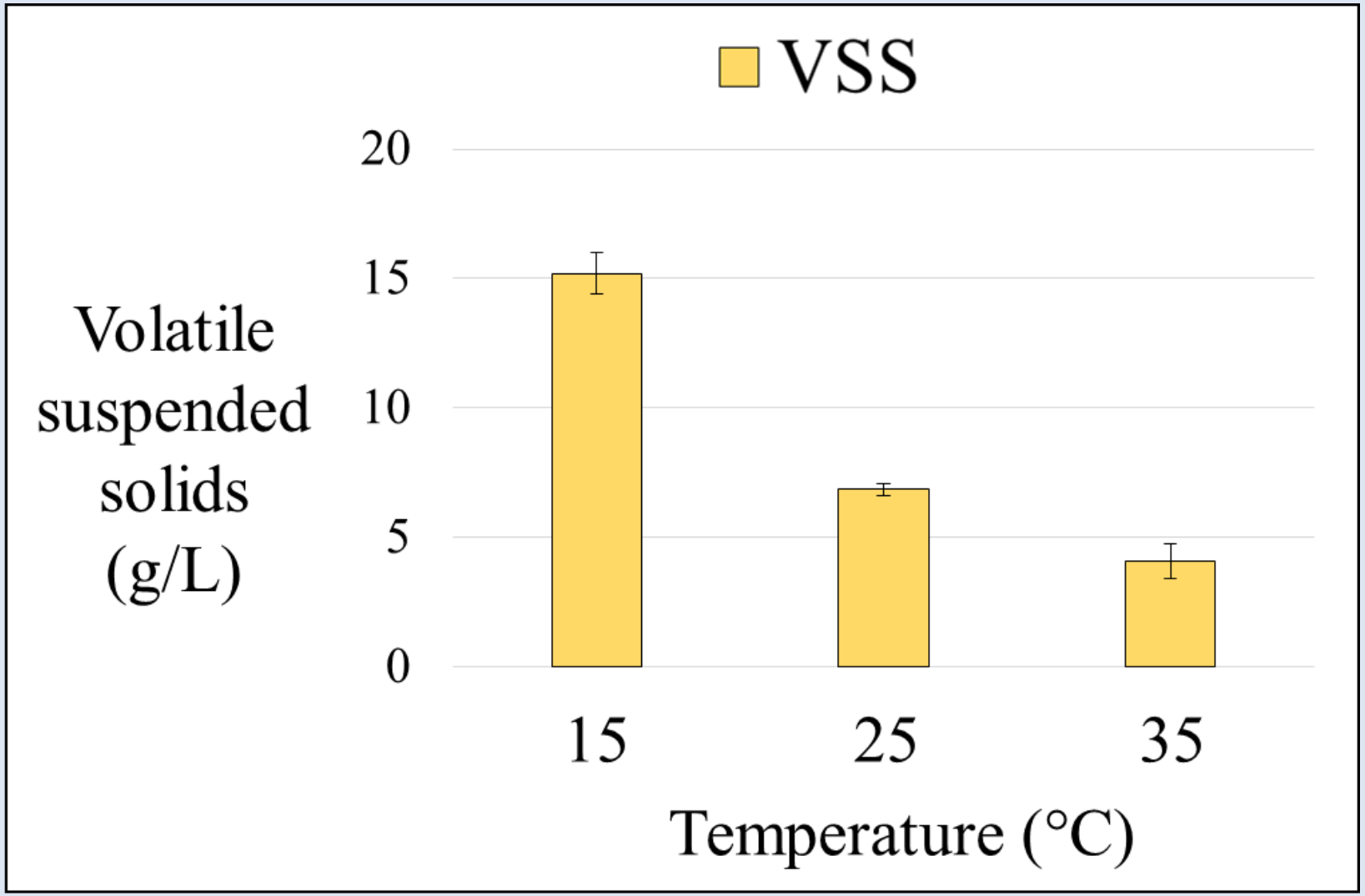
Process less efficient above 50 g sCOD/m²d

Attached solids – T°C



UASB Vs AMBBR solids – T°C

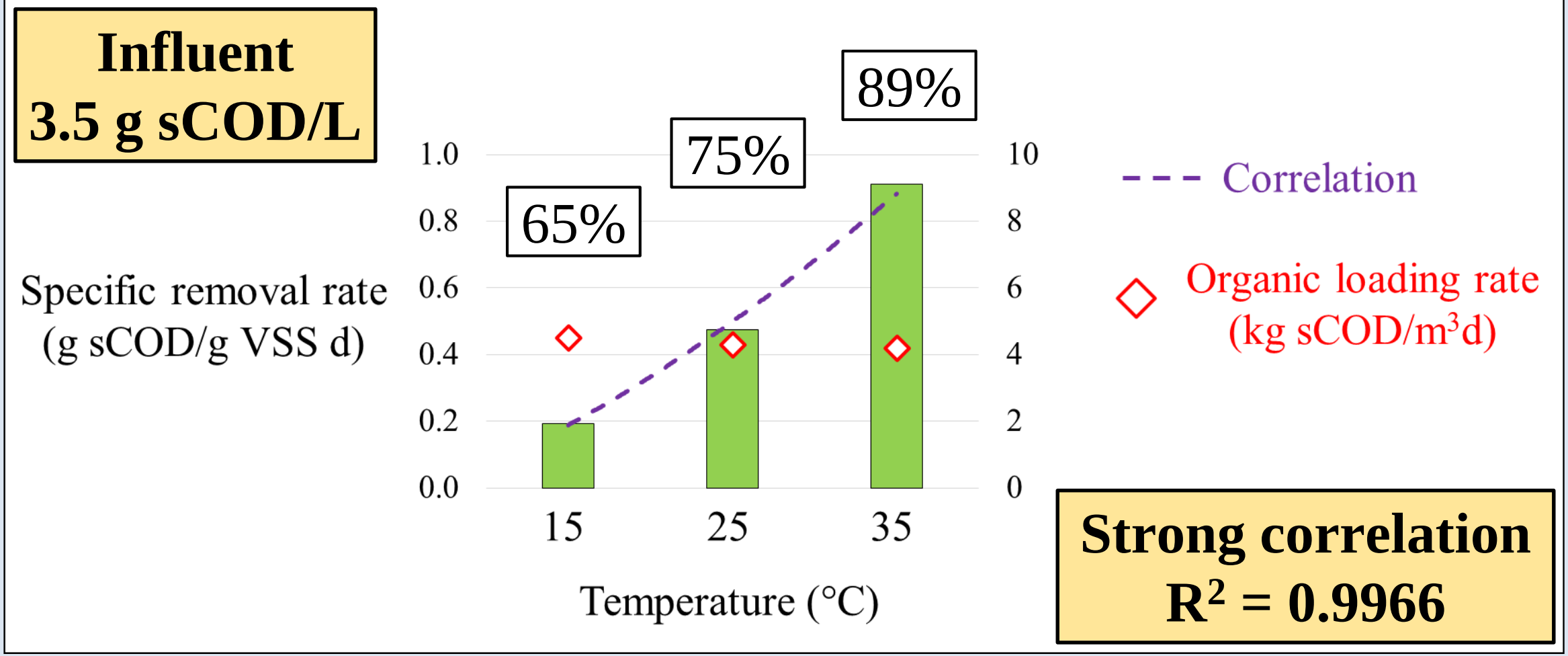
Upflow anaerobic sludge blanket* ~ 6.2 g VSS/L at room temperature (19-24 °C) with organic loading rate of 3 kg COD/m³d



* Cronin (1998) "Anaerobic treatment of brewery wastewater using a UASB reactor seeded with activated sludge". Bioresource Technology 64; 33-38.

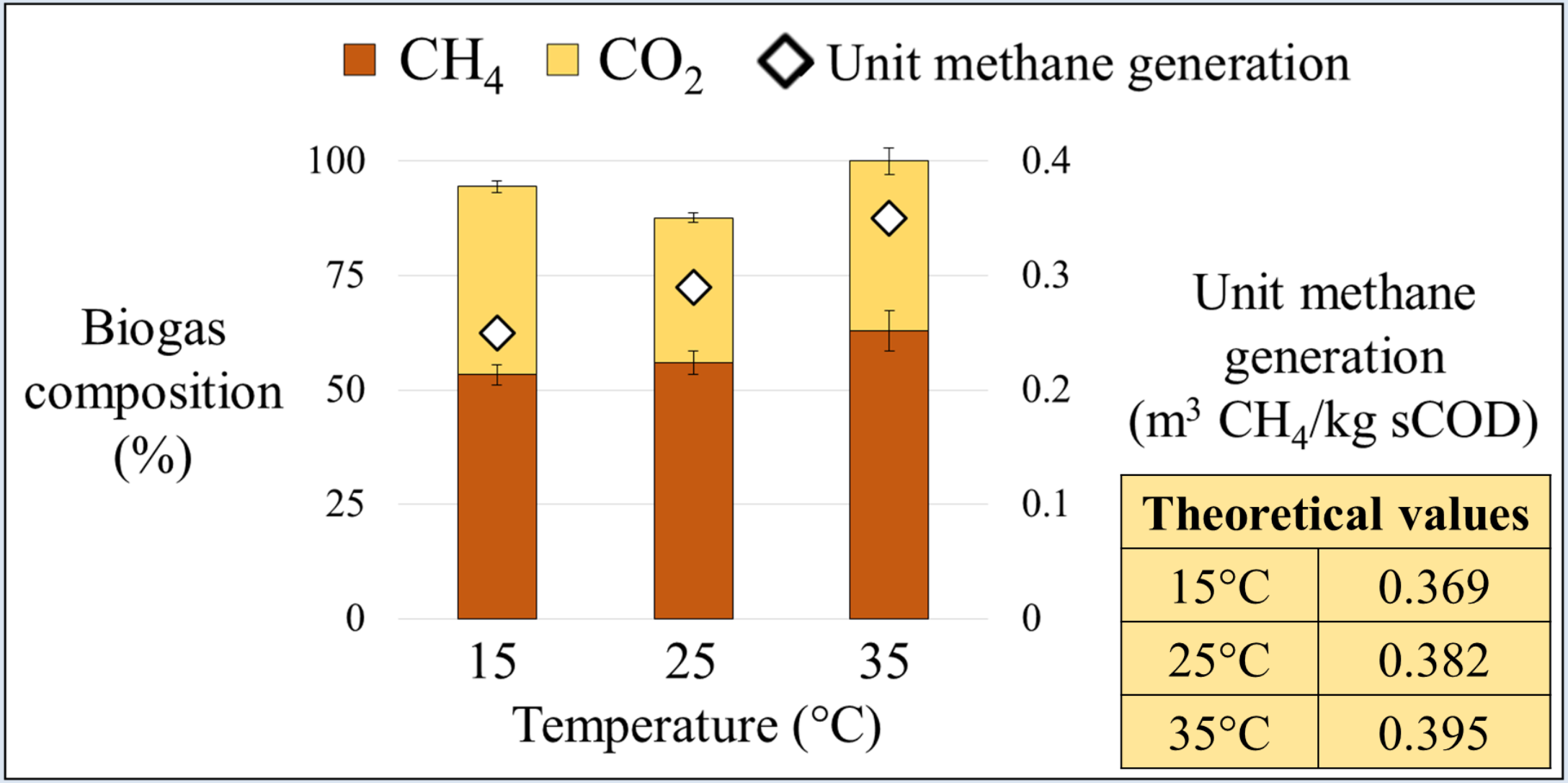
Performance – T°C

Influent
3.5 g sCOD/L



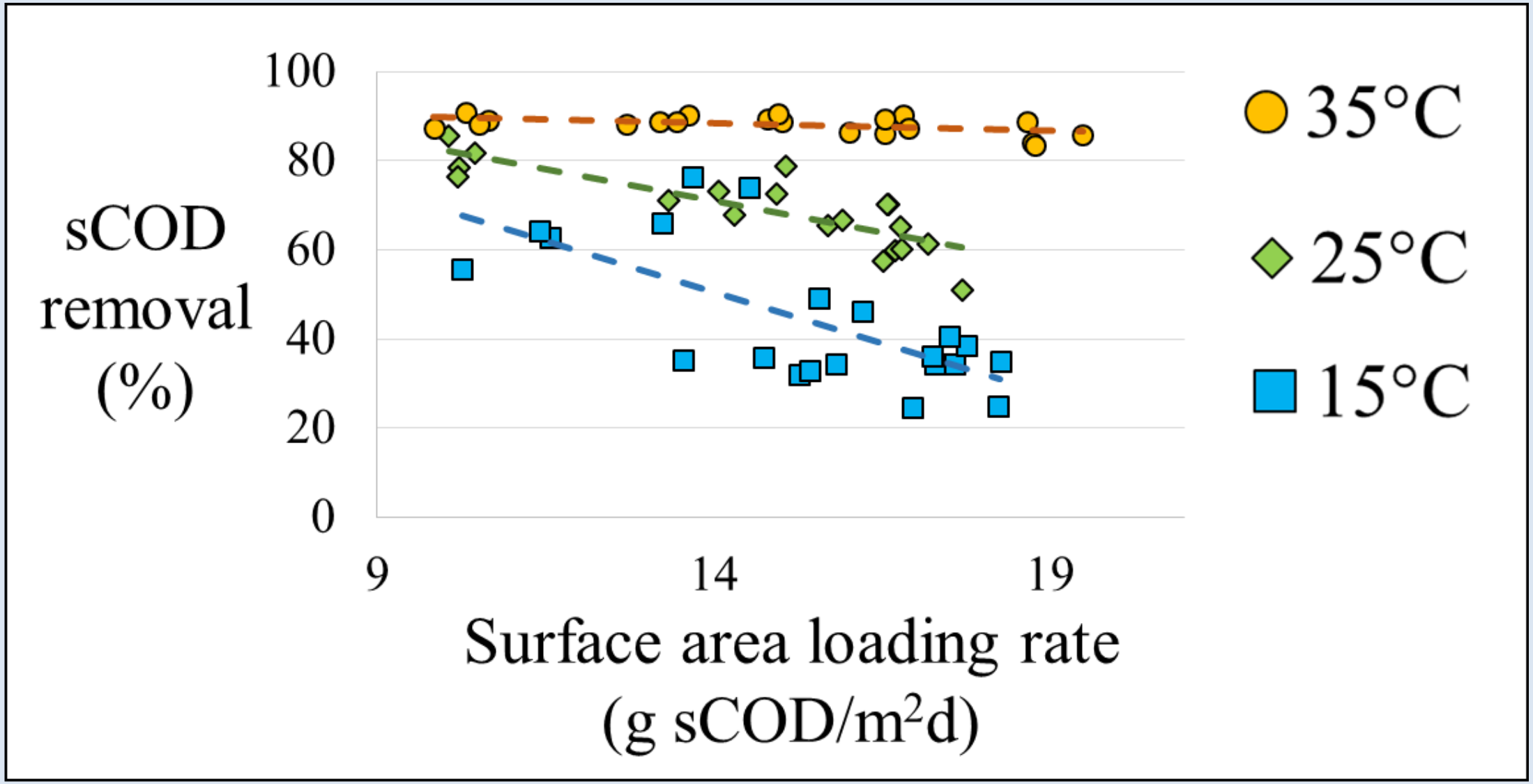
Strong correlation
R^2 = 0.9966

Biogas – T°C



Theoretical values	
15°C	0.369
25°C	0.382
35°C	0.395

Engineering significance – T°C



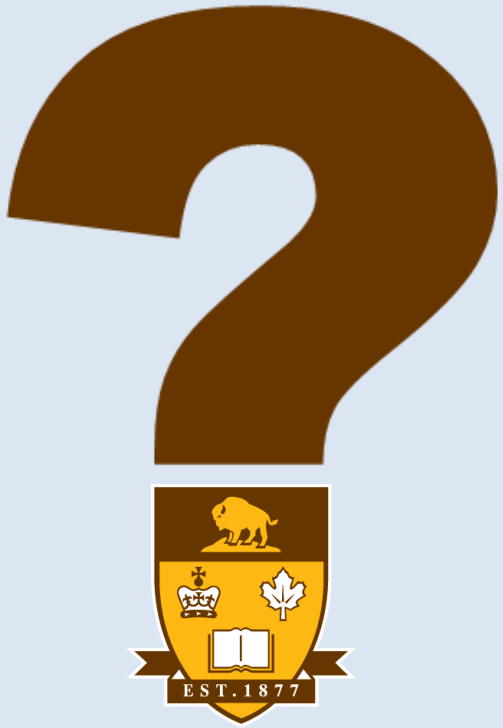
Conclusions

- **At organic loading rates above 20 kg sCOD/m^3 d methanogenesis started to be decoupled from fermentation**
- **80% COD removal with a methane yield of 0.36 m^3 CH_4/kg COD_{rem}**
- **Surface area loading rates must not exceed 50 g sCOD/m^2d**

At typical brewery wastewater temperature of 28°C:

- **Methane yield of 0.31 m^3 CH_4/kg COD_{rem} is expected**
- **Surface area loading rates of 11 g sCOD/m^2d will ensure 80% sCOD removal**

Questions?



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