

# Effect of thermal and thermo-chemical pre-treatments on OFMSW anaerobic digestion

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# Background


- Nowadays waste disposal in landfills is more and more limited, nevertheless 12% global  $\text{CH}_4$  emissions are related to organic waste landfilling.
- According to European Union 65% of municipal solid waste (MSW) must be recycled by 2035.
- 486 Kg of MSW per capita (Eurostat, 2019).
- Organic Fraction of Municipal Solid Waste (OFMSW) represent 40–60% of the MSW produced in EU (Eurostat, 2019).

# Background

**OFMSW composition:** Domestic kitchen – Restaurants wastes  
Gardening wastes  
Farmers market or supermarkets wastes  
Other domestic wastes

**Current strategies for OFMSW in EU:** 64% anaerobic digestion  
26% composting  
10% other treatments

# Current limitations OFMSW as feed for mesophilic anaerobic digestion (AD)

- Contains recalcitrant or slowly-degradable compounds
  - High percentage of particulate organic matter
  - High heterogeneity
- 
- Hydrolyzation represents the rate-limiting step of AD process
  - Limited overall AD effectiveness
  - Typical hydraulic retention time (HRT) in the range: 15-20 d

## Proposed approach

Thermal and thermo-chemical pre-treatment in order to improve organic matter solubilization or enhance particulate organic matter biodegradability

# Test conditions

**Working volume:** 700 mL

**HRT:** 19 d

**Temperature:**  $35 \pm 1$  °C

**Composition:** diluted OFMSW + sewage (Blank: Sewage + tap water)

**F/M** ~ 1:1 (VS/VS)

## Investigated pre-treatment:

- Shredding
- Shredding + thermal treatment (121°C, 20 min)
- Shredding + thermo-alkali (NaOH) treatment (121°C, 20 min, pH: 10)
- Shredding + thermo-acid (HCl) treatment (121°C, 20 min, pH: 2)



# OFMSW characterization (after shredding)

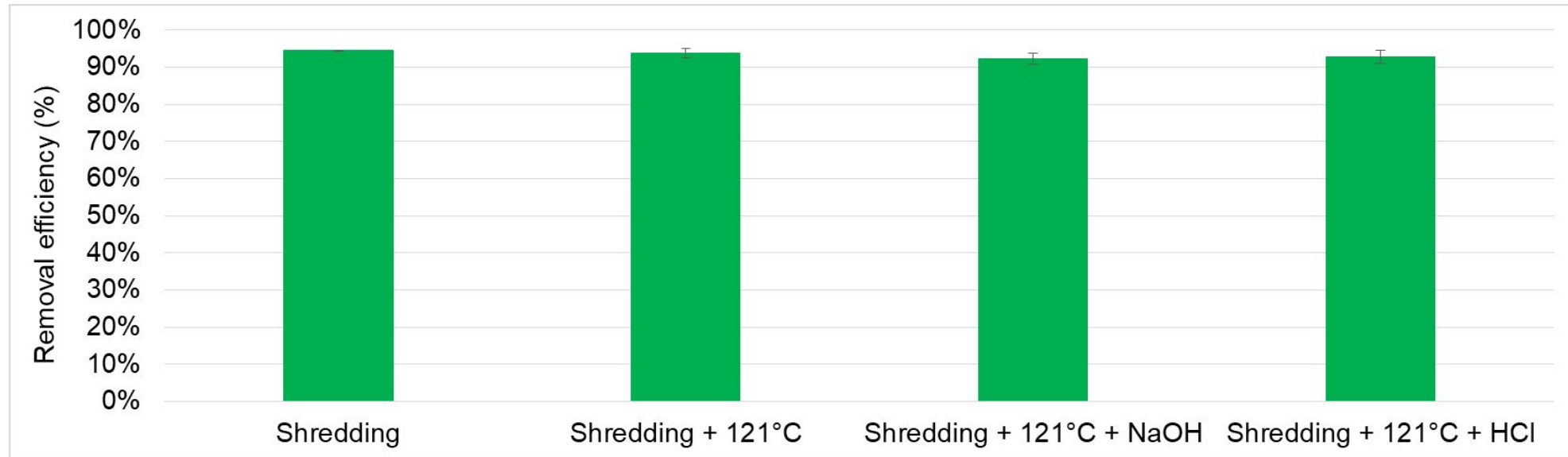
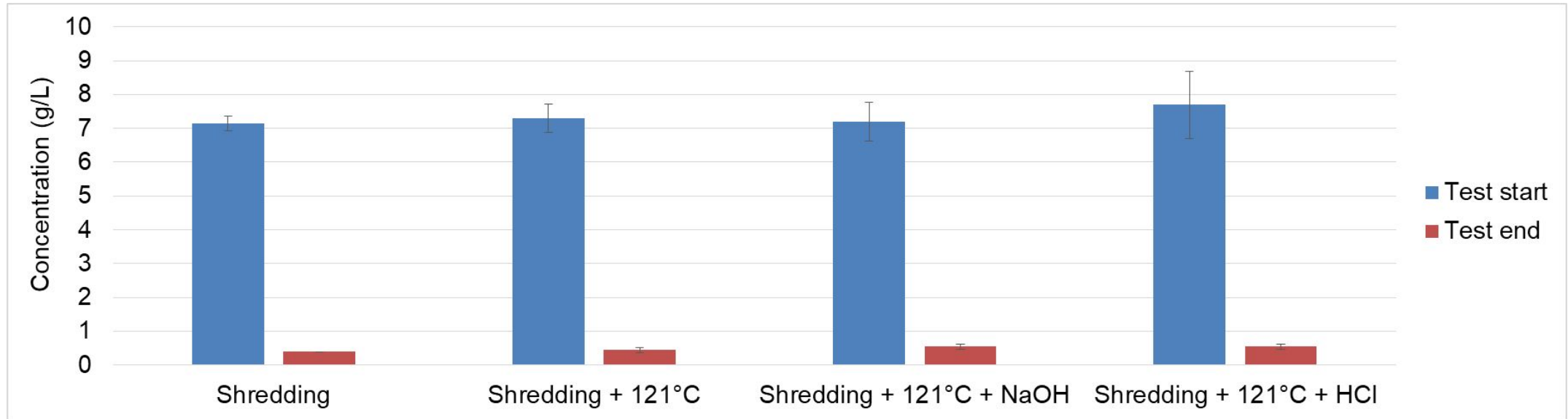
Parameter	Average $\pm$ St. dev.
<b>COD (g/L)</b>	280.5 $\pm$ 134.9
<b>sCOD (g/L)</b>	155.0 $\pm$ 79.8
<b>TN (g/L)</b>	3.27 $\pm$ 1.71
<b>TP (g/L)</b>	0.34 $\pm$ 0.12
<b>TSS (g/L)</b>	108.3 $\pm$ 51.8
<b>VSS/TSS (%)</b>	100% $\pm$ 0%
<b>TS (g/L)</b>	176.2 $\pm$ 36.9
<b>VS/TS (%)</b>	98% $\pm$ 2%

Parameter (%VS)	Average $\pm$ St. dev.
<b>Grease</b>	8.3 $\pm$ 1.2
<b>Starch/Hemicellulose</b>	25.8 $\pm$ 3.1
<b>Cellulose</b>	7.1 $\pm$ 1.5
<b>Lignin</b>	10.7 $\pm$ 2.3
<b>Galacturonic acid</b>	6.1 $\pm$ 0.9
<b>Glucose</b>	3.3 $\pm$ 0.4
<b>Fructose</b>	5.6 $\pm$ 0.6

# Substrate characterization: pre-treatment effect

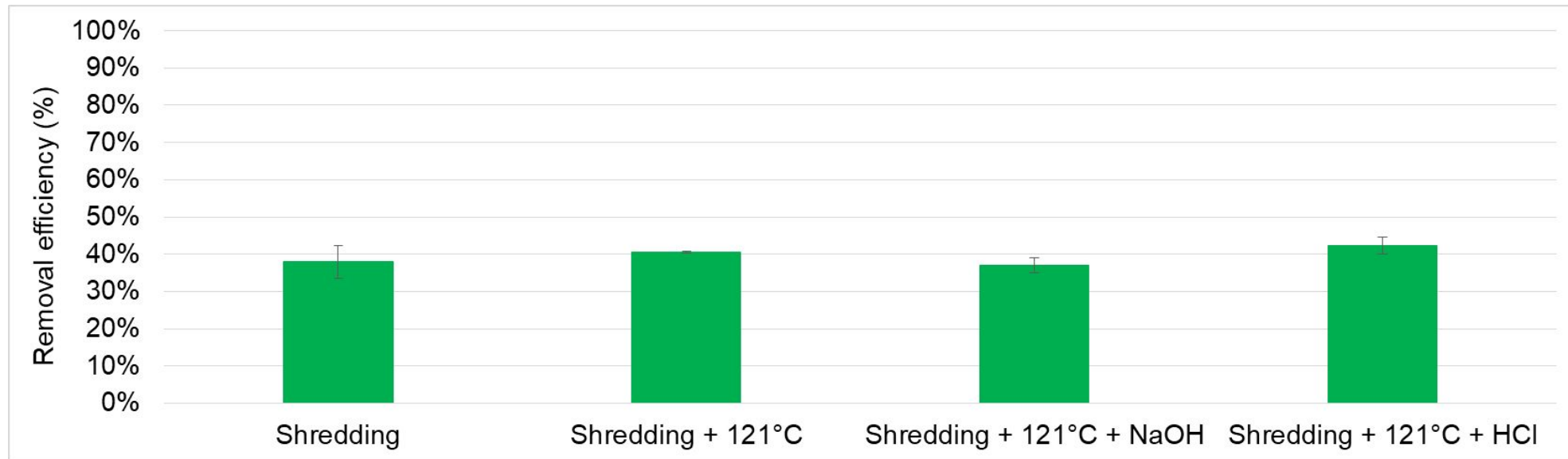
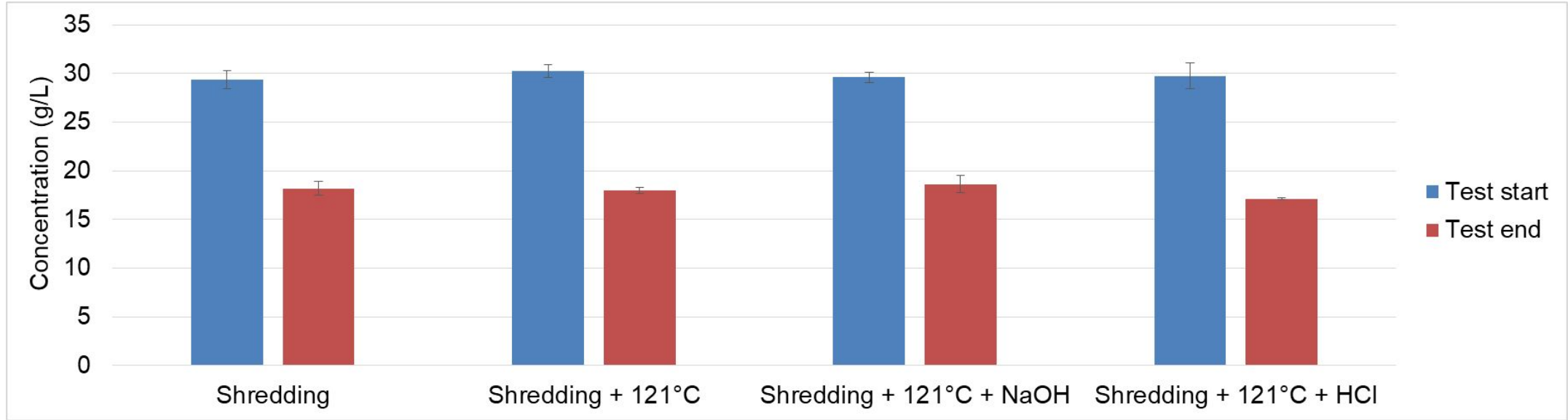
	Shredding	Thermal	Thermo-alkali	Thermo-acid
Parameter	Mean ± St. dev.	Mean ± St. dev.	Mean ± St. dev.	Mean ± St. dev.
Conductivity (µS/cm)	1321 ± 9	1662 ± 5	2805 ± 21	3795 ± 50
COD (g/L)	26.9 ± 0.9	26.8 ± 0.9	26.5 ± 0.0	26.7 ± 2.1
<b>sCOD/COD (%)</b>	<b>56.2 ± 1.9</b>	<b>57.6 ± 5.2</b>	<b>58.5 ± 1.6</b>	<b>63.6 ± 0.7</b>
TSS (g/L)	10.4 ± 0.6	9.2 ± 1.1	8.5 ± 0.3	7.5 ± 1.6
SSV/SST (%)	100 ± 0	97 ± 4	100 ± 0	100 ± 0
ST (g/L)	14.5 ± 0.9	15.1 ± 0.7	15.1 ± 0.3	15.2 ± 0.0
SV/ST (%)	96 ± 1	97 ± 2	92 ± 1	89 ± 2
<b>VSS/VS (%)</b>	<b>74.5 ± 0.8</b>	<b>62.5 ± 8.7</b>	<b>61.2 ± 1.4</b>	<b>55.6 ± 12.7</b>

# Results: soluble COD

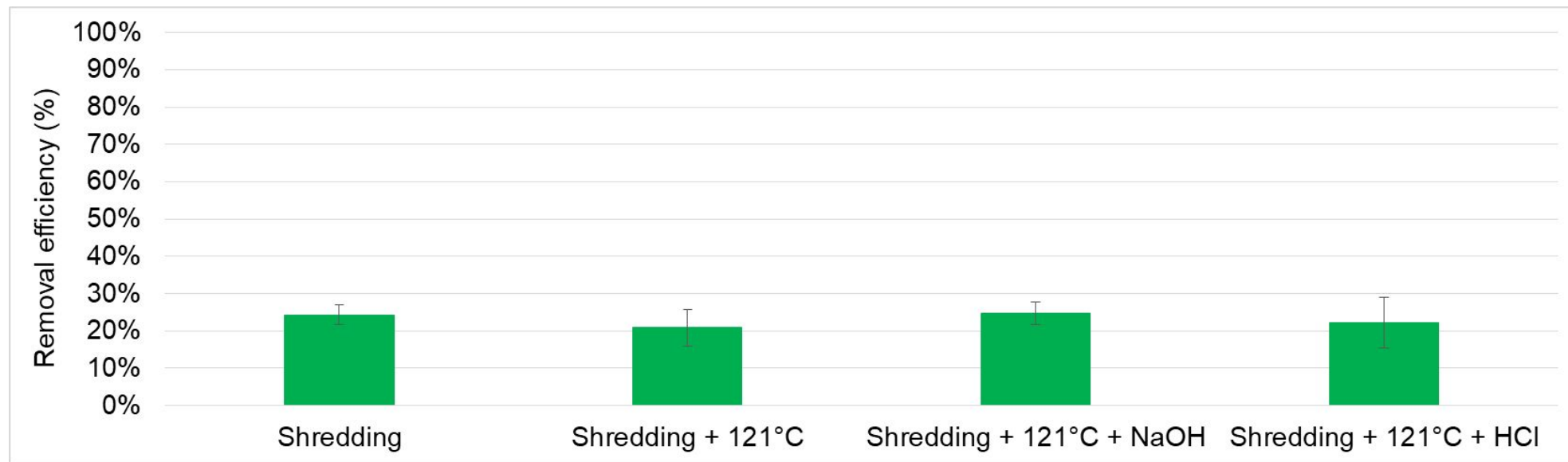
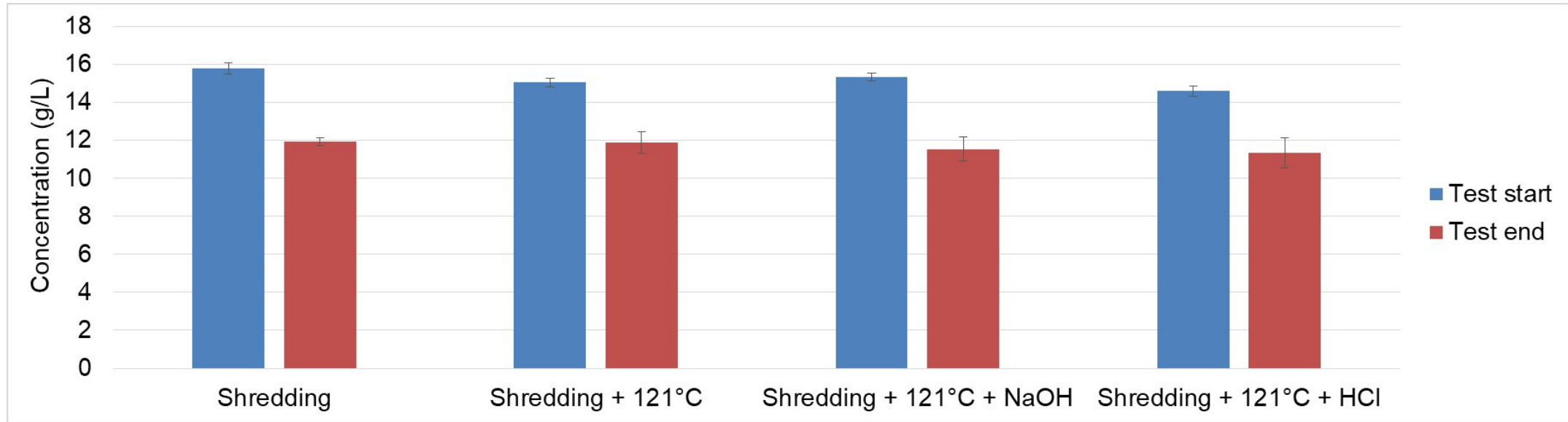




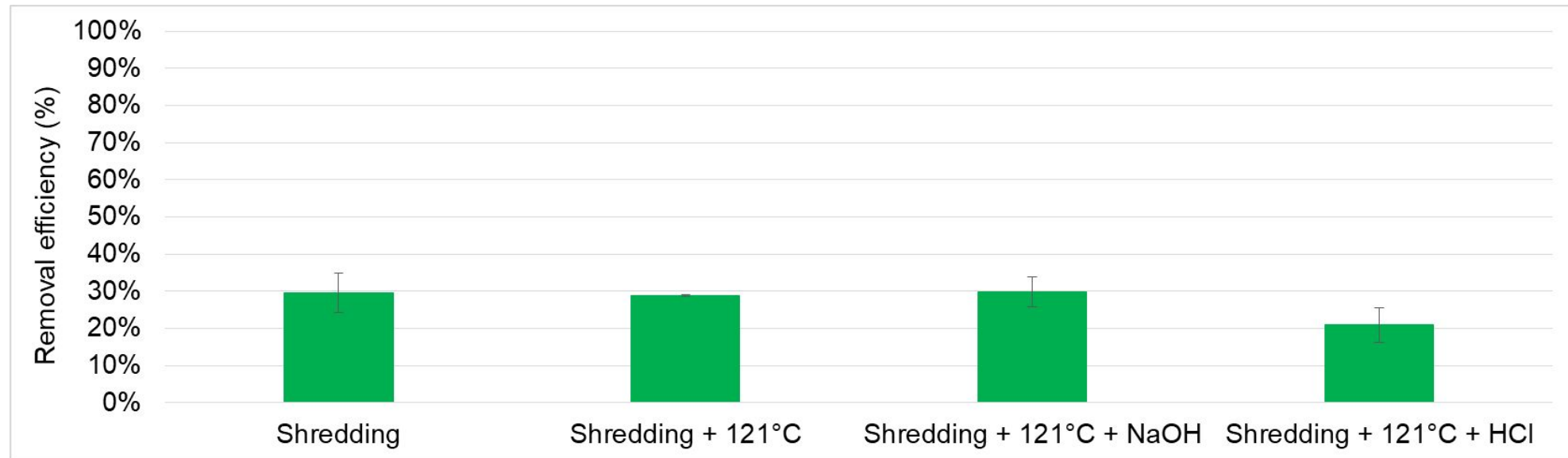
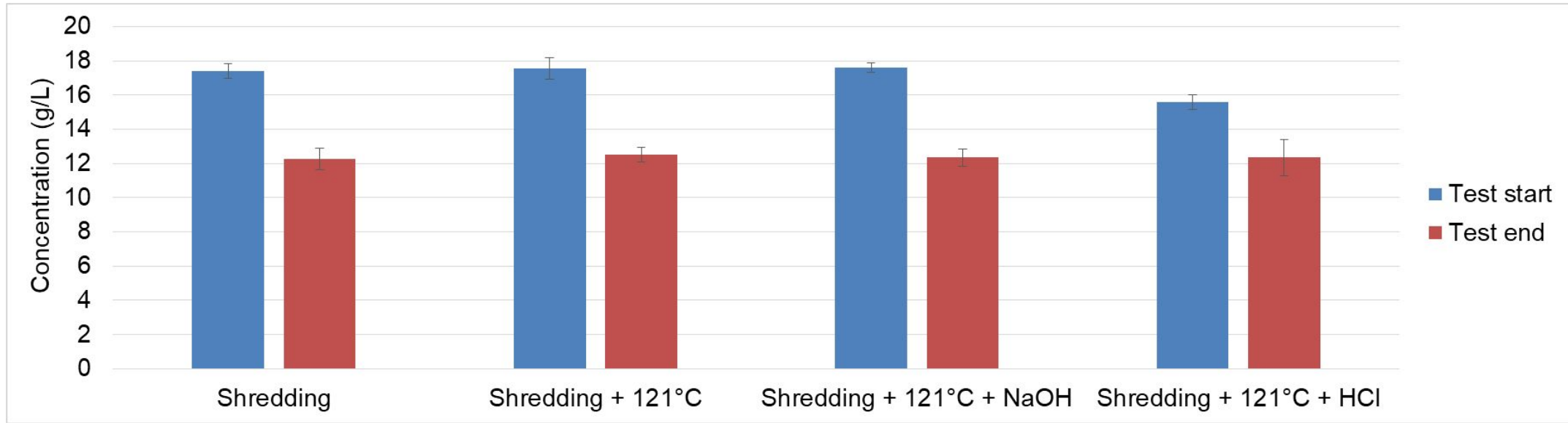
# Results: COD



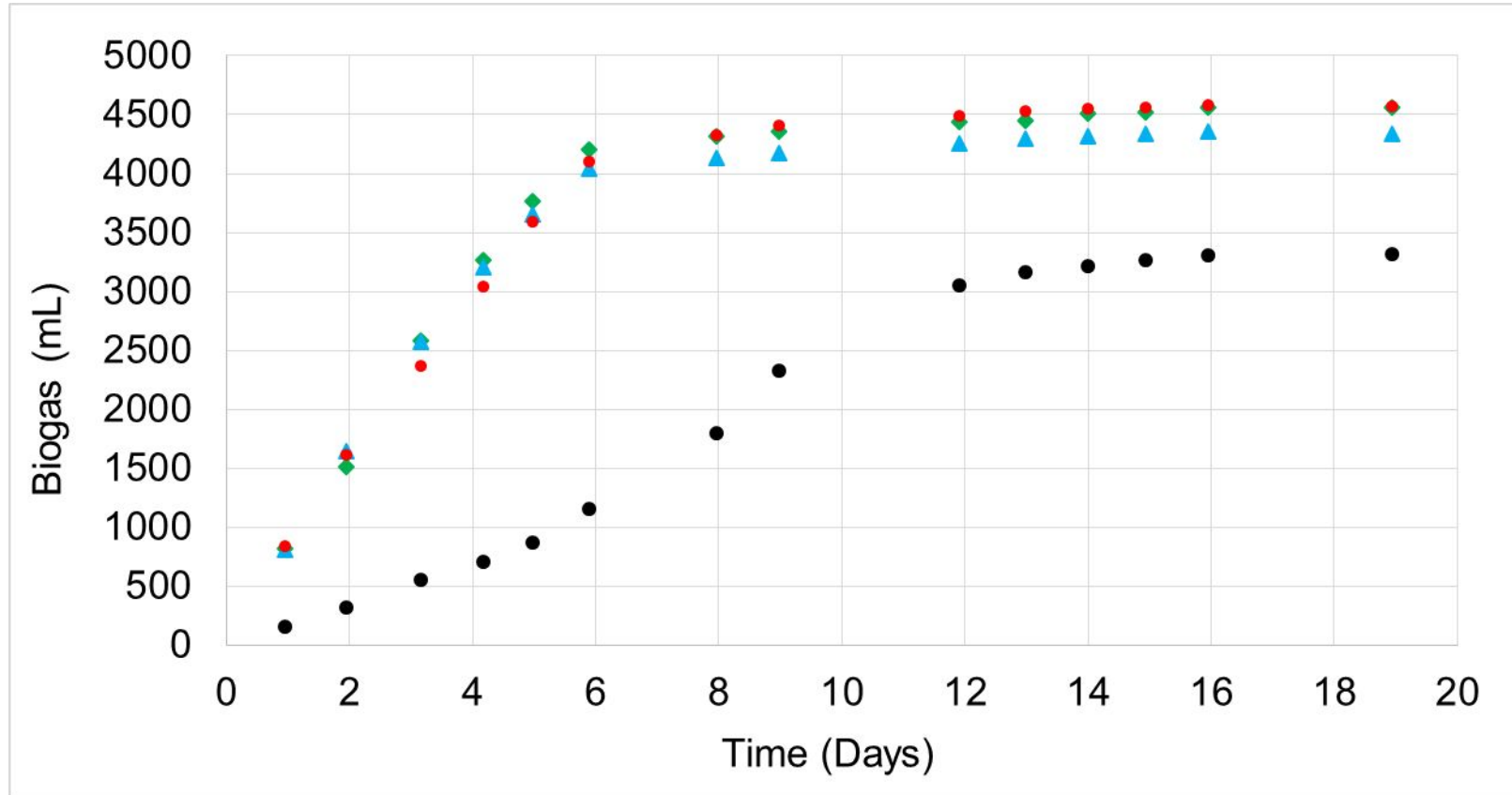
# Results: VSS



# Results: VS



# Results: biogas



- Shredding
- ◆ Shredding + 121°C
- ▲ Shredding + 121 °C + NaOH
- Shredding + 121 °C + HCl

# Results: biogas

## Biogas increase (19 d)

Pre-treatment/Shredding	
Shredding + 121°C	137.7%
Shredding + 121°C + NaOH	130.9%
Shredding + 121°C + HCl	138.0%

## Biogas yield (mL/gCOD<sub>rem</sub>)

	Mean	St. dev.
Shredding	430	61
Shredding + 121°C	533	16
Shredding + 121°C + NaOH	566	20
Shredding + 121°C + HCl	523	53

# Results: biogas

## Biogas yield: 7 vs 19 days

Shredding	54.2%
Shredding + 121°C	94.5%
Shredding + 121°C + NaOH	95.3%
Shredding + 121°C + HCl	94.7%



130.2%
124.8%
130.7%

7 d biogas compared to  
19 d biogas production  
by shredded OFMSW

# Conclusions...

- No inhibition phenomena due to thermal or thermo-chemical pre-treatments;
- Almost no differences among investigated pre-treatments in terms of organic matter solubilization and removal, as well as, biogas yield;
- Pre-treatments resulted in a moderate increase of the biogas yield (~ 30%);
- Thermal pre-treatments speeded-up anaerobic digestion process (~ 3 times).

# Work in progress...

## Done

Plant operating condition: 3 kgCOD/m<sup>3</sup>\*d

Feed: OFMSW after shredding

CH<sub>4</sub> yield: 274 NmLCH<sub>4</sub>/gCOD<sub>rem</sub>

COD rem: 88 ± 6%

VS rem: 94 ± 3%

## Ongoing

Plant operating condition: 3 kgCOD/m<sup>3</sup>\*d

Feed: OFMSW after shredding and  
thermal pre-treatment

**THANK YOU FOR THE ATTENTION**

**ANY QUESTION?**

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