BIOGAS PRODUCTION POTENTIAL OF THE MICROWAVE, H_2O_2/MW AND $S_2O_8^{2-}$/MW PRETREATED WASTEWATER SLUDGES

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Introduction

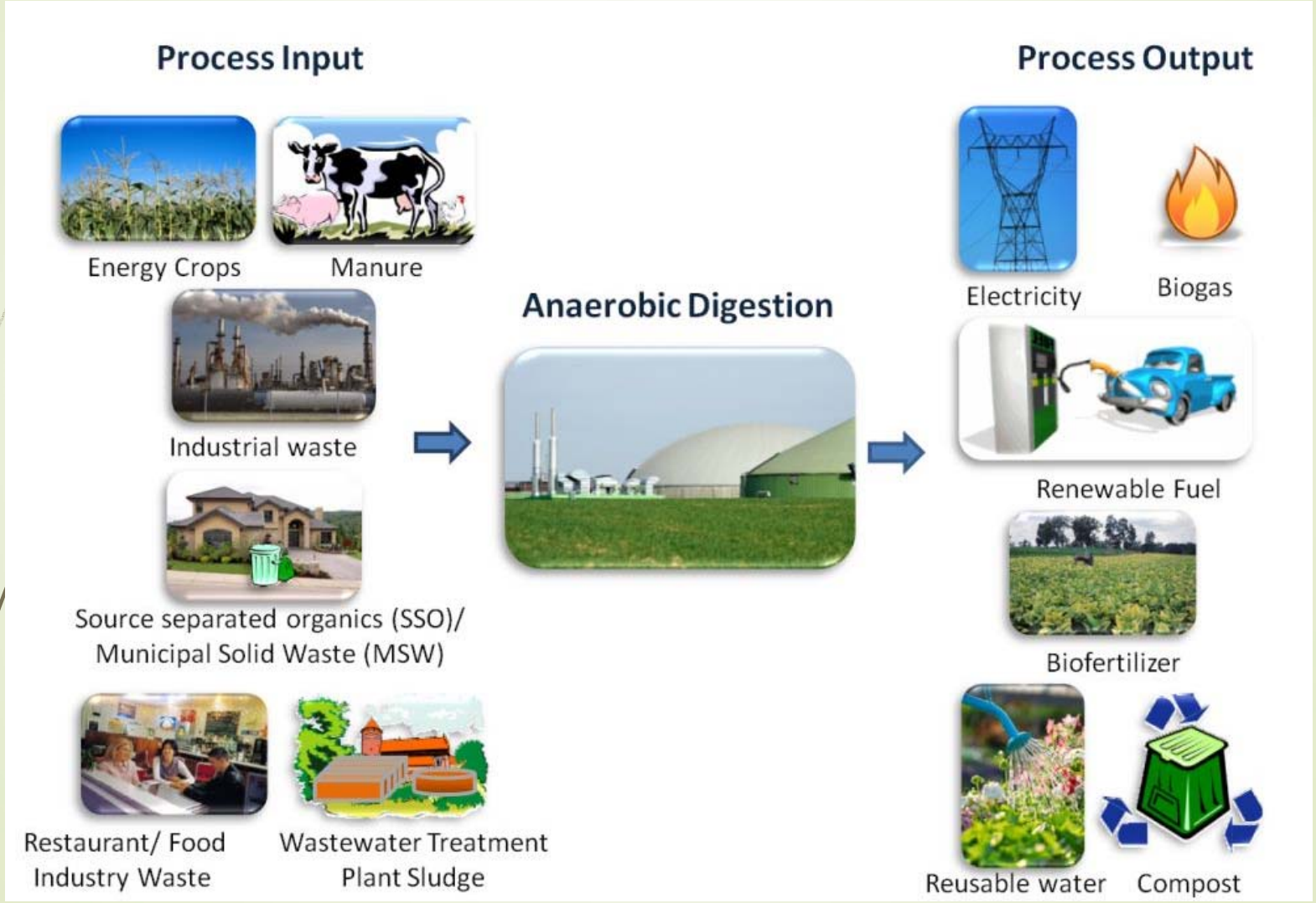
- The sewage sludge production increases with gradual growth of human population.
- Sewage sludge production after treatment operations of wastewater in Turkey was 299 ktons (on dry basis) in 2017.
- Expected to reach 911 ktons by year 2040.
  - To solve the problem: Sludge stabilization is essential, and anaerobic stabilization of sludges improves the energy efficiency.

Introduction

Sludge Stabilization and Anerobic Digestion

- Sludge volume reduction
- Organics and pathogens removals
- Odor problems elimination
- Renewable energy production in terms of biogas and methane
- Lower capital cost

Anaerobic Digestion



http://www.theecoambassador.com/Biogas.html

Aim of this Study

to investigate the effects of:

- combined hydrogen peroxide/microwave (H_2O_2/MW),
- combined persulfate/MW ($S_2O_8^{2-}$/MW) and
- microwave (MW)

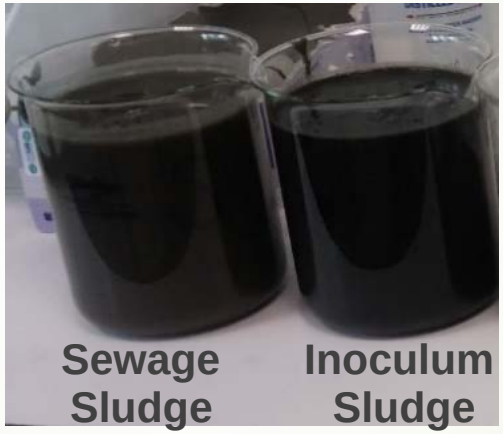
sludge pre-treatment methods on the anaerobic digestion efficiency and the the biogas production potential of wastewater sludges.

Materials and Methods

Sludge Samples

Sewage Sludge (SS)

- from the recirculation line of an advanced biological WWTP in Istanbul
- TS = 13.6 g/L
- VS = 8.4 g/L



Inoculum Sludge

- from the anaerobic digesters of an advanced biological WWTP in Istanbul
- TS = 45 g/L
- VS = 21 g/L

Sludge Characteristics

Parameter	Unit	Sewage Sludge	Inoculum
TS	g/L	13.5	44
VS	g/L	8.3	20.2
TSS	g/L	13	41
VSS	g/L	8.2	18.4
pH	-	6.6	7.6
COD	mg/L	19576	41805
sCOD	mg/L	255	1106
TOC	mg/L	230	235
TKN	mg/L	880	1935
P	mg/L	310	720
VFA (as acetic acid)	mg/L	3.9	18.8
Alkalinity	mg $CaCO_3$/L	1220	8365

Pre-treatments

- Microwave (MW) Pre-treatment
- Combined Hydrogen Peroxide and MW (H_2O_2/MW) Pre-treatments
- Combined Persulfate and MW ($S_2O_8^{2-}$/MW) Pre-treatments

MW Pre-treatment

- at 160°C for 15 minutes by using Berghof, MWS-3+ Digestion System

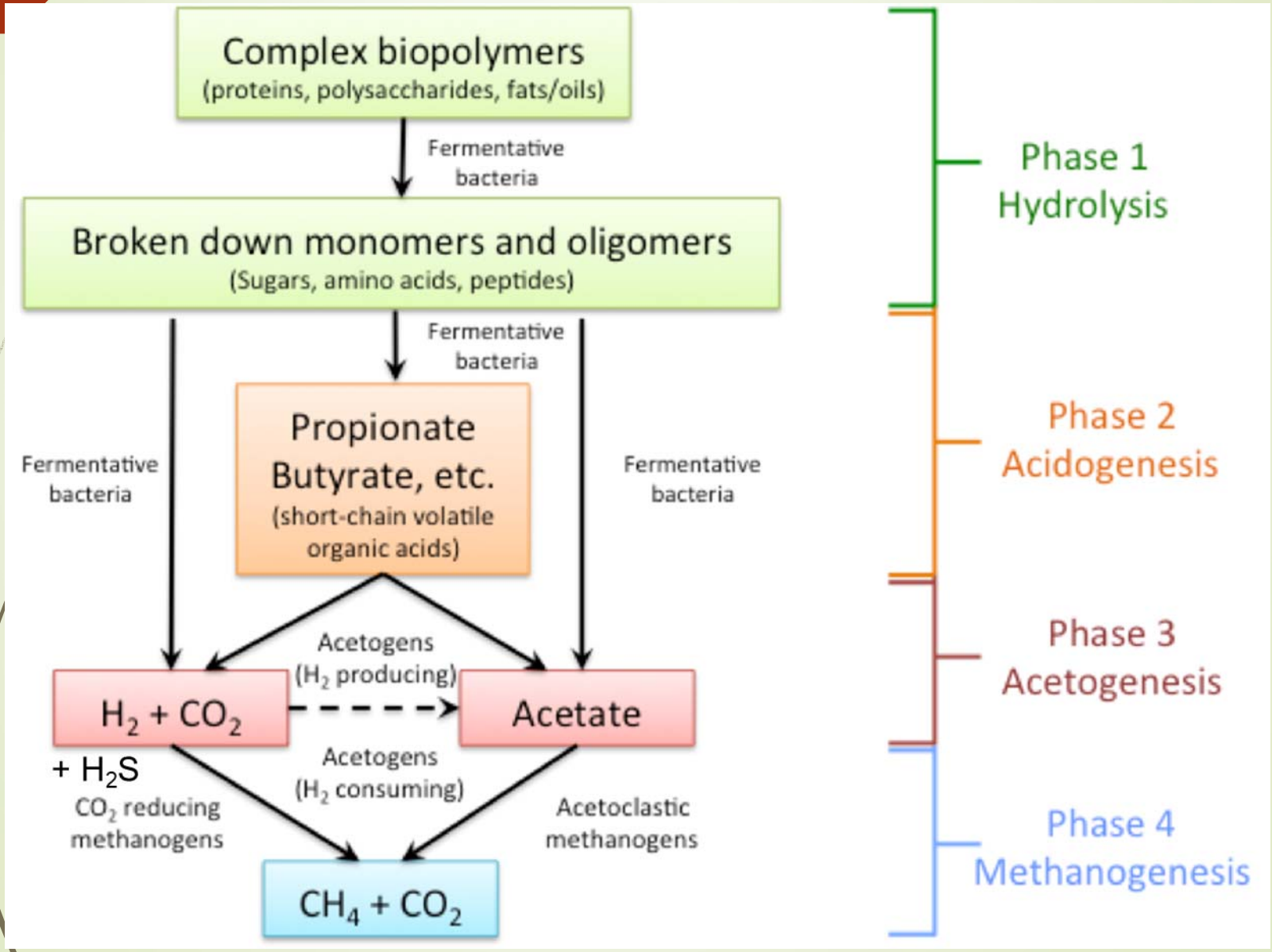
Combined Hydrogen Peroxide and MW (H_2O_2/MW) Pre-treatments

- Pre-heating stage at 120°C for 15 minutes
- 1 g H_2O_2 / g TS
- MW treatment at 160°C for 15 minutes **(H_2O_2/MW)**

Combined Persulfate and MW ($S_2O_8^{2-}$ /MW) Pre-treatments

- 1 g $S_2O_8^{2-}$ / g TS
- MW treatment at 160°C for 15 minutes **($S_2O_8^{2-}$/MW)**

Steps in Anaerobic Digestion



https://www.e-education.psu.edu/egee439/node/727

Preparation of the Reactors

- **S:I** ➡ **1:1** **(VS basis)**
- **80** mL active volume.
- **6** parallels for each reactor.

- Initial pH values = **7-7.2.**
- Initial alkalinities = **3000-4500** mg/L as $CaCO_3$
- Serum bottles were flushed with **N_2** gas.

Anaerobic Digestion Period

- Mesophilic conditions at 37°C (in water baths).

- 40 days of digestion period.

BMP Tests

Daily gas productions

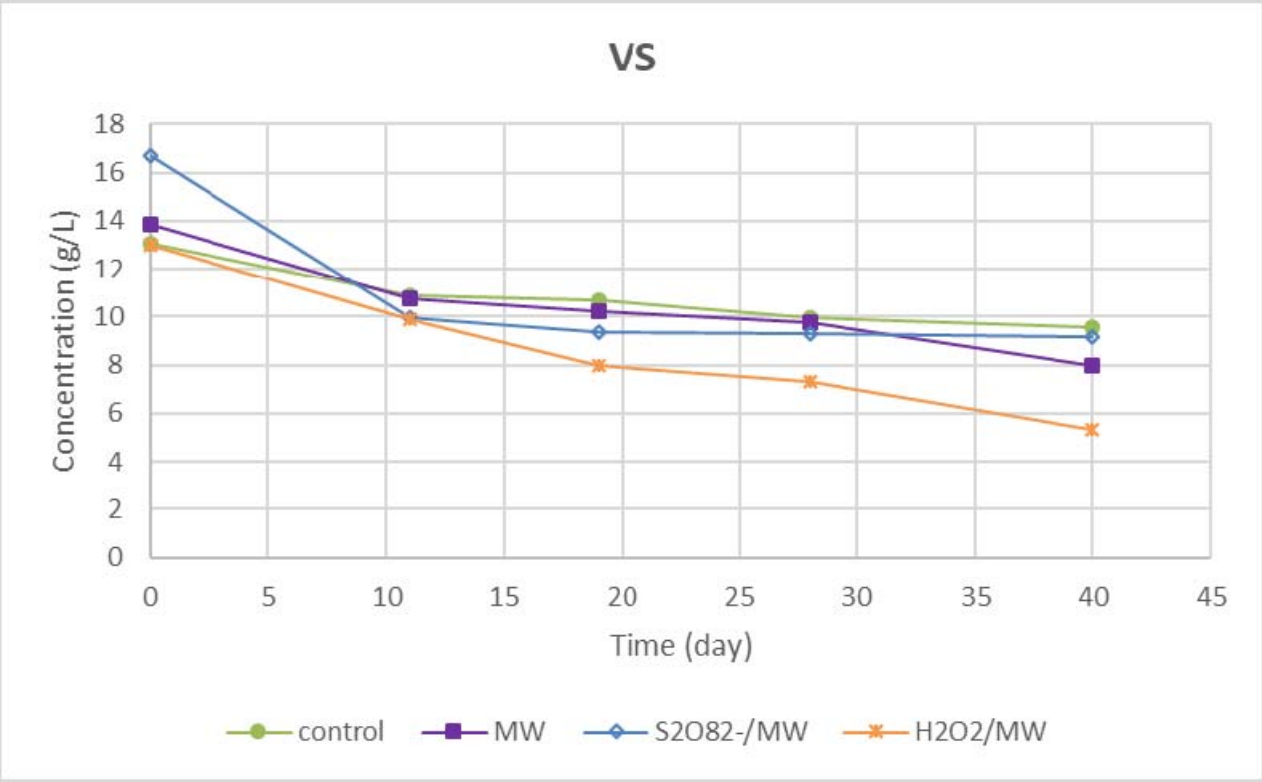
- Lutron PM-9107 Electronic Manometer

The biogas compositions

- Agilent HP 6850 Gas Chromatograph (each week)

Results and Discussion

VS Variations

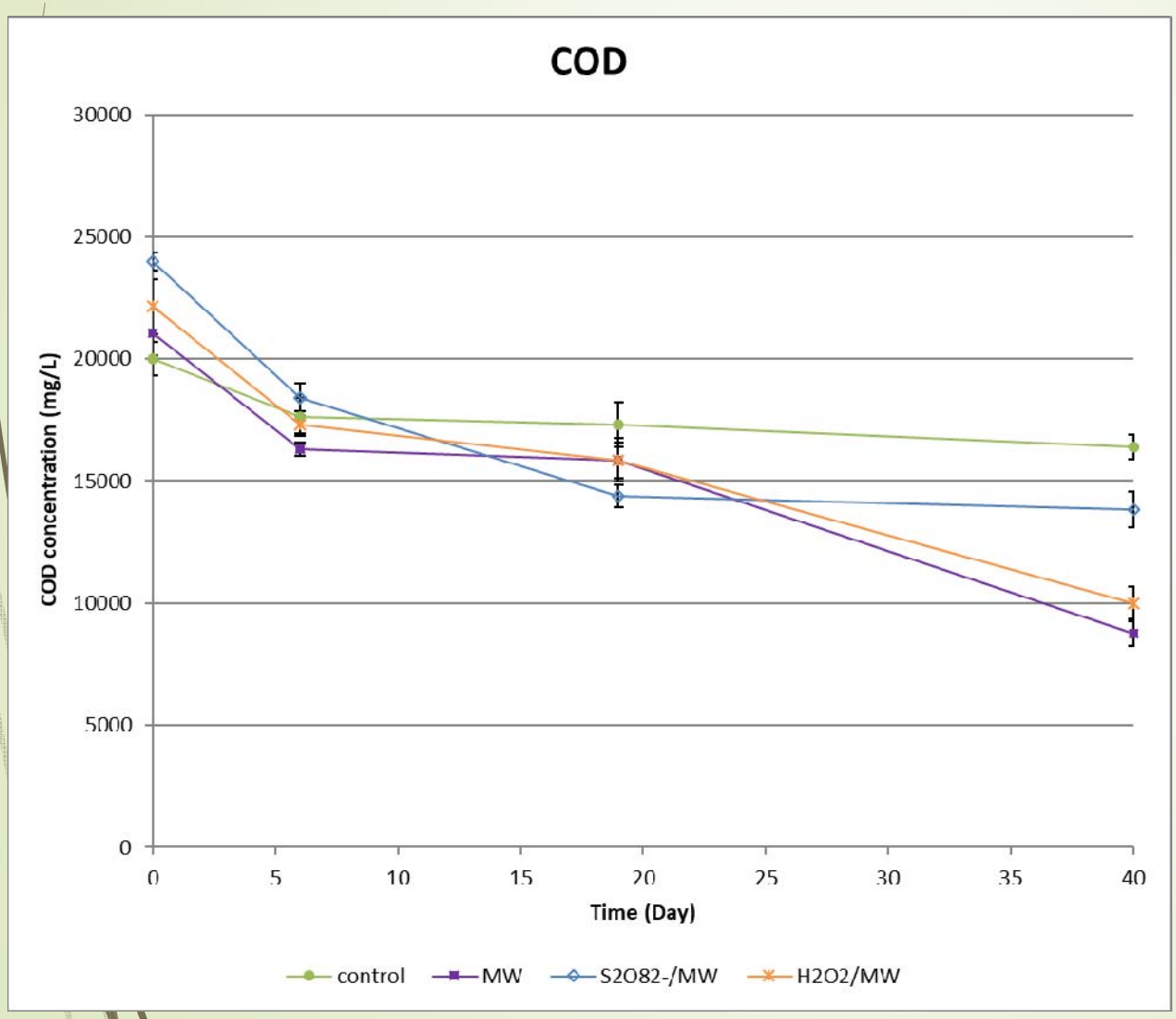


Removal rates in reactors:

- **H_2O_2/MW >> 59%**
- $S_2O_8^{2-}$/MW >> 45%
- MW >> 42%
- **Control >>24%**

18-35% increase in VS removal

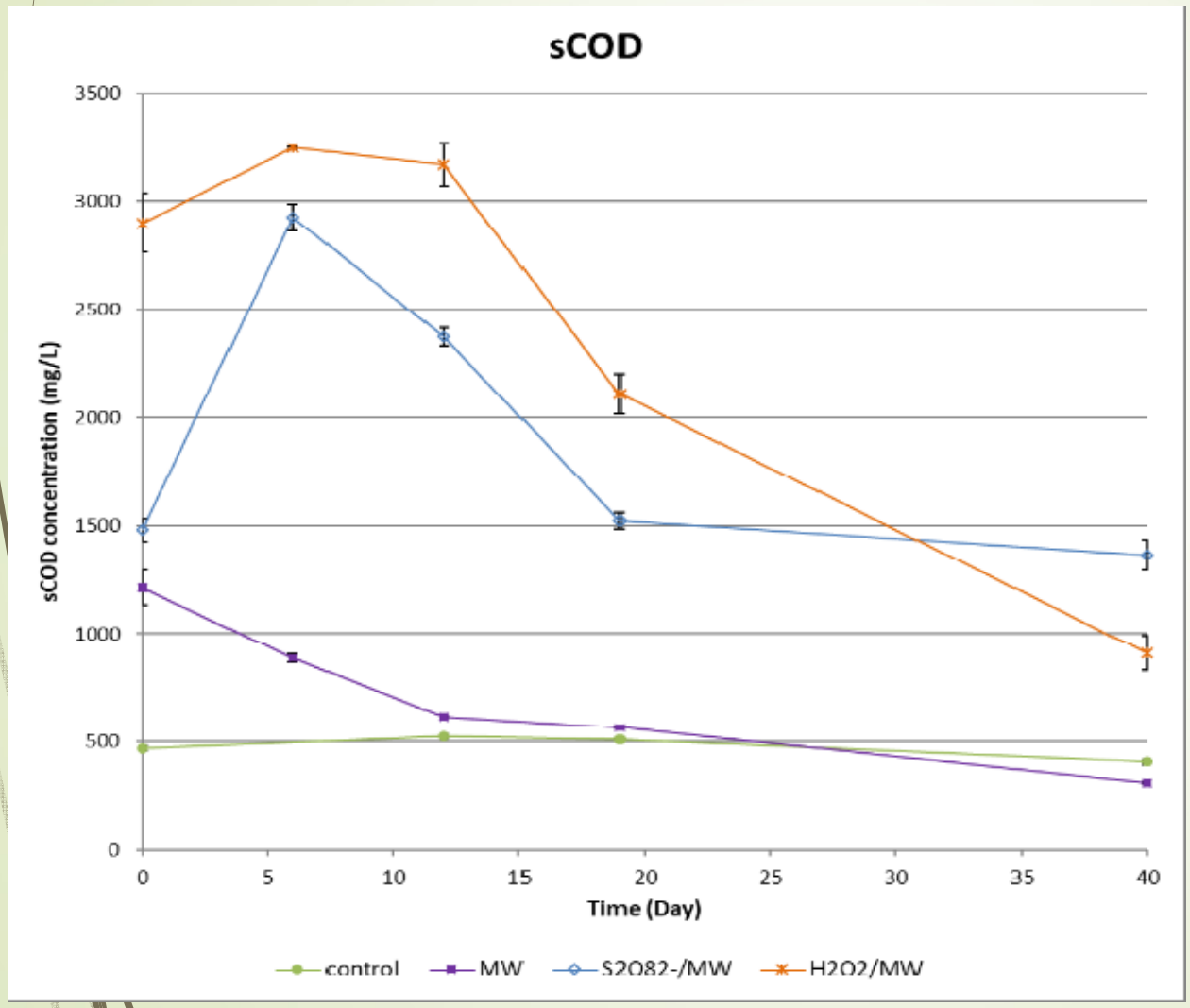
COD



Removal rates in reactors:

- **MW >> 58%**
- H_2O_2/MW >> 55%
- $S_2O_8^{2-}$/MW >> 41%
- **Control >>18%**

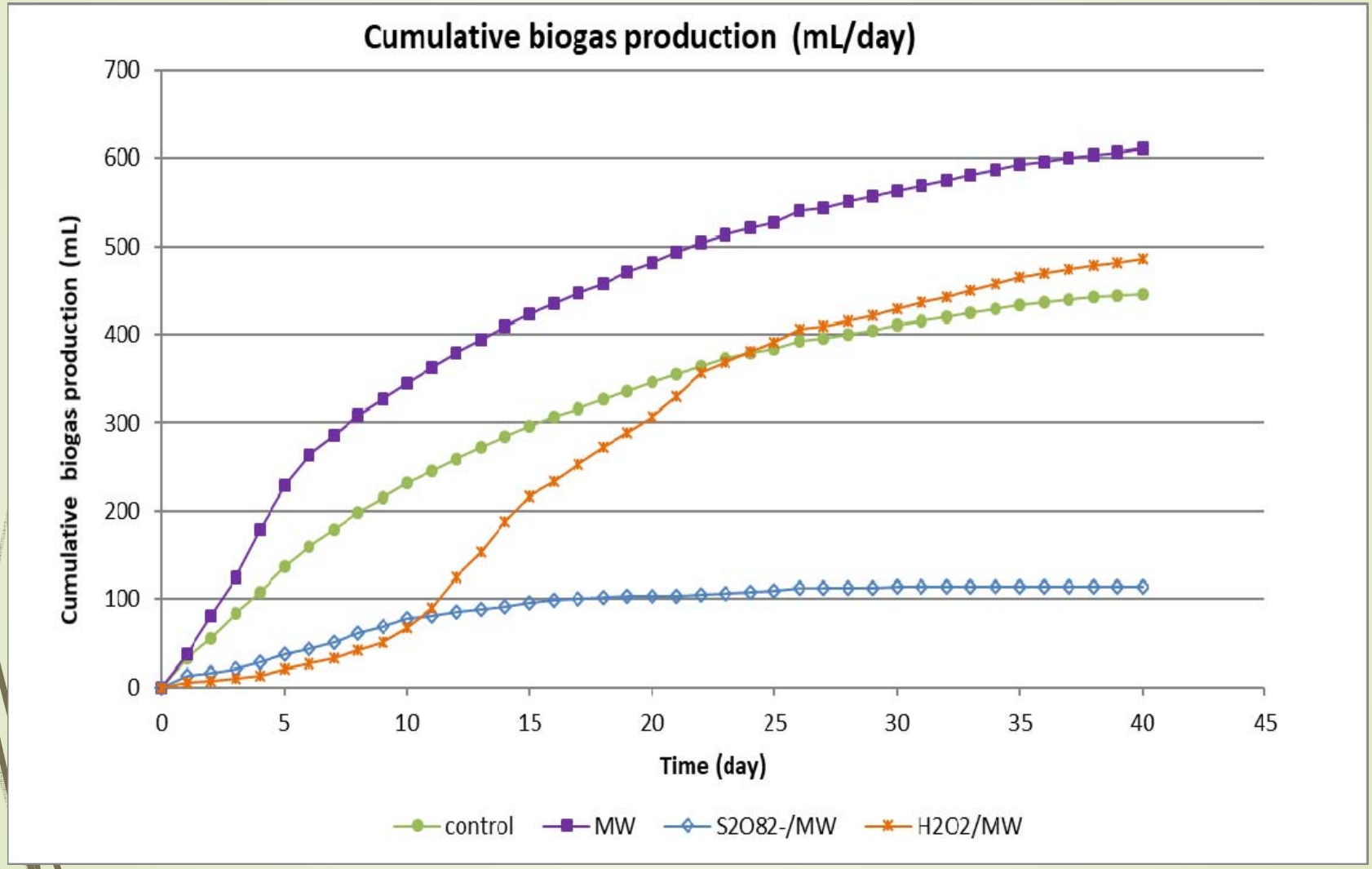
sCOD



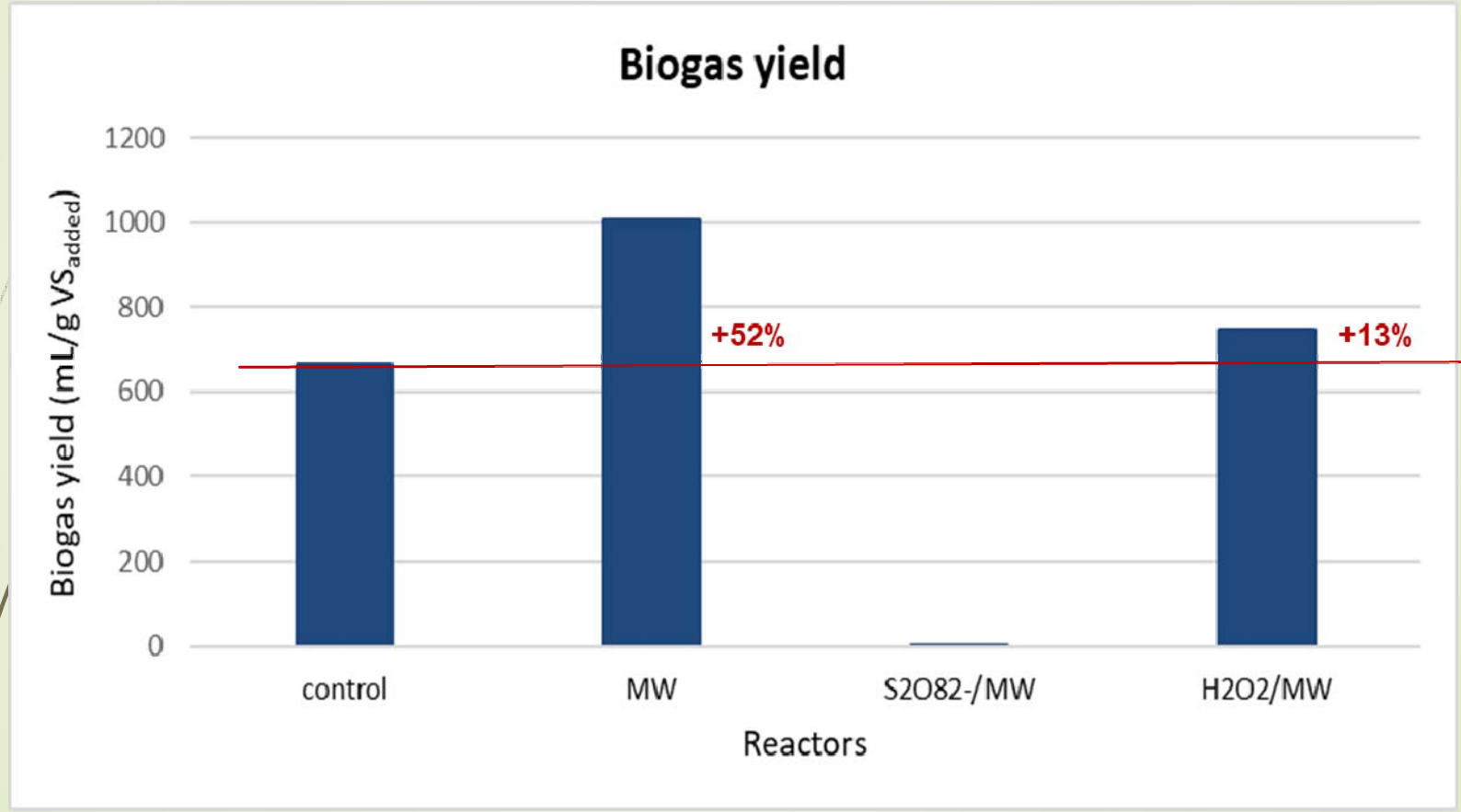
<u>Removal rates in reactors:</u>

- **MW >> 74%**
- H_2O_2/MW >> 68%
- $S_2O_8^{2-}$/MW >> 8%
- **Control >>14%**

Cumulative Biogas Production



Biogas Yield



Conclusions

- ✓The pre-treatments applied prior to anaerobic digestion speeded up the hydrolysis step and improved the biodegradability of the organics in sludge by increasing their solubility.
- ✓The potential of the biogas and the methane productions at the end of the AD process was enhanced by the applications of microwave and H_2O_2/MW pre-treatments.
- ✓Biogas yields increased as 52% and 13%.

Conclusions

- The residual H_2O_2 or its byproducts limited the activity of methanogens, and decreased the biogas production and the yield.

- The $S_2O_8^{2-}$ concentration applied to the sludge samples eliminated the biogas and methane productions by creating an inhibition effect on the survival of the methanogenic bacteria.

THANK YOU!