



Politecnico
di Torino



Optimisation of anaerobic digestion of Organic Fraction Municipal Solid Waste (OFMSW)

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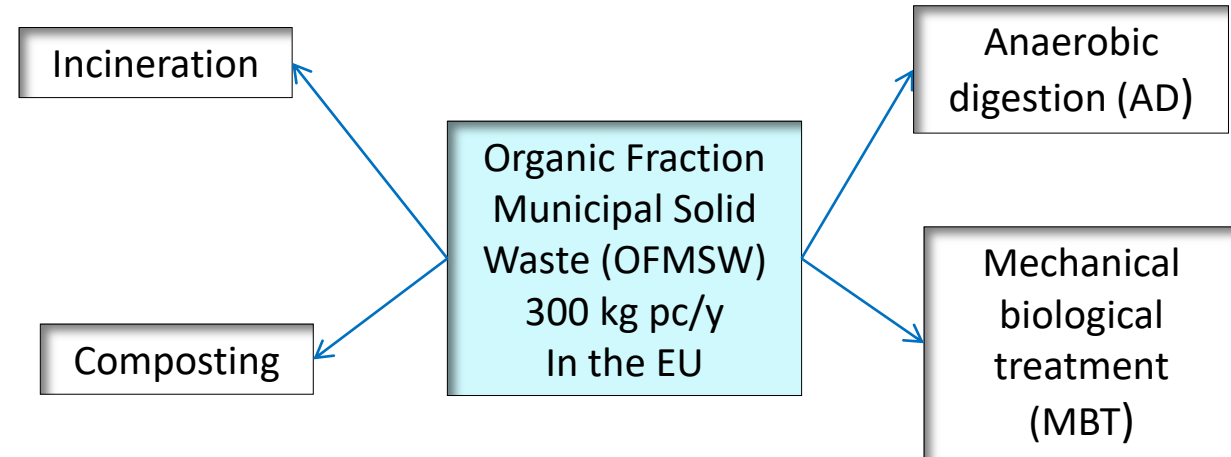
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State of the art

Current management

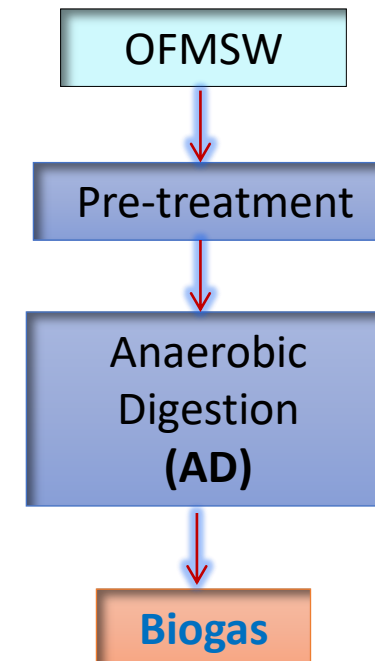
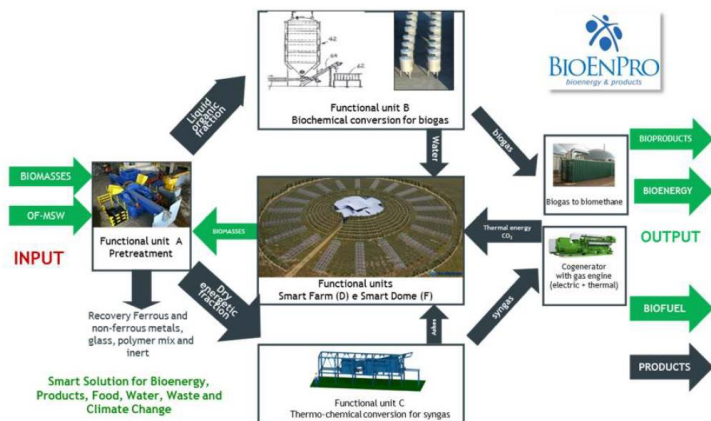


Proposed management

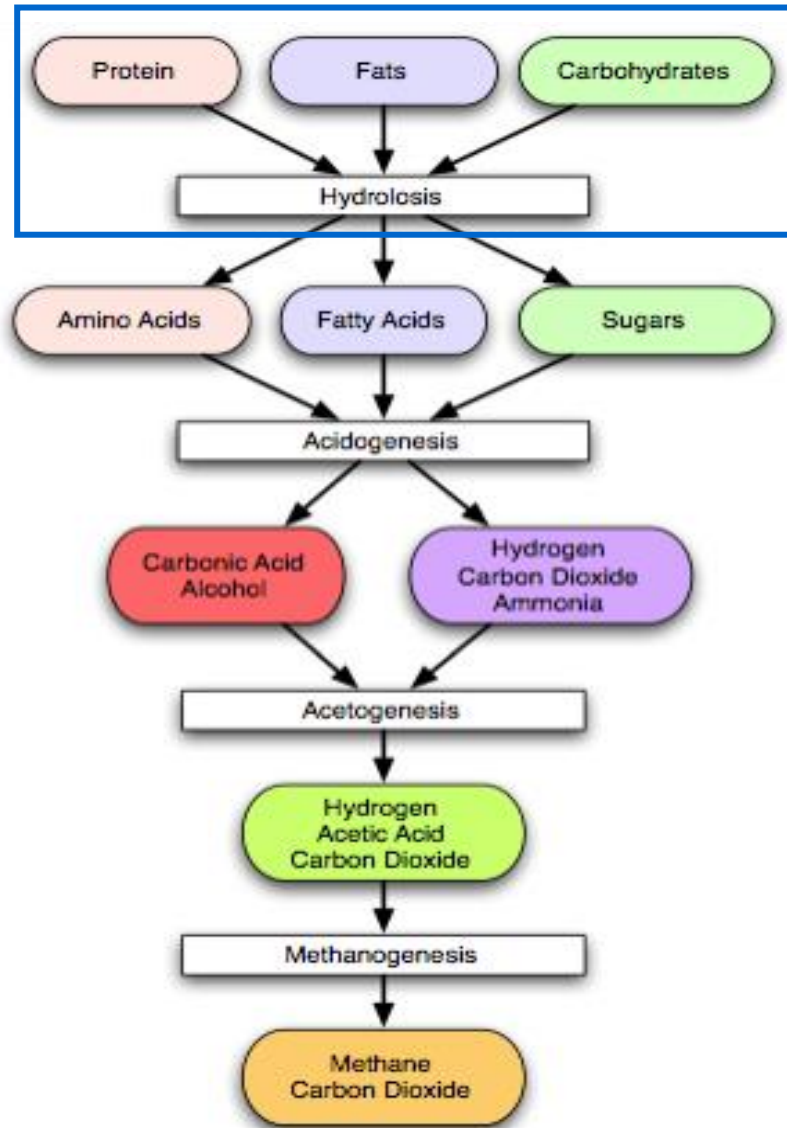
BIOENPRO4TO – SMART SOLUTIONS FOR SMART COMMUNITIES:

Bio-energy and sustainable product for Green Chemistry (output) through integrated valorisation of urban and industrial waste and biomass (input)

Concept Diagram (BioEnergy & Products)



Design and evaluation of physical pre-treatments



Pretreatment is an additional stage to improve substrate availability and digestibility in the AD process, especially for hydrolysis step.

Efficiency evaluation through Disintegration Rate (DR):

$$DR = \frac{SCOD_1 - SCOD_0}{TCOD - SCOD_0} \cdot 100$$

$$DR = \frac{SN_1 - SN_0}{TN - TN_0} \cdot 100$$

- $SCOD_0$ = soluble COD before pre-treatment;
- $SCOD_1$ = soluble COD after pre-treatment;
- $TCOD$ = total COD;
- SN_0 = soluble Nitrogen before pre-treatment
- SN_1 = soluble Nitrogen after pre-treatment;
- TN = Total Nitrogen.

Evaluation of physical pre-treatments

Pretreatment is an additional stage to improve substrate availability and digestibility in the AD process, especially for hydrolysis step.

Mechanical

Target:

OFMSW comminution

Parameters:

- Time of pre-treatments:
 - 15 min
 - 30 min
 - 45 min
- Energy:
 - 0.023 kWh/L

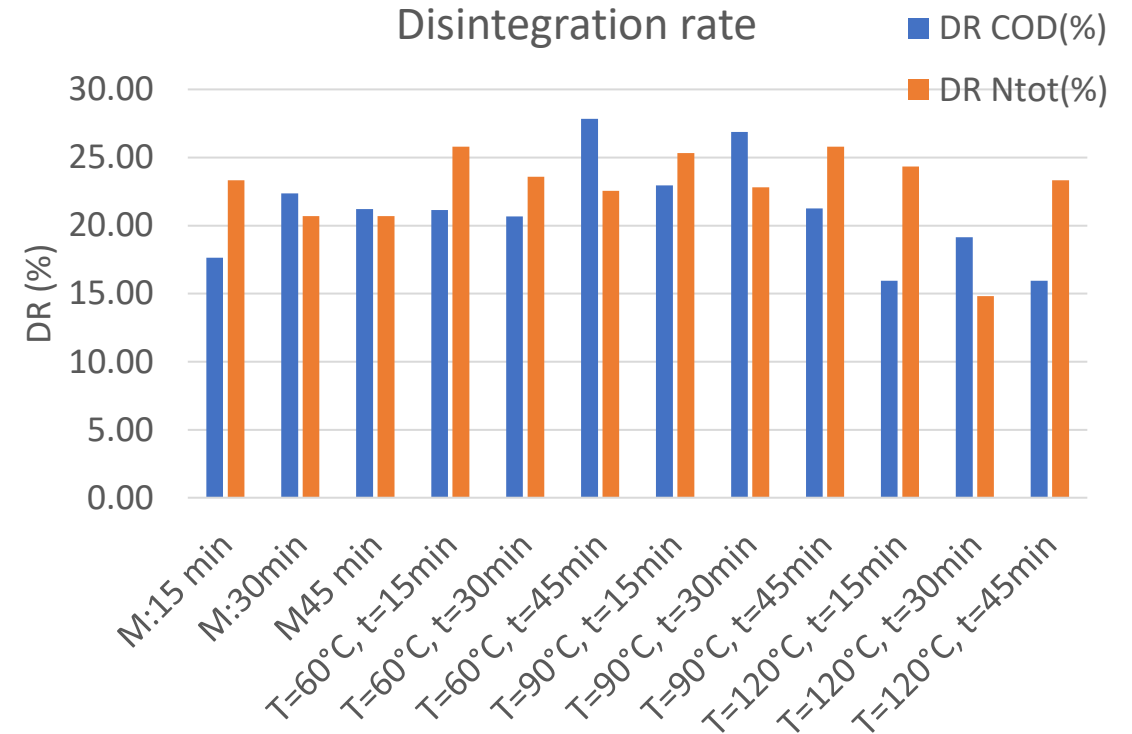
Thermal

Target:

OFMSW solubilisation

Parameters:

- Temperature:
 - 60°C
 - 90°C
 - 120°C
- Time of pre-treatments:
 - 15 min
 - 30 min
 - 45 min
- Energy:
 - 0.040 kWh/L per T=60° C
 - 0.048 kWh/L per T=90° C
 - 0.059 kWh/L per T=120° C



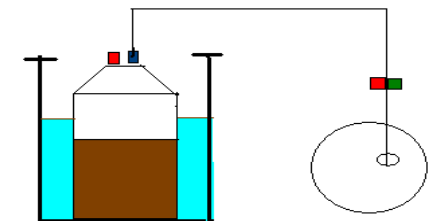
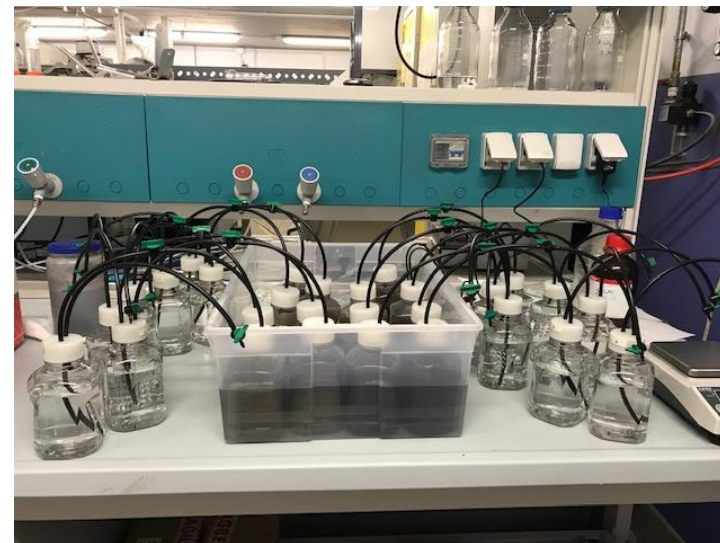
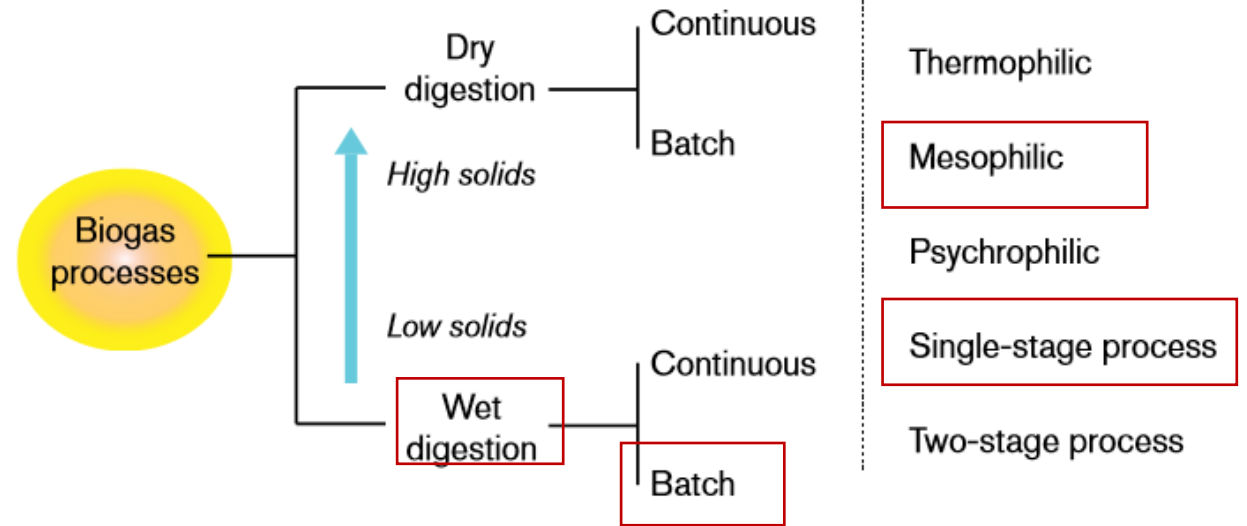
Material and methods: Biogas production from OFMSW

Improvement of AD through the combining acclimatation of inoculum and physical pre-treatment

Target: enhance the biogas production and CH₄ content

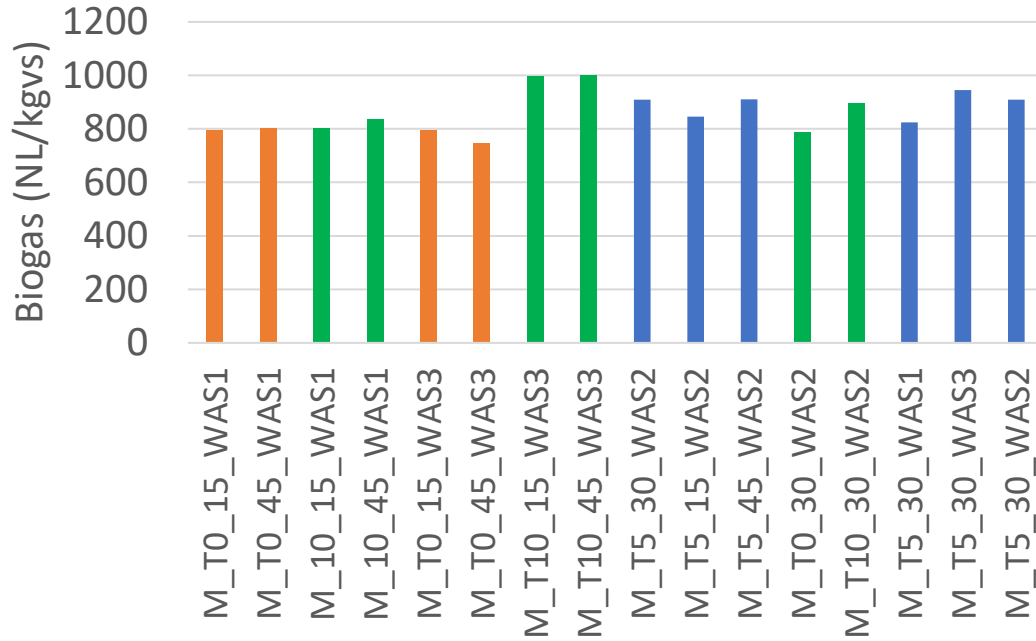
Experimental set up

- OFMSW was provided by San Carlo S.p.a.
- **Evaluation of inocula origins**
 - Waste active sludge: WAS
 - Cow agricultural sludge: CAS
- **Evaluation of incubation time of inocula:**
 - 0 day
 - 5 days
 - 10 days
- **Evaluation of substrate inoculum ratio: S:I**
 - 1:2
 - 1:1
 - 2:1
- **Design of Experiments: Star with double centre**

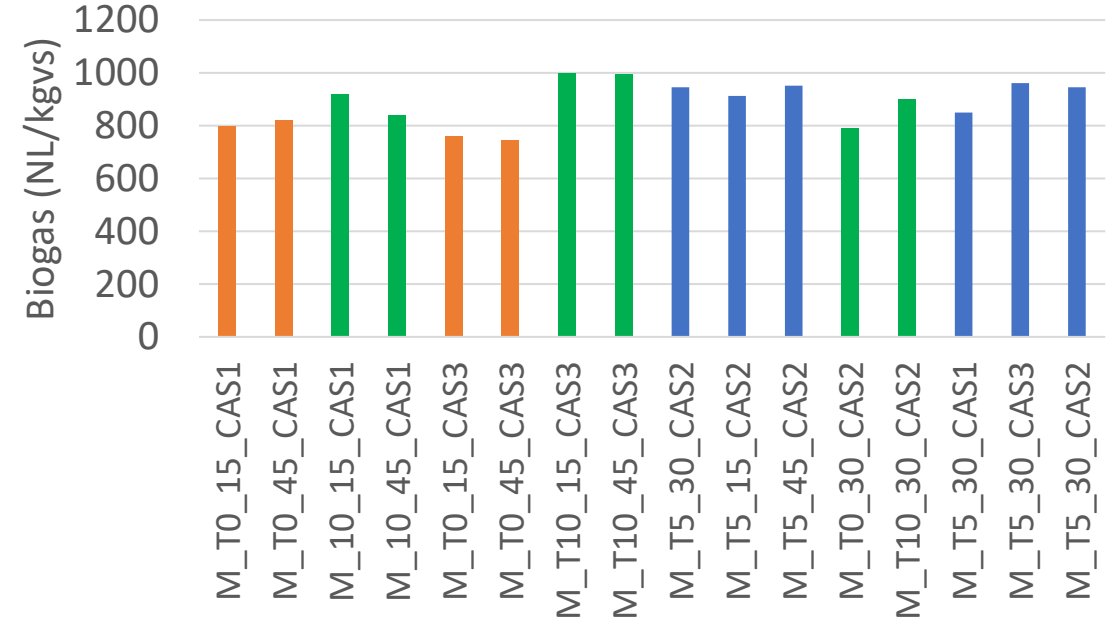


Mechanical pre-treatment AD

Mechanical pre-treatment with inoculum WAS



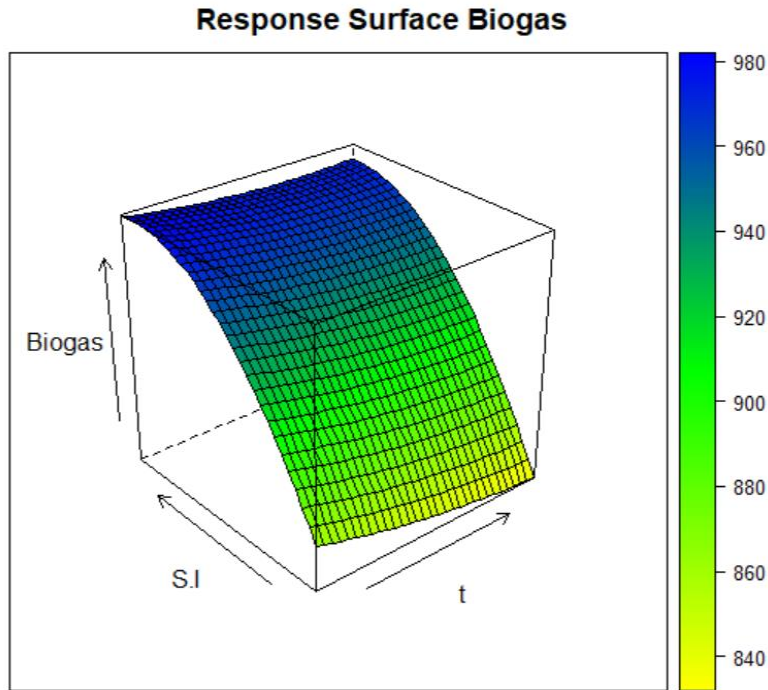
Mechanical pre-treatment with inoculum CAS



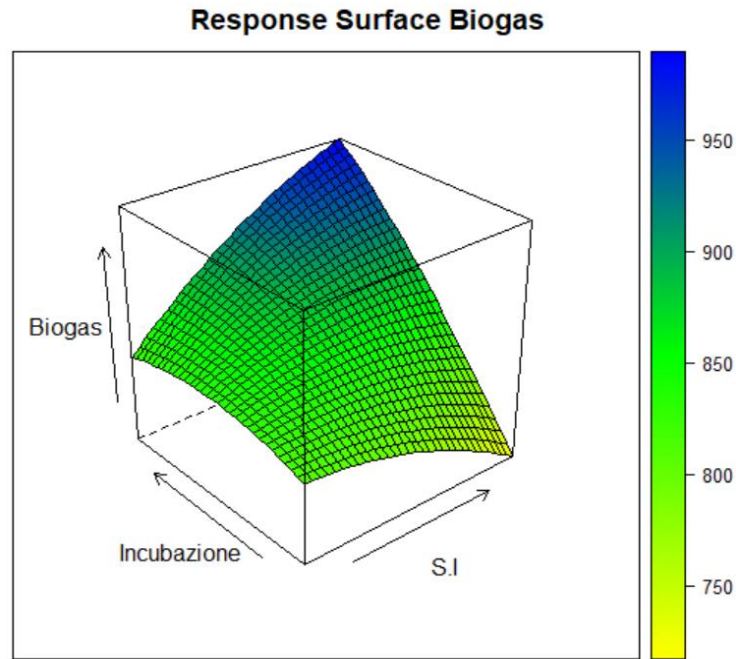
Configuration	Energy Sustainable Index (-)	Disintegration constant (1/d)
M_T10_15_WAS3	1.09	0.19
M_T10_45_WAS3	1.20	0.27
M_T5_30_WAS3	1.18	0.22
M_T5_45_WAS3	1.11	0.20

Configuration	Energy Sustainable Index (-)	Disintegration constant (1/d)
M_T10_15_CAS3	1.11	0.20
M_T10_45_CAS3	1.23	0.29
M_T5_30_CAS3	1.20	0.24
M_T5_45_CAS3	1.13	0.23

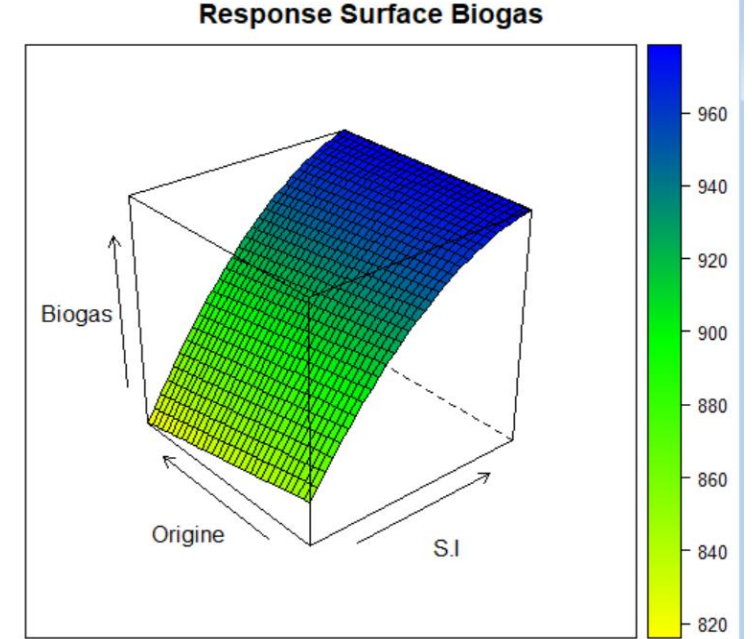
Mechanical pre-treatment AD



Biogas production is independent from pre-treatment time



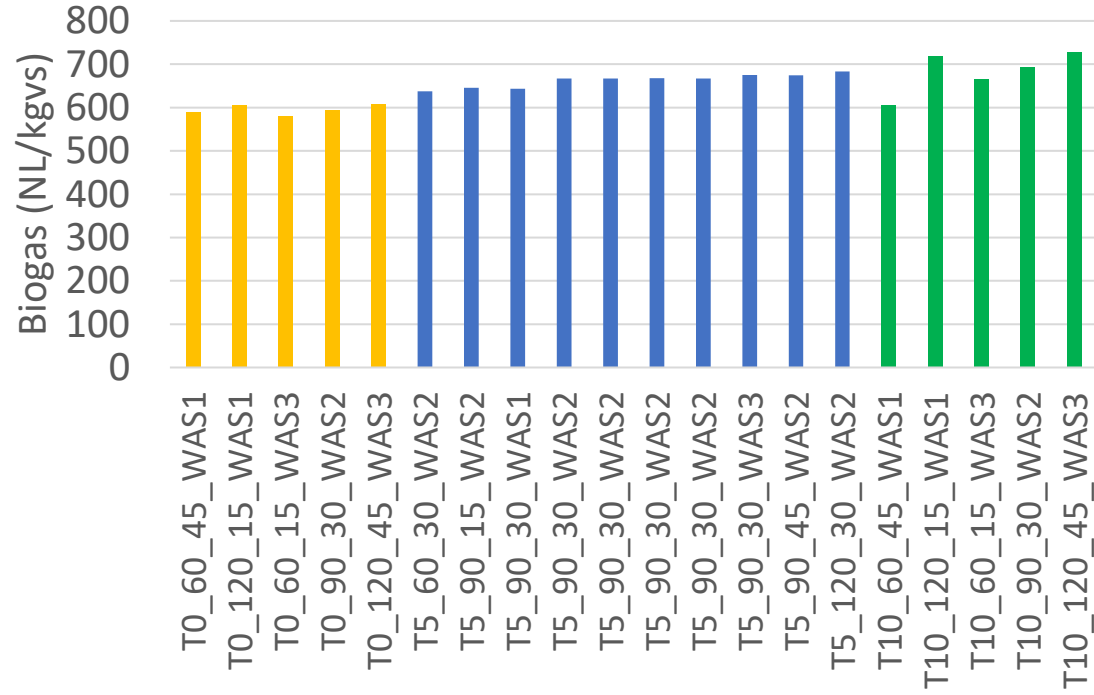
Biogas production increases increasing the S:I ratio and the inoculum time incubation



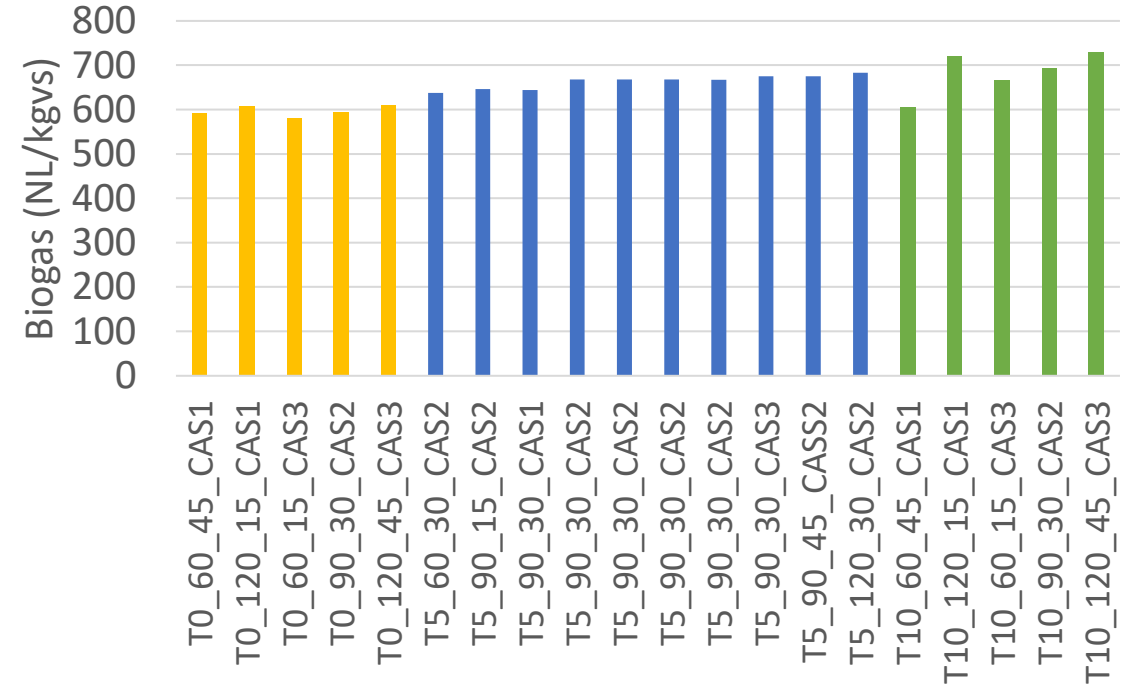
Biogas production increases increasing the S:I ratio and using the inoculum (CAS)

Thermal pre-treatment AD

Biogas production with inoculum WAS



Biogas production with inoculum CAS



Configuration	Energy Sustainable Index (-)	Disintegration constant (1/d)
T10_120_15_WAS1	1.14	0.23
T10_120_45_WAS3	1.21	0.25
T5_90_30_WAS2	1.30	0.32
T5_90_30_WAS3	1.29	0.29

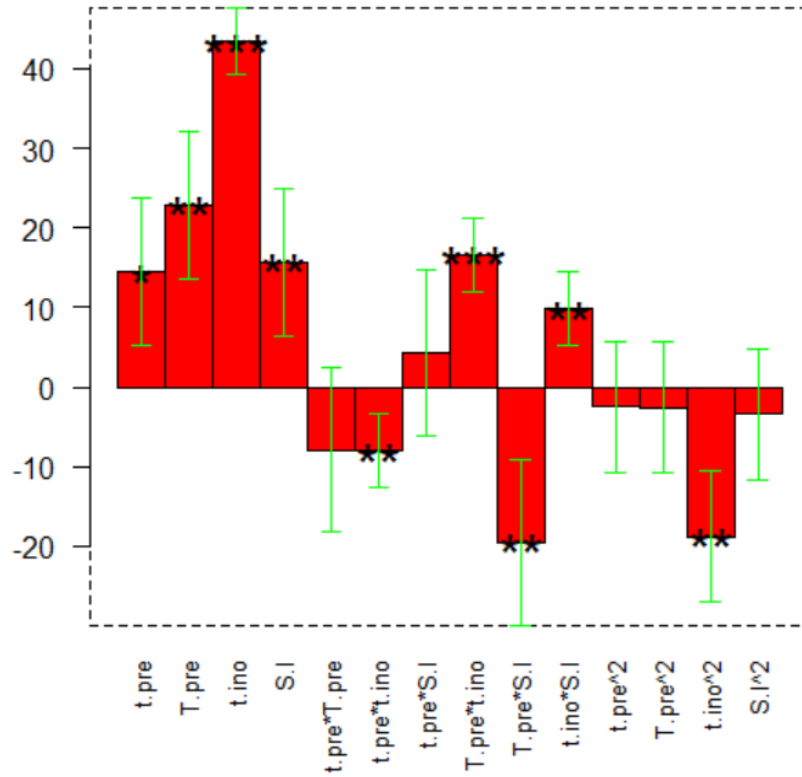
Configuration	Energy Sustainable Index (-)	Disintegration constant (1/d)
T10_120_15_CAS1	1.16	0.24
T10_120_45_CAS3	1.20	0.27
T5_90_30_CAS2	1.32	0.34
T5_90_30_CAS3	1.31	0.30

Thermal pre-treatment

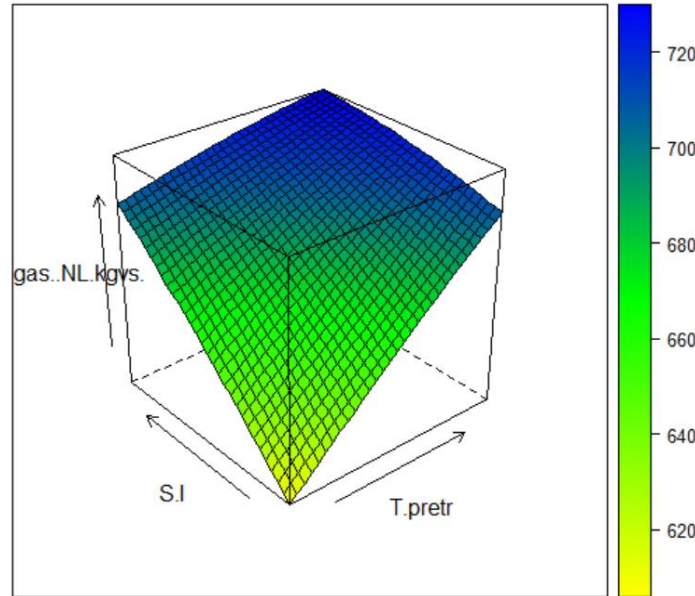
With inoculum WAS

With inoculum CAS

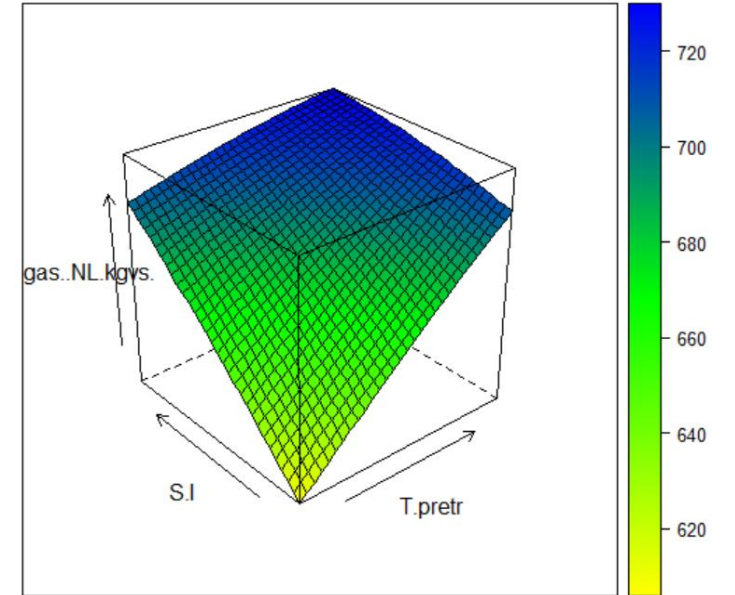
Coefficients Biogas..NL.kgvs.



Response Surface Biogas..NL.kgvs.



Response Surface Biogas..NL.kgvs.



Biogas production is strongly dependent on inoculum incubation and temperature and time of pre-treatment both for AD with WAS and CAS

Conclusions

- Physical pre-treatments were investigated: mechanical and thermal;
- Thermal pre-treatments reached higher disintegration rate than mechanical pre-treatments;
- For mechanical pre-treatments time of pre-treatments was non significant;
- For thermal pre-treatments the significant parameters were inoculum incubation, temperature and time of pre-treatments;
- The highest specific biogas productions were achieved for anaerobic digestion at highest S:I ratio and inoculum incubation time.