Effect of the duration of the first-stage anaerobic digestion on the efficiency of intermediate treatments carried out on Waste Activated Sludge (WAS)

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Pre- vs. Intermediate Treatments

WAS

PREATREATMENTS

A.D.

http://www.cambi.com

INTERMEDIATE TREATMENTS

Bacteria

Dark-brown color

from Shana et al., 2015

Extracellular Polymeric Substance (EPS)

Glowing color

WAS

Digester I

HPI

Digester II
Materials and Methods

Castiglione Torinese SMAT WWTP 2,300,000 e.p.

Pre-Treatments

WAS sample
Thickened to 5% TS

Intermediate Treatments

7-day Digestate sample
Thickened to 4.5% TS

Intermediate Treatments

15-day Digestate sample
Thickened to 4.3% TS

Treatment conditions

Alkali agents
NaOH
Doses
4 g alkali/100 g TS
Contact time
90 min
Temperatures
70 - 90°C

Anaerobic Digestion tests
Batch, mesophilic
Substrate: inoculum = 1.6
• The 7-day untreated digestate produced 16% less methane than the untreated WAS (0.166 Nm³CH₄/kg VSadded)
  → In the hybrid treatment, the Specific Methane Production increased by 31% and 54%, at 70°C and 90°C, respectively, if compared to the untreated digestate

• The 15-day untreated digestate produced 250% less methane than the untreated WAS (0.166 Nm³CH₄/kg VSadded)
  → In the hybrid treatment, the Specific Methane Production increased by 131% and 184% at 70°C and 90°C, respectively

• The results demonstrated that a significant amount of organic matter could be released yet after a 15-day mesophilic AD process
Results

• CURVES (1) Specific methane production of WAS after a hybrid pretreatment at 70°C (upper side slide) or 90°C (lower side slide)

• CURVES (2) Combination of a 7-day SMP of untreated WAS with a SMP due to an intermediate treatment on a 7-day digestate at 70°C or 90°C

• CURVES (3) Combination of a 15-day SMP of untreated WAS with a SMP due to an intermediate treatment on a 15-day digestate at 70°C or 90°C

- For both temperatures (70, 90°C), a process that combines an intermediate treatment of a 7-day digestate with a two-stage digestion of 20 day (7+13) could produce more methane than the sequence of pre-treatment and AD with the same duration

- 70°C intermediate t. produced 0.286 Nm³CH₄/kg VS_added vs 0.232 Nm³CH₄/kg VS_added generated with pre-treatment → + 23%

- 90°C intermediate t. produced 0.317 Nm³CH₄/kg VS_added vs 0.274 Nm³CH₄/kg VS_added → + 16%

15-day combination treatments could equal the methane production of the pretreated WAS only if the combined process had a length of 30 days or more.
Technical and economic assessment

FULL SCALE IHP TREATMENT 7-day

\[ Q_{WARM} + Q_{LOSS1} + Q_{HYD} + Q_{PRIM} + Q_{LOSS2} = Q_{AD1} + Q_{AD2} + Q_{HYD\_SLUD} \]

HYPOTHESIS:
- Heat produced from A.D. to sustain the system
- Flow rate primary sludge = secondary sludge
- Thermal efficiency of the combined heat and power (CHP) unit = 0.42
- Electrical efficiency of the CHP unit = 0.42
- Efficiency in thermal exchange processes = 1
- Primary sludge TS content = 3.5%
- Primary sludge mixed and heated by treated digestate

WAS

DYN. THICKENING

\( Q_{WARM} \)

HEATING EXCHANGE

1 digestor

38 °C

I STAGE A.D. 38°C

Biogas

\( Q_{HYD} \) 70-90 °C

Biogas

Electric energy

II STAGE A.D. 38°C

STATIC THICKENING → 3.5% TS

Q\_LOSS 2

4 digestors

Q\_HYD\_SLUD

Primary sludge

\( Q_{LOSS1} \)
IS THE PROCESS SUSTAINABLE?

INCREASE OF REVENUES FROM ELECTRICITY SALE:

- **PRETREATMENTS** → +13% \((70°C + \text{NaOH 4% TS})\), +25% \((90°C + \text{NaOH 4% TS})\)
- **IHP TREATMENTS** 7-day dig. → +26% \((70°C + \text{NaOH 4% TS})\), +32% \((90°C + \text{NaOH 4% TS})\)
The main results obtained in the experimentation demonstrated that:

- Intermediate treatments were effective in making the residual organic substance of a 7-day digestate usable for a second-stage AD process. Under this scenario, the methane generated in a two-stage AD process, with an intermediate treatment, was 23% and 16% higher than the scenario that considers traditional pretreatments, with 4% NaOH, at 70 and 90 °C, respectively.

- Conversely, in no cases (70 or 90 °C) the combination of a 15-day AD process of untreated WAS followed by an intermediate treatment and a second-stage AD, made possible to obtain SMPs higher than those obtained with pre-treatments.

- The treatment scheme, for full scale intermediate treatments, showed that the positive terms of the thermal balance equaled the negative terms when the TS content of secondary sludge was of 3.25% at 70 °C, and 4.25% at 90 °C, respectively.
The introduction of thermal or hybrid **pre-treatments** in a full scale WWTP (2,000,000 e.p.) could increase the revenues from the electricity sale between 13% and 25%, in comparison with the present scenario. Conversely, **intermediate** treatments on a 7-day digestate could provide a gain of 26% or 32%, depending on the process temperature (70 or 90 °C).
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Thank you for your attention!

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