Effect of the Hydraulic Retention Time (HRT) on the efficiency of a two-stage anaerobic digestion with intermediate treatments for Waste Activated Sludge (WAS)

A. Cerutti¹, G. Campo¹, M.C. Zanetti¹, L. Polimeno¹, G. Scibilia², E. Lorenzi², B. Ruffino¹

¹Department Environment, Land and Infrastructure Engineering, Politecnico di Torino, Torino, I-10129, Italy
²SMAT S.p.A., Società Metropolitana Acque Torino, Castiglione Torinese (TO), I-10090, Italy
Pre- vs. Intermediate Treatments

How different Hydraulic Retention Times (HRT) affect the efficiency of a two-stage anaerobic digestion with intermediate treatments for Waste Activated Sludge (WAS) in terms of biogas production?

Adapted from Molokwu & Rus, 20th European Biosolids & Organic Resources Conference, 9-11 November, 2015, Manchester UK
Materials and Methods

10 L C.S.T.R. MESOPHILIC DIGESTER – HRT X

INTERMEDIATE HYBRID TREATMENT

6, 6L MESOPHILIC BATCH REACTORS

PRE-THICKENED WAS (TS, VS, pH, FOS / TAC)

BIOGAS (CH₄, CO₂, O₂, Bal.)

sCOD<sub>before</sub>, sCOD<sub>after</sub>, pH, FOS-TAC

I.H.P. 90 °C  
90 °C- NaOH 4% TS

DIGESTATE (TS, VS, pH, FOS / TAC)

DIGESTATE (TS, VS, pH, FOS / TAC)

BIOGAS (CH₄, CO₂, O₂, Bal.)

10 L C.S.T.R. H.R.T. X

1<sup>st</sup> STEP  |  5 days
2<sup>nd</sup> STEP  |  10 days
3<sup>rd</sup> STEP  |  15 days
Castiglione Torinese SMAT WWTP 2,300,000 e.p.

Static pre-thickener

WAS sample
Thickened from 2.5 to 3% TS

Sludge line: from pre-thickeners to digesters
Alkali agents
NaOH
Doses
4 g alkali/ 100 g TS
Contact time
90 min
Temperatures
90°C

10 L C.S.T.R. Pilot Digester, mesophilic

Intermediate treatments

Anaerobic Digestion tests

Batch, mesophilic
Substrate : inoculum = 1.6
Specific methane productions at fixed HRT, 5 - 10 - 15 days,
Semicontinuous fed CSTR 10 L pilot digester with W.A.S.

Results

- 5 d H.R.T. 0,069 Nm³ / kg VS
- 10 d H.R.T. 0,095 Nm³ / kg VS
- 15 d H.R.T. 0,109 Nm³ / kg VS

Pilot digester shutdown
CUMULATED METHANE PRODUCTIONS:
5, 10, 15 DAYS HRT CSTR 10 L + 20 DAYS BATCH A.D.

CH₄ [Nm³/kg VS]

5 d HRT
WAS CSTR 10L
HRT 5 d
0.069 Nm³/kg VS

10 d HRT
WAS CSTR 10L
HRT 10
0.095 Nm³/kg VS

15 d HRT
WAS CSTR 10L
HRT 15
0.109 Nm³/kg VS
CUMULATED METHANE PRODUCTIONS:
5, 10, 15 DAYS HRT CSTR 10 L + 20 DAYS BATCH A.D.

- Untreated digestate batch
  - 5 d HRT
    - 0.096 Nm³/kg VS
  - 10 d HRT
    - 0.069 Nm³/kg VS
  - 15 d HRT
    - 0.095 Nm³/kg VS

- Untreated digestate
  - 0.072 Nm³/kg VS

- WAS CSTR 10L
  - HRT 5 d
    - 0.069 Nm³/kg VS
  - HRT 10
    - 0.095 Nm³/kg VS
  - HRT 15
    - 0.109 Nm³/kg VS

- WAS CSTR 10L
  - 0.053 Nm³/kg VS
CUMULATED METHANE PRODUCTIONS:
5, 10, 15 DAYS HRT CSTR 10 L + 20 DAYS BATCH A.D.

- Untreated digestate batch 0,096 Nm³/kg VS
- Digestate 90 °C batch 0,136 Nm³/kg VS + 41 %
- WAS CSTR 10L HRT 5 d 0,069 Nm³/kg VS
- WAS CSTR 10L HRT 10 0,095 Nm³/kg VS
- WAS CSTR 10L HRT 15 0,109 Nm³/kg VS

- Digestate 90 °C batch 0,112 Nm³/kg VS + 56 %
- Untreated digestate batch 0,072 Nm³/kg VS

- Digestate 90 °C batch 0,100 Nm³/kg VS + 89 %
- Untreated digestate batch 0,053 Nm³/kg VS
CUMULATED METHANE PRODUCTIONS:
5, 10, 15 DAYS HRT CSTR 10 L + 20 DAYS BATCH A.D.
Conclusions

• The measurements carried out on the CSTR digester returned a methane specific production of 0.069 Nm³/kg VS, 0.095 Nm³/kg VS and 0.109 Nm³/kg VS, for the 5-day, 10-day, 15-day HRT condition respectively.

• A. d. batch tests showed that Intermediate treatments were more effective in terms of methane production on digestate carachterized by a 15 days HRT if compared to the untrated digestate with the same hrt carachteristic.

• The results indicated that, after an IHT, the difference in the overall methane specific production among the three systems was of limited extent.

• The system with a first stage HRT of 5 days performed better (+7%) in terms of s.m.p. than the systems with a longer duration of the CSTR digestion (10 and 15 days).
Effect of the Hydraulic Retention Time (HRT) on the efficiency of a two-stage anaerobic digestion with intermediate treatments for Waste Activated Sludge (WAS)

Thank you for your attention!

A. Cerutti\textsuperscript{1}, G. Campo\textsuperscript{1}, M.C. Zanetti\textsuperscript{1}, L. Polimeno\textsuperscript{1}, G. Scibilia\textsuperscript{2}, E. Lorenzi\textsuperscript{2}, B. Ruffino\textsuperscript{1}

alberto.cerutti@polito.it

\textsuperscript{1}Department Environment, Land and Infrastructure Engineering, Politecnico di Torino, Torino, I-10129, Italy

\textsuperscript{2}SMAT S.p.A., Società Metropolitana Acque Torino, Castiglione Torinese (TO), I-10090, Italy