High-rate anaerobic co-digestion of kraft mill fibre sludge and activated sludge by CSTRs with sludge recirculation

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Background and Aim

Fibre sludge and activated sludge are two large and costly waste streams from the pulp and paper industry, that are often dewatered and incinerated at low or no energy gains. The aim of this study was:

1. To show that AD of kraft mill fibre sludge and activated sludge is possible
2. To achieve process conditions applicable for full-scale implementation, i.e. decreasing the hydraulic retention time (HRT) and increasing the organic loading rate (OLR).

Material and Methods

- Two lab-scale reactors (4L; R1 and R2) were run for 800 days.
- Fiber sludge and activated sludge were sampled from a kraft pulp and paper mill in Sweden.
- Reactor sludge was concentrated by centrifugation and returned to the reactor.
- Macro-nutrients (N, P) and trace metals were supplied from the start of the reactor experiment.

Phase I

Day 1-36: R1 and R2 were both digesting fiber sludge (see Figure 1)

- The alkalinity of the substrate was low → Additions of lime were necessary to maintain an optimal pH

Phase II

Day 37-283: R1 was digesting fiber sludge, while R2 co-digested fiber sludge and activated sludge

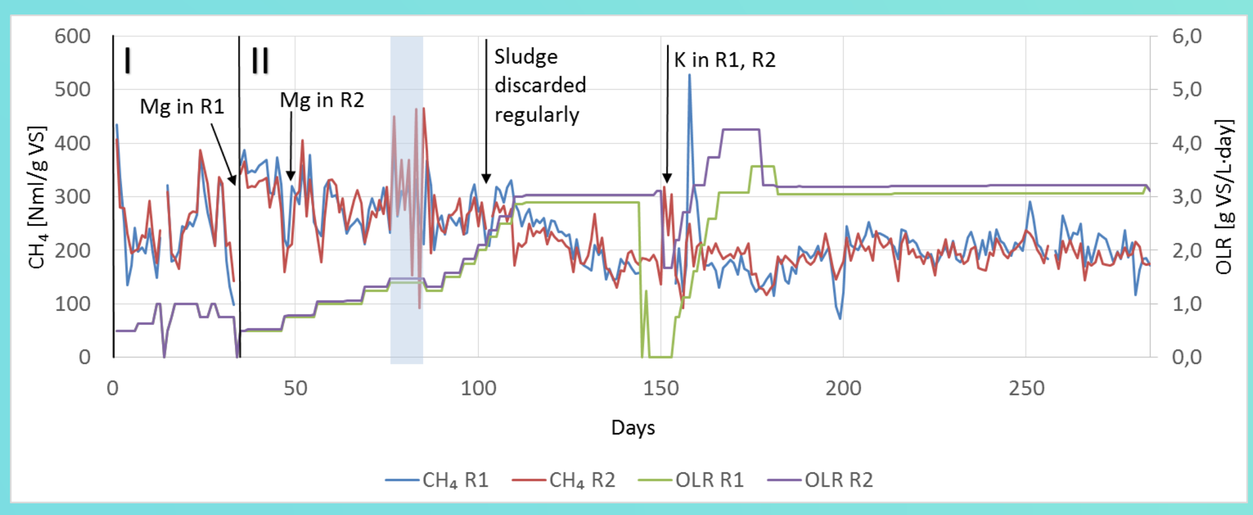

Figure 1. Methane production for biogas reactors R1 and R2 over time for Phase I and Phase II. During the shaded period, R1 and R2 were given pulp instead of fiber sludge as substrate.

- Co-digestion (R2) was a more robust process, showing less accumulation of VFA during process disturbances.
- The Ca:Mg ratio was important for process stability, and additions of Mg and K were necessary.
- Foaming was abated by short but frequent mixing (4 minutes, 20 times per day), from day 248.

Phase III

Day 284-459: R1 and R2 were both co-digesting fiber sludge and activated sludge (see Figure 2)

- The OLR was increased from 3 g VS/L·day to 4 g VS/L·day in both reactors, showing no VFA-accumulation, which was not possible with mono-digestion.

Phase IV

Day 460-800: HRT was decreased from 8 days to 4 days, followed by an increase in OLR from 3 g VS/L·day to 4 g VS/L·day

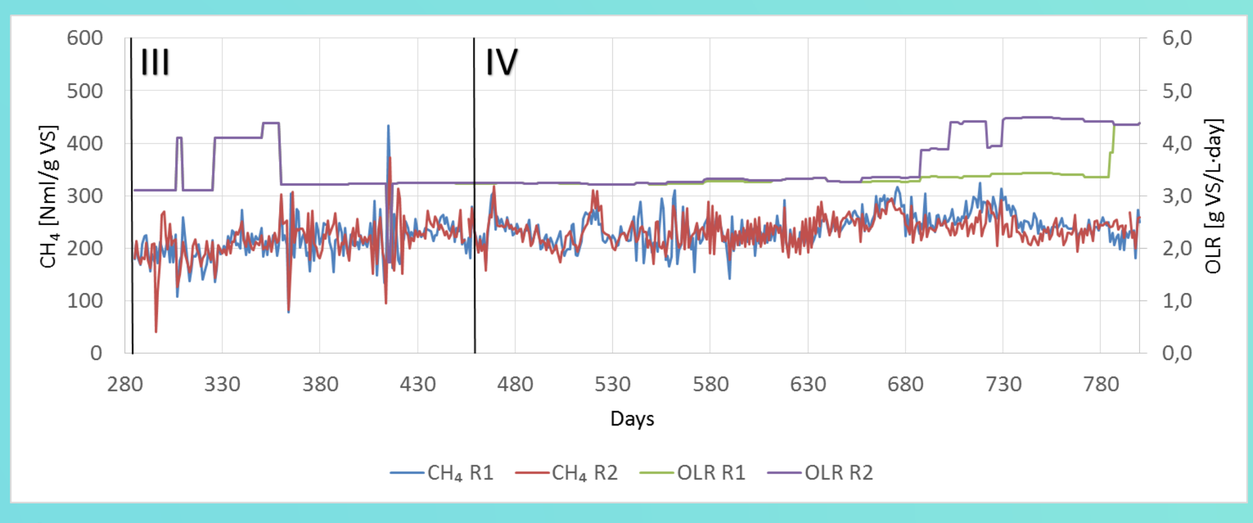

Figure 2. Methane production for biogas reactors R1 and R2 over time for Phase III and Phase IV.

- Methane production and VS reduction remained stable during the decrease in HRT and increase in OLR.
- At maximum efficiency (HRT of 4 days, OLR of 4 g VS/L·day), the methane production was 230±10 NmL per g VS and the VS reduction was 59±3 %.

Conclusions

- Kraft mill fibre sludge and activated sludge was successfully co-digested at low HRT in a CSTR with sludge recirculation.
- Additions of Mg and K were needed for a stable process, and the ratio of Ca:Mg was important.
- Methane production reached 230±20 NmL per g VS at a HRT of 4 days and an OLR of 4 g VS/L·day.
- Foaming was abated by short but frequent mixing.

Future implications

- Our study shows an important possibility of applying AD on two costly waste streams in the pulp and paper industry. This gives an opportunity for the mills to decrease waste treatment costs while producing energy-rich methane gas.