Enhancing anaerobic digestion of organic waste through micro-aeration

Kuyler, J, Mamphweli, N.S., Görgens, J.F., van Rensburg, E.

Stellenbosch University, Department of Chemical Engineering, Banghoek Street, Stellenbosch, Western Cape, South Africa

1. Introduction/Background

- South Africa: heavily reliant on coal >> releases large amounts of greenhouse gases (GHG) [1].
- **Anaerobic digestion (AD)** - processes organic wastes >> produces biogas and digestate >> decreases GHG emissions by capturing methane produced in biogas[2].
- Biogas >> produce heat and electricity - digestate >> recover water and use as fertiliser[3].
- **AD pitfalls:** slow hydrolysis rate of lignocellulosic biomass, process instability >> volatile fatty acid (VFA) accumulation at high organic loading rates, production of hydrogen sulphide gas (H_2S) >> highly corrosive[4,5].
- **Micro-aeration (MA)** - exposes facultative bacteria to low levels of O_2 >> increases bacteria growth rate, activity and diversity >> increases hydrolytic enzyme production >> improves hydrolysis and methane yield, controls VFAs (stable process), and H_2S scavenging[6,7].
- **Three MA ranges:** 0.005 – 0.01 (low), 0.01 – 0.2 (medium), 0.2 – 5.0 L O_2/L reactor/day (high)[7].
- Range used depends on substrate and desired outcome >> medium/high for hydrolysis and low for process stability[7].

2. Aim and Objectives

Aim:

Enhance AD of organic wastes by improving hydrolysis of lignocellulosic biomass and controlling VFA accumulation through MA.

Objectives:

- Develop MA system to introduce and control aeration rates.
- Determine baseline for methane yield, VFA production, and composition of corn stover (CS) before and after AD.
- Investigate effect of MA on hydrolysis of mono-digested CS and process stability of co-digested CS and food waste (FW).

3. Methodology

Substrates and inoculum:

- CS milled in knife mill and sieved to remove fines.
- FW blended and homogenised in bowl cutter.
- Inoculum from cow manure digester.
- Inoculum-to-substrate = 2:1
- Total solids of substrate diluted to 10% with deionised H_2O.

Carbon-to-nitrogen (C/N) optimisation:

- Biochemical methane potential (BMP) tests conducted to determine optimal C/N ratio for co-digestion.

Micro-aeration:

- Conducted in nine digesters (35 L working volume).
- MA system: compressed air, flow meter, pressure regulators, flow control valves, and spargers.

Figure 1: FW before blending

Figure 2: Milled CS

Figure 1: Digesters for experimental work.

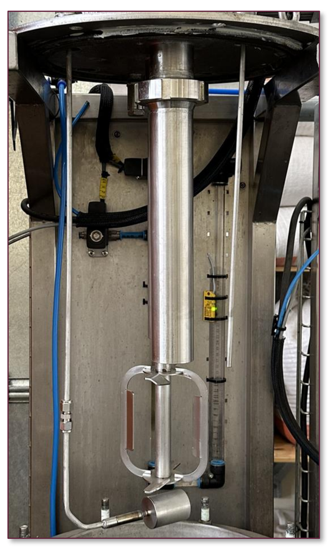

Figure 2: Sparger in digester.

Figure 3: MA system

4. Progress to date

Carbon-to-nitrogen optimisation:

- 20:1; 25:1; 30:1 ratios investigated -> 30:1 best methane yield.
- C/N ratio 30:1 used in further co-digestion runs.

Micro-aeration: Corn stover hydrolysis

- 0.1, 0.6, 1.0 L O_2/L reactor/day investigated >> equivalent to 12, 70, 100 ml_{air}/min.
- 0.1 L O_2/L reactor/day highest specific methane yield (SMY) of 193.95 ml CH_4/g VS among aerated runs >> 10.2% less than non-aerated CS (216.09 ml CH_4/g VS).

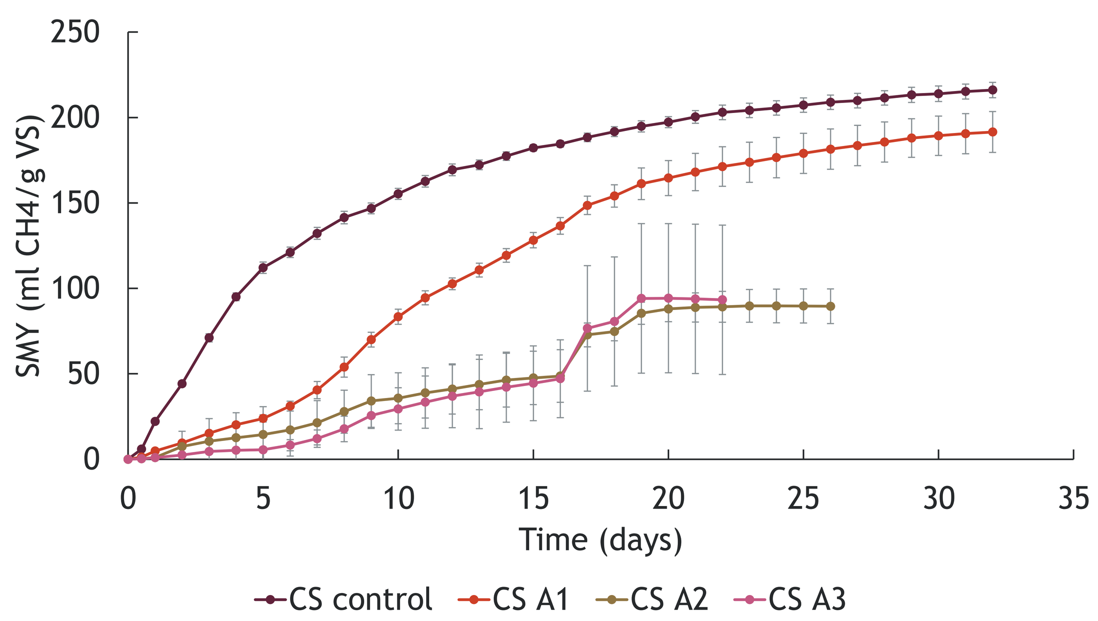

Figure 6: SMY for the aerated and non-aerated CS runs (A1 = 12 ml/min, A2 = 70 ml/min, A3 = 100 ml/min)

- Aerated runs showed higher VFA concentrations compared to control >> specifically acetic acid.

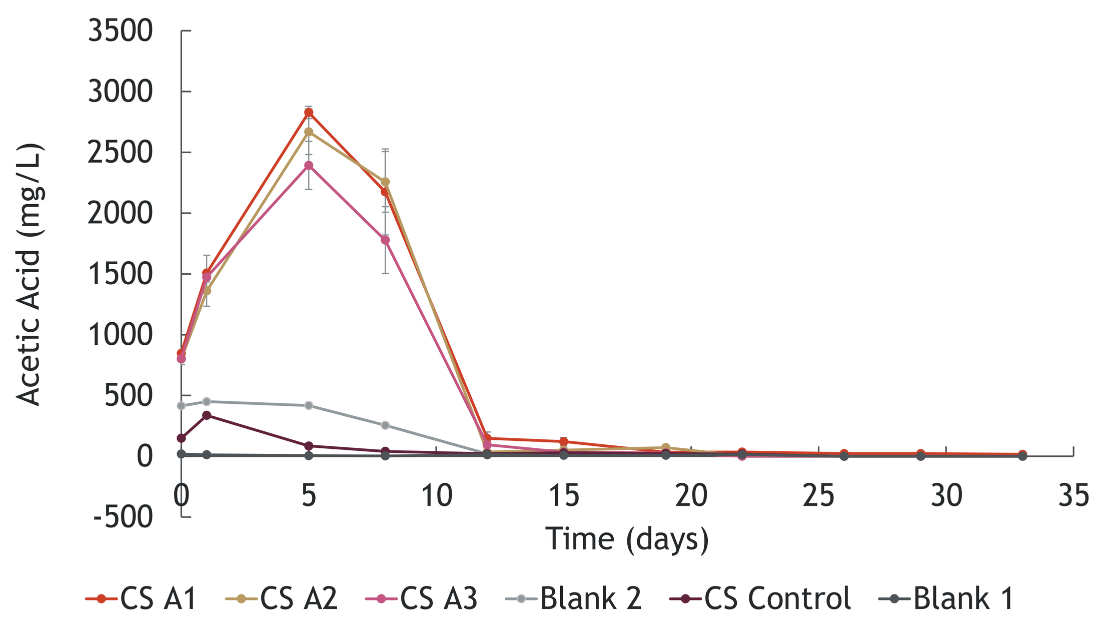

Figure 8: Acetic acid concentration of the aerated and non-aerated CS runs (A1 = 12 ml/min, A2 = 70 ml/min, A3 = 100 ml/min, Blank 1 = inoculum used in control runs, Blank 2 = inoculum used in aerated runs).

5. Conclusions and way forward

- MA CS runs do not show SMY or hydrolysis rate improvement >> indicating O_2 levels are too high.
- Next steps include investigating lower O_2 levels before moving on to the process stability of co-digestion.

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