Anaerobic digestion of cheese farm waste using continuously-stirred tank reactors under two different feeding regimes: semi-continuous feeding and batch loading.

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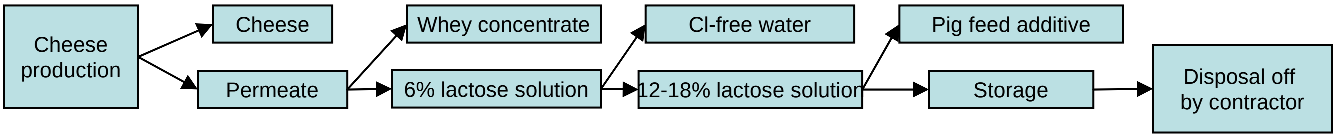
Introduction

The source of waste and current methods of disposal:

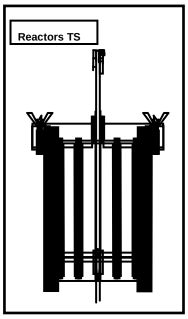


Problems posed by current situation:
- ✖ High expense to pay the contractor for the lactose disposal (£120 per tank, 1-2 tanks per day).
- ✖ Storage space required for lactose prior the collection by the contractor (145-166 m^3 of lactose are produced daily).

Advantages offered by the anaerobic digestion:
- ✓ Reduction of daily costs.
- ✓ Production of valuable gases (e.g. methane and hydrogen) that can provide energy for running the plant.
- ✓ Effective utilisation of freed space.

Laboratory-scale trials

Reactors



Source: University of Southampton

- ◎ Plastic, cylinder shaped
- ◎ 4-litre effective volume
- ◎ Mechanically stirred by electric motors attached to stainless steel stirrers
- ◎ Heated by water to 36-38^{O}C
- ◎ Kept in an insulator box
- ◎ Connected to gas collectors, filled with acidified (pH<4) water
- ◎ Fitted with a sampling/feeding port

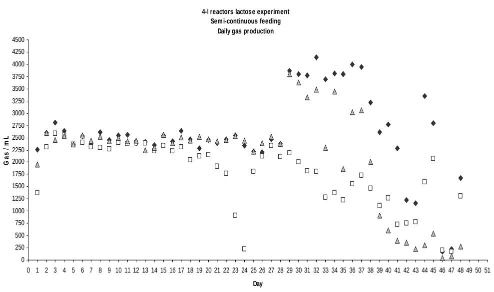
Characteristics of the substrate – lactose solution:

Parameter	**Concentration, g l^{-1}**
Chemical oxygen demand (COD)	130 +/- 40
Total solids (TS)	142 +/- 25
Volatile solids (VS)	129 +/- 24
Total suspended solids (TSS)	0.39 +/- 0.02
Volatile suspended solids (VSS)	0.37 +/- 0.02
Nitrogen (as NH_3)	0.21 +/- 0.04
VFA (as acetic acid)	~1.3

Basal nutrient medium (g l^{-1}): macronutrients -NH_4Cl (0.53), $CaCl_2.2H_2O$ (0.08), $MgCl_2.6H_2O$ (0.1); micronutrients as a solution at 1ml l^{-1}.

Results

Semi-continuous feeding regime: Organic loading rate (OLR) for all reactors 1 g COD l^{-1} day^{-1}

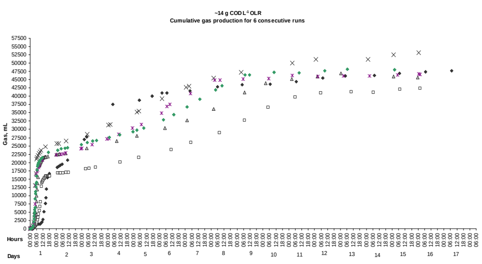


◆ **Reactor 1**: 50 days retention time (RT). Steady gas production was established during the first 30 days – 2.45 l per day, 45% CH_4, 0.27 m^3 kg^{-1} COD added. Increase of OLR to 1.5 g COD l^{-1} day^{-1} raised the gas production levels, but after 10 days resulted in accumulation of volatile fatty acids (VFA), decrease in alkalinity and digester failure within the next 10 days.

☐ **Reactor 2**: 16 days RT. Steady gas production was established during the first RT period – 0.23 m^3 CH_4 kg^{-1} COD added. In the next 7 days the gas production has fallen dramatically and VFA accumulation was observed. Addition of alkalinity (as $NaHCO_3$) did not provide a long-term improvement to the process.

△ **Reactor 3**: 16 days RT and sludge re-circulation. Steady gas production was established during the 30 days – 0.27 m^3 CH_4 kg^{-1} COD added. Increased OLR to 1.5 g COD l^{-1} day^{-1} resulted in rapid fall in gas production levels, decrease in pH, and VFA accumulation.

Batch shock loading feeding regime: OLR ~14.0 g COD l^{-1} (other loadings of 0.5, 1.0, and 1.5 g COD l^{-1} were also tried).



Four distinct stages were observed during each run:

❶ ***Hydrogen fermentation stage*** - first 24 hour period: up to 50% of the total gas is produced, with high contents of hydrogen (up to 68%).

❷ ***VFA production stage*** - 2nd-4th days of the run: VFA concentration is at its highest during this period, gas production slows down, hydrogen contents drop and methane contents rise.

❸ ***Methanogenic stage*** - 4th-7th days of the run: gas production rates rise, high contents of methane observed (up to 75%), VFA levels decrease. Up to 35% of the total gas volume is produced during this stage.

❹ ***Trailing-off stage*** - 7th-14th days: gas production slows down, methane contents are still high, alkalinity rises and IA:PA ratio falls.

Conclusions

A long-term stable anaerobic digestion process could not be achieved in a single-stage CSTR operating on a semi-continuous feeding regime, even at a loading as low as 1 g COD l^{-1} day^{-1}. Increased retention times, recirculation of solids, pH and alkalinity adjustments did not provide long-term solutions. The reactors, however, showed an ability to cope with shock loadings of up to 17g COD l^{-1} per load. The work is currently still in progress. To apply these observations to the design of full scale experiments, the possibilities of shortening the trailing-off period as well as separating each stage are being investigated.

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