



Measurement for the optimisation of the anaerobic digestion process

Robin Eccleston

robin.eccleston@th-koeln.de

Cologne University of Applied Sciences



Technology
Arts Sciences
TH Köln



Funded by
the European Union

Agenda

- Project Overview
- MEMS VFA measurements
- MEMS gas measurements
- Gas transient response

Project Overview

- General theme: Optimisation of biogas production using spectroscopy
- Evaluate performance of new sensor technology for the AD process.
- Develop machine learning methods to analyse data.
- Develop method to determine optimum loading rate for individual digesters.

Measurement of VFAs

- Important intermediate product in process.
- Time consuming to measure.
- High levels stop process.
- New sensor technology if functional could measure this better than UV/Vis/NIR.
- Measurements would be online with automatic cleaning of sensor.
- Then use data to optimise performance.

Liquid Phase MEMS Sensor



MEMS VFA Sensor Details

- Two sensors:
 - 6.320 – 7.570 μm
 - 8.350 – 9.970 μm
- Issues with SNR.



- Approximately 11 minutes per scan per sensor.
- Total measurement time around 45 minutes with BG scans.
- Longer scan time doesn't give required improvement.
- Coupled with Diamond ATR probe from art photonics.

MEMS VFA Sensor Results

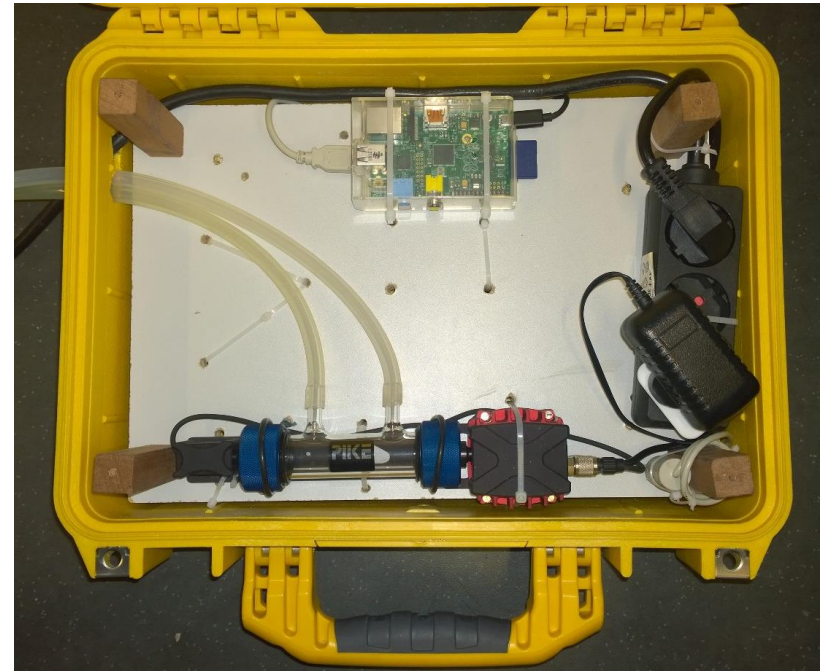
- Can detect VFAs at 10% concentrations.
- 0.1% acetic acid already inhibits process.
- Ratios between other acids is also important.
- Need sensitivity greater than 0.1%.

MEMS Biogas Sensor

- Also uses MEMS technology.
 - Wavelength range 3 - 3.7 μ m
- Tested response in laboratory.
- Tested sensor at different scales
 - 5L CSTR system
 - 1000L pilot scale plant in :metabolon
 - 1.2MW landfill site in :metabolon
- Advantages over both chemical sensor and single/dual wavelength IR sensors.

Sensor for :metabolon

- Raspberry Pi
- Gas Sensor
- Fitted in Pelican case
- Performs 1 scan every 45 seconds





Gas Measurement Results

- Methane prediction very good, <1% RMSEP
- Other gases have lower accuracy
 - Carbon dioxide causes weaker absorption.
 - Hydrogen not possible for IR sensor to measure.
 - Hydrogen sulphide concentrations too low.

Methane Response



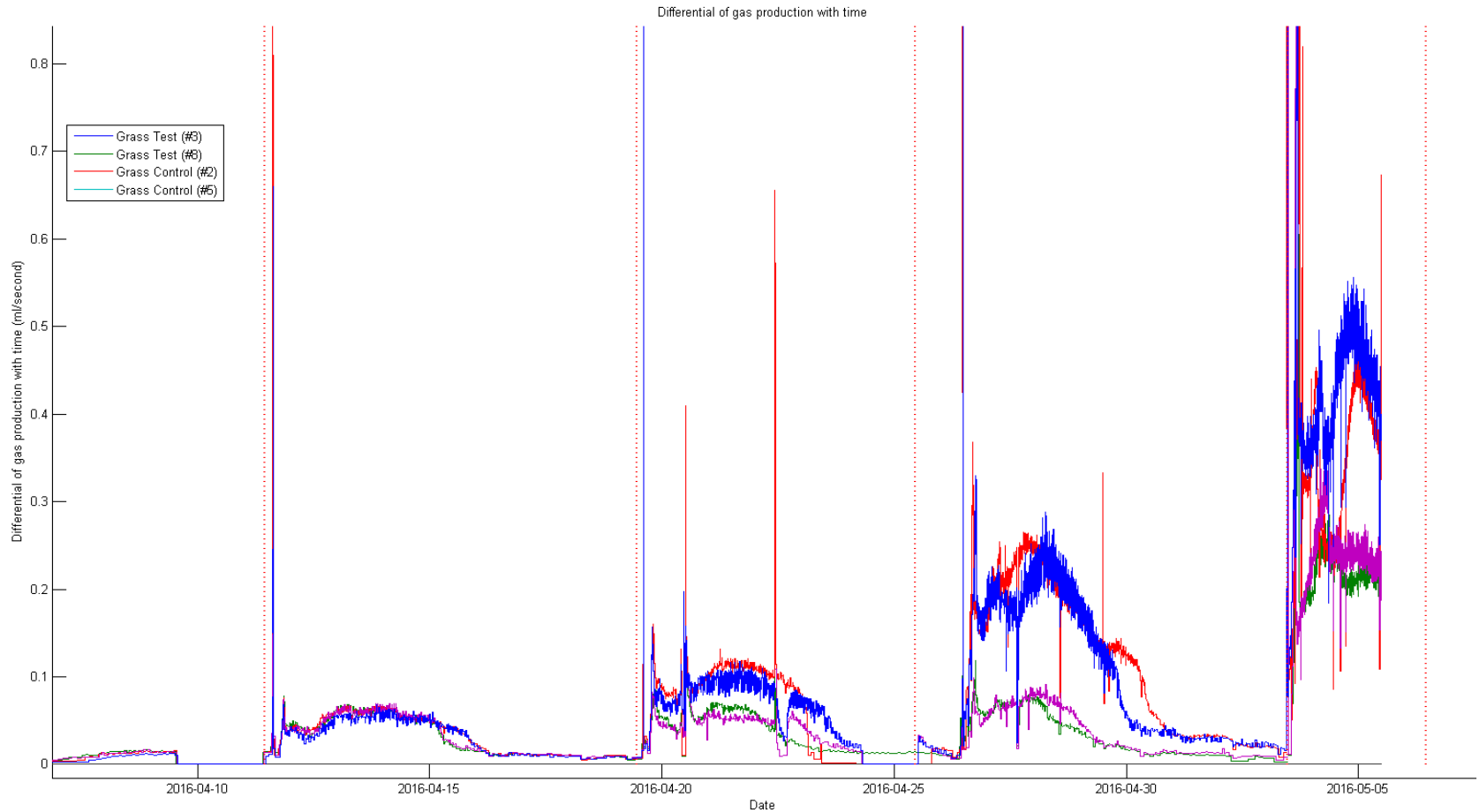
Gas transient response for optimisation

- Previous work completed by J-P Steyer et al.
- Method only suitable for continuously fed systems.
- Principle is that as digester approaches inhibition, digester response to feeding events changes.
- Only uses gas production rate.
- Investigating applicability to batch fed reactors.

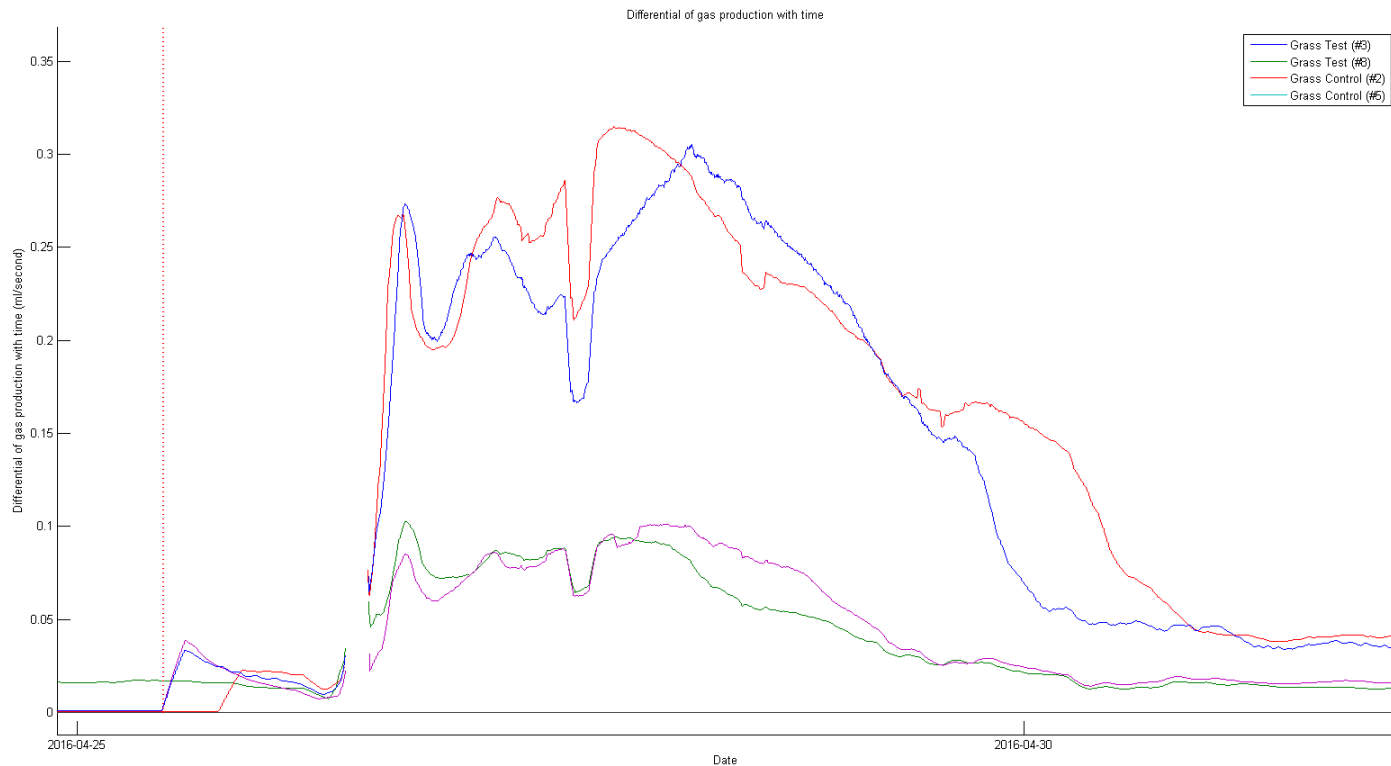
Reactor setup



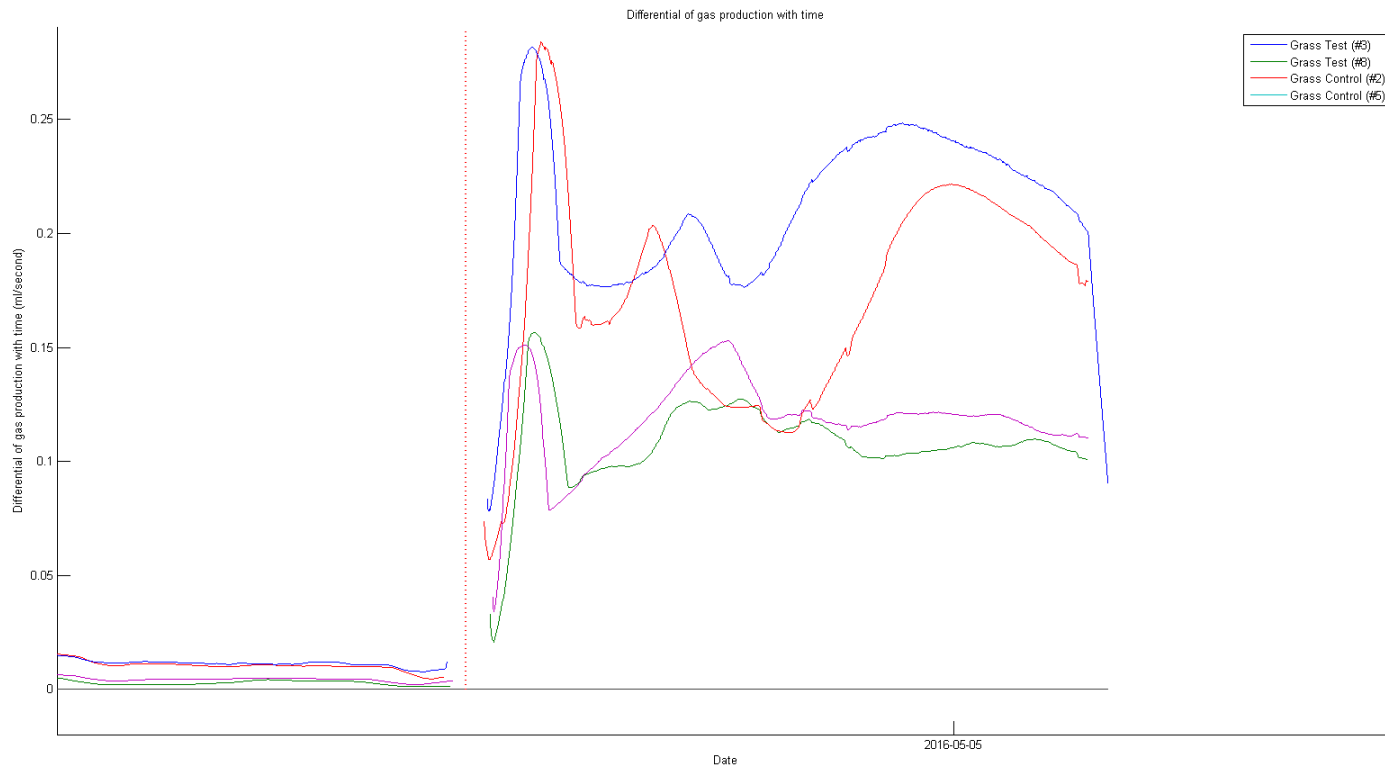
Gas Production Rate



Gas Production Profile 1



Gas Production Profile 2



Gas Production Profiles

- Different gas production profile as digesters approach inhibition.
- Goal is to create analysis method that works with existing sensors.
- Need to investigate further possible indicators (e.g. biogas composition).
- Focusing on gas, but will also investigate VFA patterns in simulations.

Conclusions

- MEMS Spectroscopy for VFA measurement still has challenges with technology.
- MEMS technology works for gas measurement.
- Changes in gas production as digester approaches inhibition have been observed in lab.
- Currently running simulations to replicate results and create optimisation technique.
- Finalised technique will then be tested again in lab.



Thanks for listening



This project has received funding from the European Union's Seventh Framework Programme for research, technological development and demonstration under grant agreement n. 316838



Project coordinated by the QUESTOR Centre
at Queen's University Belfast
www.qub.ac.uk/questor