Anaerobic Digestion of Brewery Waste

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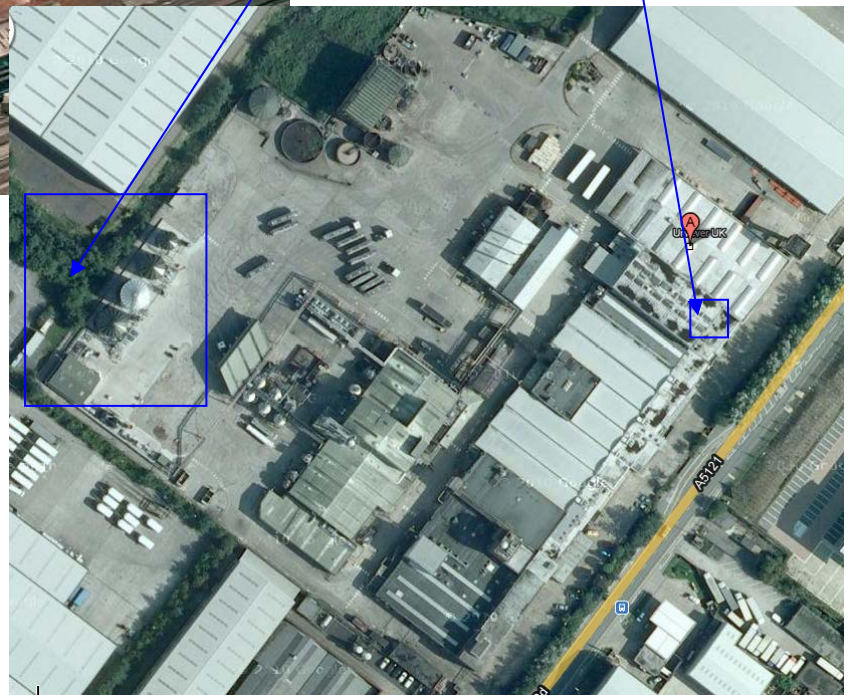
Presentation Outline

- Marmite Unilever-introduction/site history
- Vital statistics
- Waste water treatment plant (WWTP)
- Biogas production
- Benefits of WWTP for Unilever
- Issues with stability
- Conclusions

Site aerial view before and after

WWTP

Marmite tower

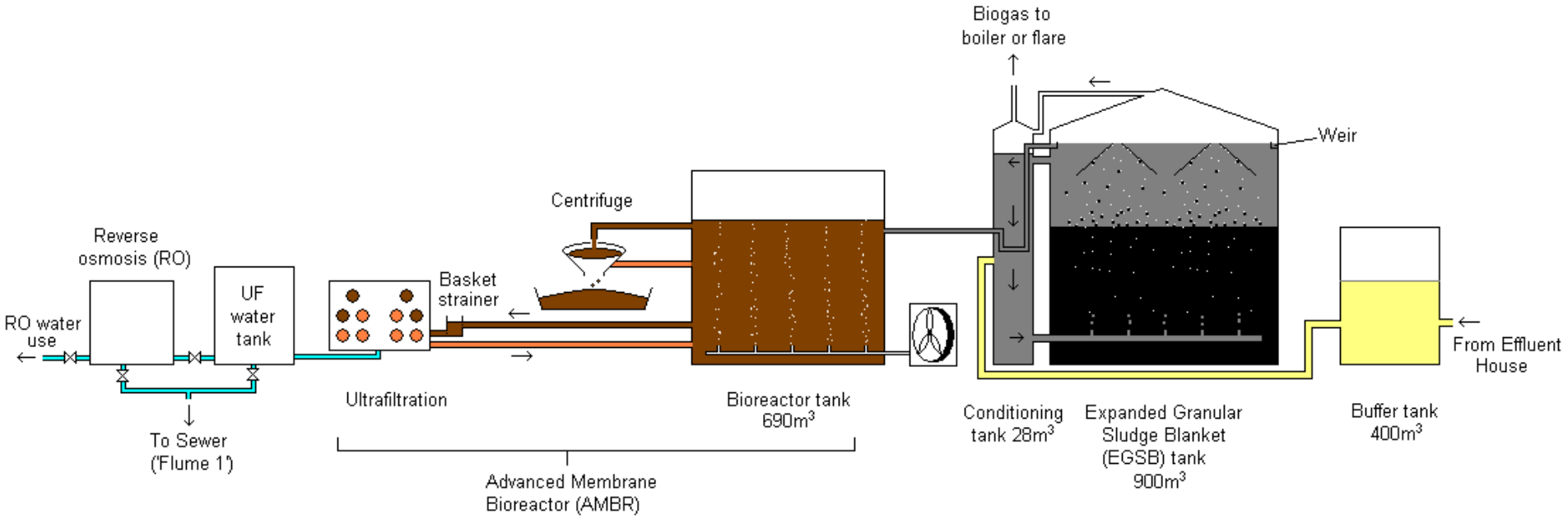


- Started planning July 2005
- Started building August 2007
- Finished building January 2008
- Contains
  - anaerobic stage
  - aerobic stage
  - reverse osmosis (RO) plant

Brewery waste

- The treatment of brewery wastewater is the most common application of high rate anaerobic digestion of wastewaters
- High biodegradability of effluent due to dissolved carbohydrates and alcohol
- High SCOD/COD ratio
- Traditional aerobic expensive due to power for aeration and high sludge yields

WWTP diagram



Pre-treatment

- Buffer tank (400 m^3 capacity, half full)
  - Mixes different strengths and compositions of effluent together
  - Averages out concentration and prevents shocks
  - Second buffering tank introduced
- Conditioning tank (circ. 200 m^3/hr)
  - Modifies temperature (35°C) and pH (7.0) of effluent

Vital Statistics

- Throughput about 250 m^3/day
- COD concentrations (mg/l)
- This is about a 99.2% reduction

COD in effluent	15000
EGSB	2000
To sewer (flume 1)	120

- Suspended solids concentrations (mg/l)

TSS in effluent	2400
EGSB	1400
To sewer (flume 1)	55

Further treatment

Aerobic part (Aquabio)

- Bioreactor (reduces suspended solids (+ COD))
- Centrifuge (removes biomass)
- UF (removes water)

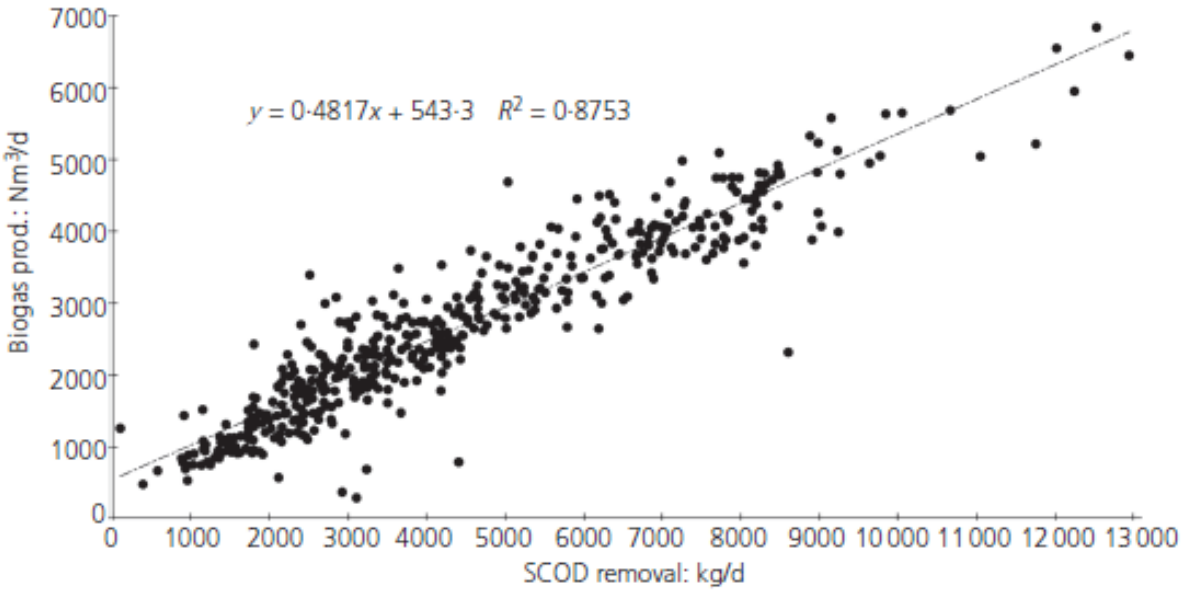
Reverse Osmosis

- Very thin membranes under high pressure
- Produces super-pure water
- Suitable for washing and boiler water
- Not suitable for drinking or adding to product

Biogas quality

- Normally 60% methane, 40% CO_2
- But here is 70±9% methane
- Can be burned or flared in boilers (for hot water to be used on site)
- Very variable production rate, which makes its use more problematic
- Average 80 m^3/hr

Biogas production



- Specific gas yield of 0.4l CH_4/g $COD_{removed}$
- The boiler biogas is cooled (refrigerated heat exchanger) to remove water vapour and then wet scrubbed with sodium hydroxide in a counter current stripping tower to remove sulphides. The gas is then pressurised and fed into one of the existing boilers
- Average SCOD was 84·5% ± 10·6%, which reduces the time for hydrolysis, a rate-limiting step. The SCOD removal efficiency was 95% in year 1 and, following the separator repairs, 98% in year 2

Control of the WWTP- Monitoring Parameters

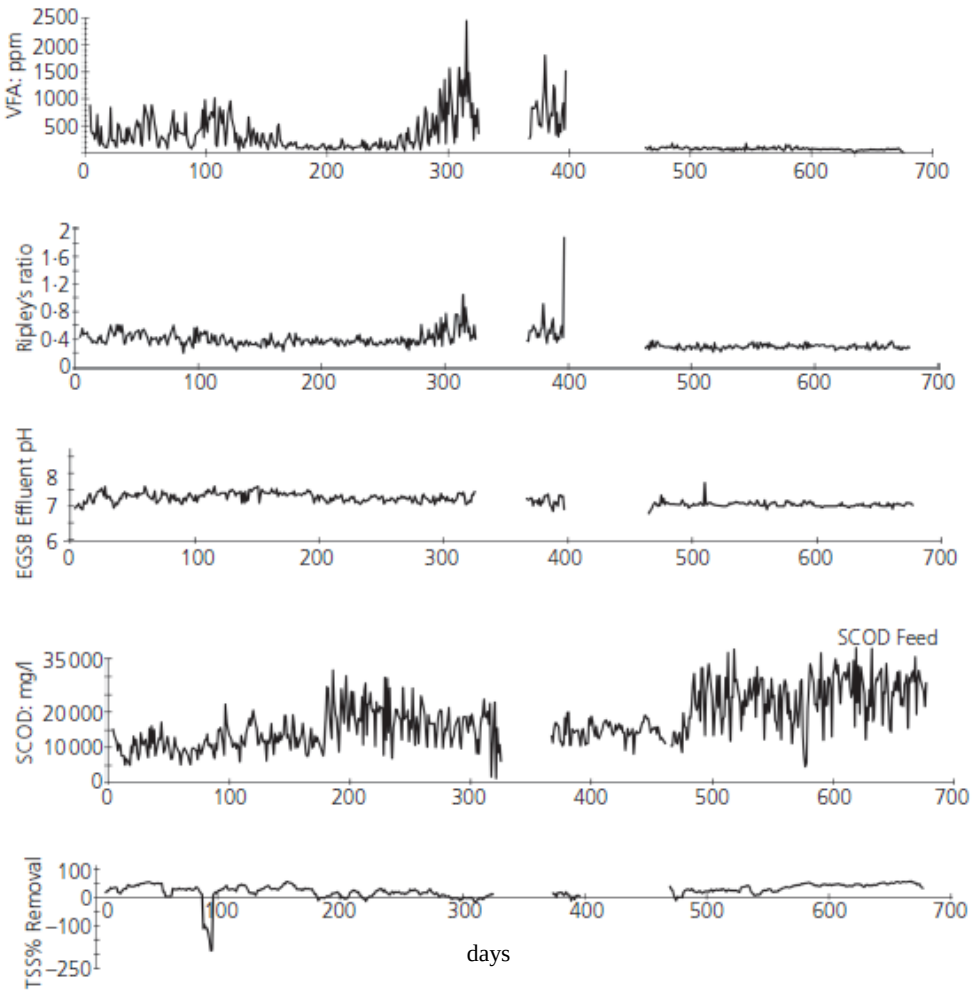
- Automatic controls (pH modification, temperature, high and low set points)
- Some manual intervention in special circumstances, e.g. high buffer tank volume, high Ripley's ratio
- Tests every day – COD, suspended solids, Ripley's ratio, VFA, biogas production
- Tests a few times a week – ammonia, phosphate
- Monthly tests – biomass content, biogas composition

Benefits

- Reduced utility costs
- Reduced smell
- Biogas
- Re-useable water
- Fertiliser production (centrifuge solids)

COD (mg/l)	TSS (mg/l)	Charge per m^3 (£)	Saving per yr @ 250m^3/day (approx. £)
15000	2400	6.44	0
2000	1400	1.52	450,000
120	55	0.48	545,000

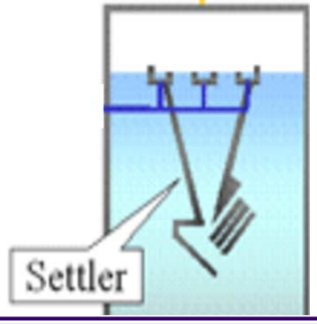
Monitoring Parameters- instability



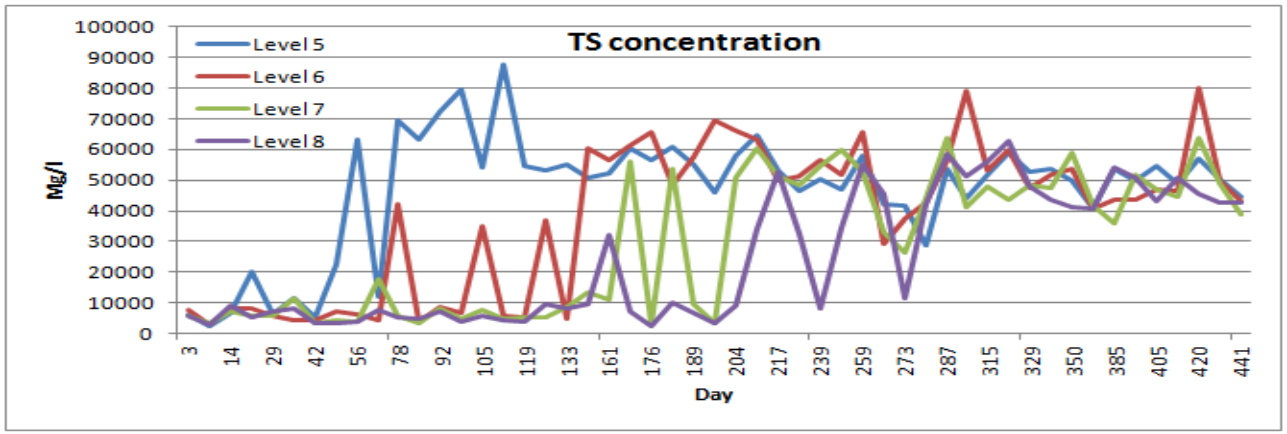
- Day ~275 an increase in VFAs noticed and slight increase in RR (note pH remains stable)
- Day 340 annual shutdown of the factory- inspection of the EGSB
- Days 400-450 further planned shutdown for repairs
- Issues with solids separator

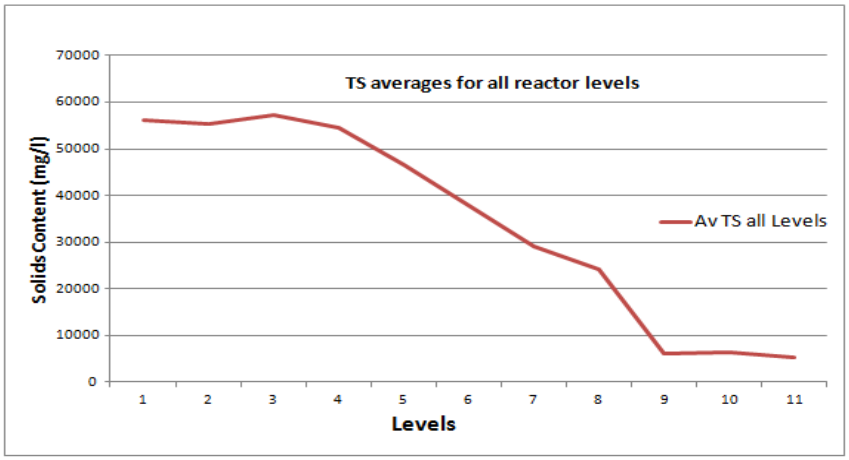
Post-shutdown performance:

- Greater stability of the process



Solids Inventory





- The height of the sludge bed can be measured with sampling taps
- Level 3- top od the fluidized bed
- Solids build-up issues
- High solids at the bottom of the tank- solids removal will be needed

Conclusions

- Newly available method for the analysis of total volatile fatty acids (VFAs) was ideal as a rapid, onsite, operational indicator of reactor stability
- Total VFAs were shown to provide an earlier warning of the separator problem than the other rapid routine methods of monitoring; COD removal, pH and gas yield were not as useful for monitoring because of their slow response
- Initial TSS removal was 20%. Following the repairs, overall TSS removal efficiency was still low at ~30%- EGSB reactors would not be expected to retain fine solids because of vigorous mixing
- The variability in feed COD meant that deterioration in COD conversion to gas was difficult to spot

Conclusions- cont'd

- No evidence of granule losses as a result of the damage to the internal separator, but solids inventory measurements are needed in order to understand mass balances and interpret specific gas yields.

- The results confirm the need for effluent buffering, as the range of in-flow rate was 12–774m^3/d, COD in the raw effluent ranged from 5500 to 41 400mg/l, and total SS values were between 260 and 4800mg/l.

- Anaerobic conversion of COD to gas was linked to its solubility, achieving a greater than 95% conversion at 20 kg COD/m^3/d.

- Great financial benefit of WWTP on site- reduced sewerage cost

Publication:

Tanja Radu, Richard Blanchard, Vincent Smedley, Helen Theaker, and Andrew Wheatley, Anaerobic Digestion of Brewery Effluent- 2 Year Operating Experiences and Key Effects on Performance, *Journal of Environmental Engineering and Science*, 9(4), 207 –213, **2014**

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Thank you!

Questions?