Hydrothermal Carbonisation of Spent Coffee Grounds and Subsequent Anaerobic Digestion of Process Water

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Waste Biomass

- Abundant
- High water content
- Low energy content

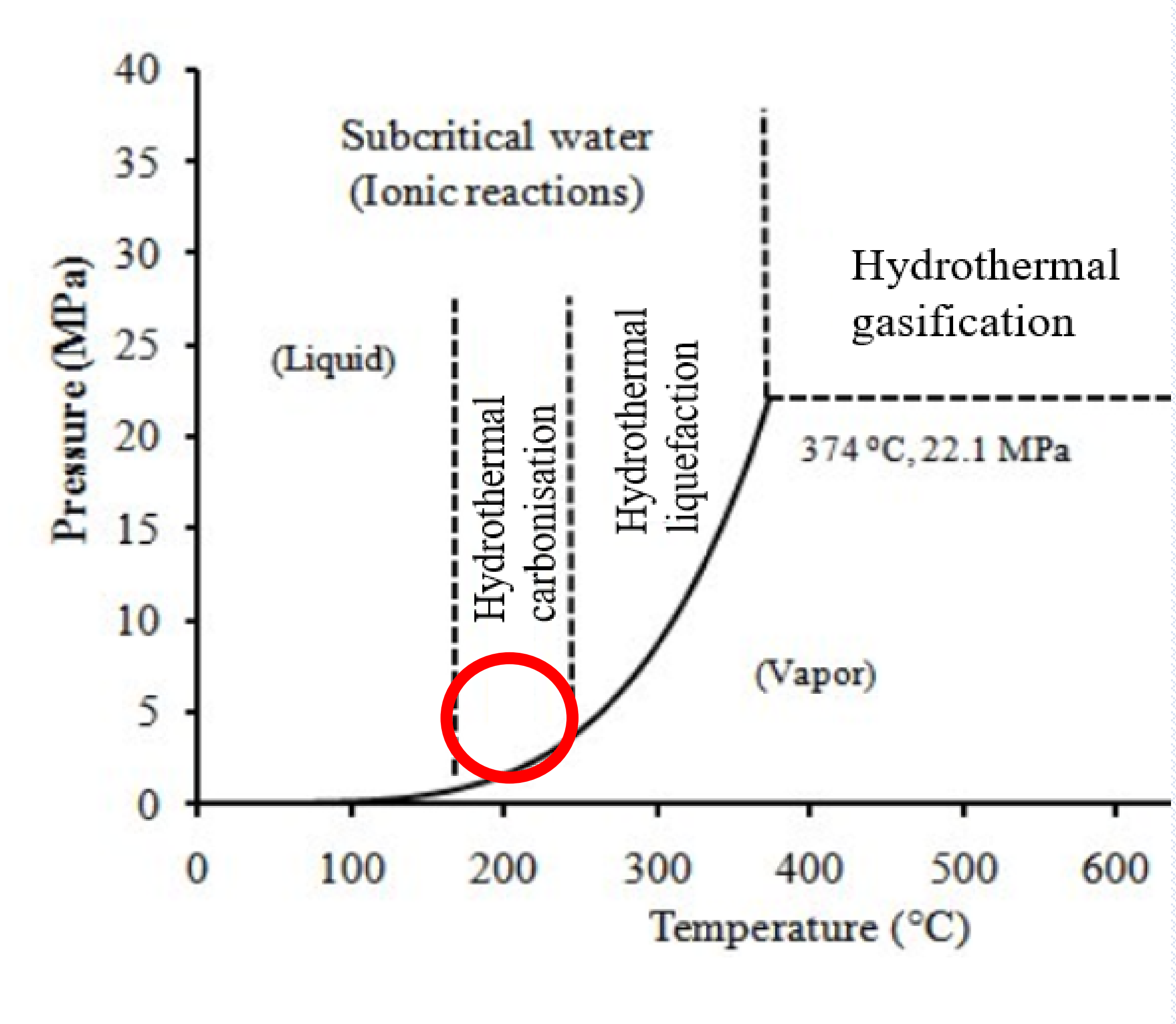
Sewage sludge
80 % moisture

Food waste
70 % moisture

Green waste
29 - 46 % moisture

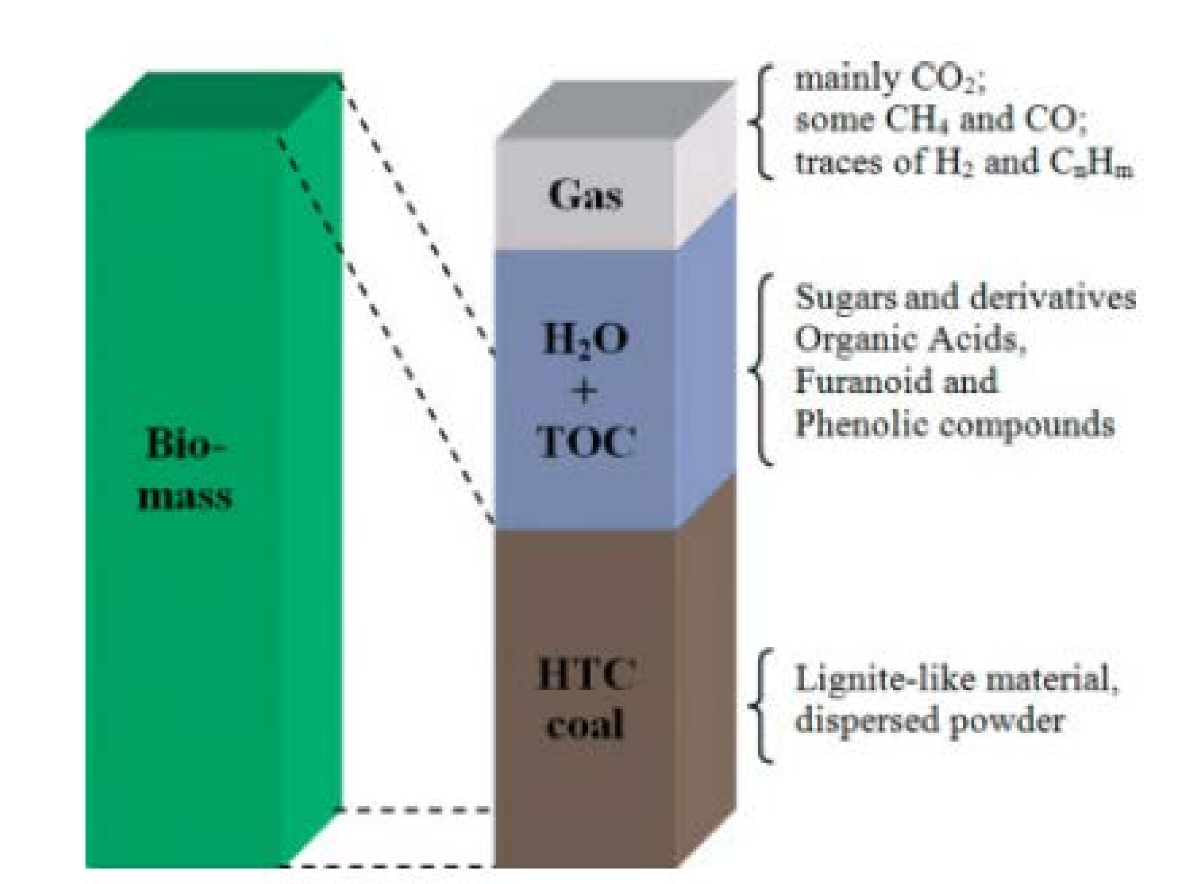
Hydrothermal carbonisation (HTC)

- Complete immersion in liquid water
- 180 – 300 °C
- Autogenous or applied pressure (10 – 50 bar)



Kumar, S. (2010) pp. 1

HTC Products



- Hydrochar solid product
  - Reduced O/C and H/C ratios
  - Improved fuel and combustion properties
  - Easier to dewater
- Polluted process water
  - High COD and BOD
  - Low pH
  - Colouring
  - Solubilised inorganic Content
- Gas

Funke, A. (2010), *Biofuels, Bioproducts and Biorefining*. 4, pp. 160, [1] Council Directive 91/271/EEC

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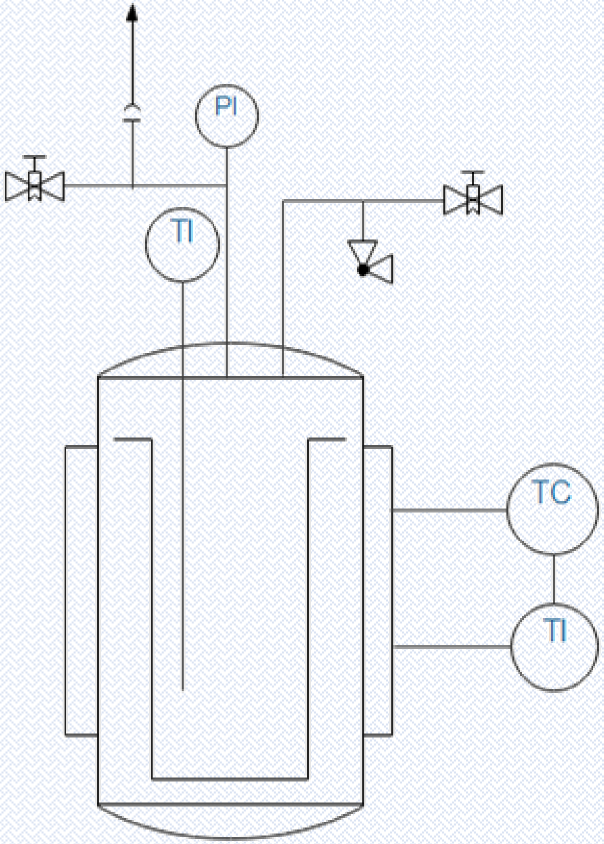
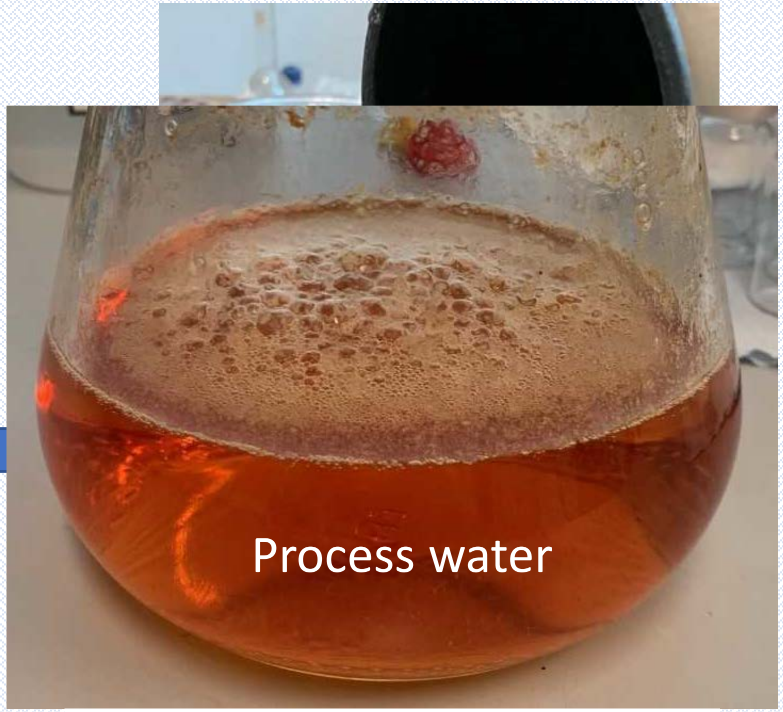
Spent coffee grounds (SCG)

- Consistent model system for scientific purposes
- 10 million tons of coffee produced in 2018 globally [1]
- ~ 6 million tons of SCG as waste each year [2]
- Currently incinerated
- Moisture content of 55 – 80 % [3]

[1] ICO - International Coffee Organization, 2018) [2] Tokimoto et al., 2005 [3] Gómez-de la Cruz, F. J. (2015) *Fuel Processing Technology*. pp. 188

10 wt%
DS input





COD = 33,700 mgO_2/L
pH = 3.92

Discharageable effluent [1]
COD < 125 mgO_2/L
Or > 75% COD reduction

[1] Council Directive 91/271/EEC

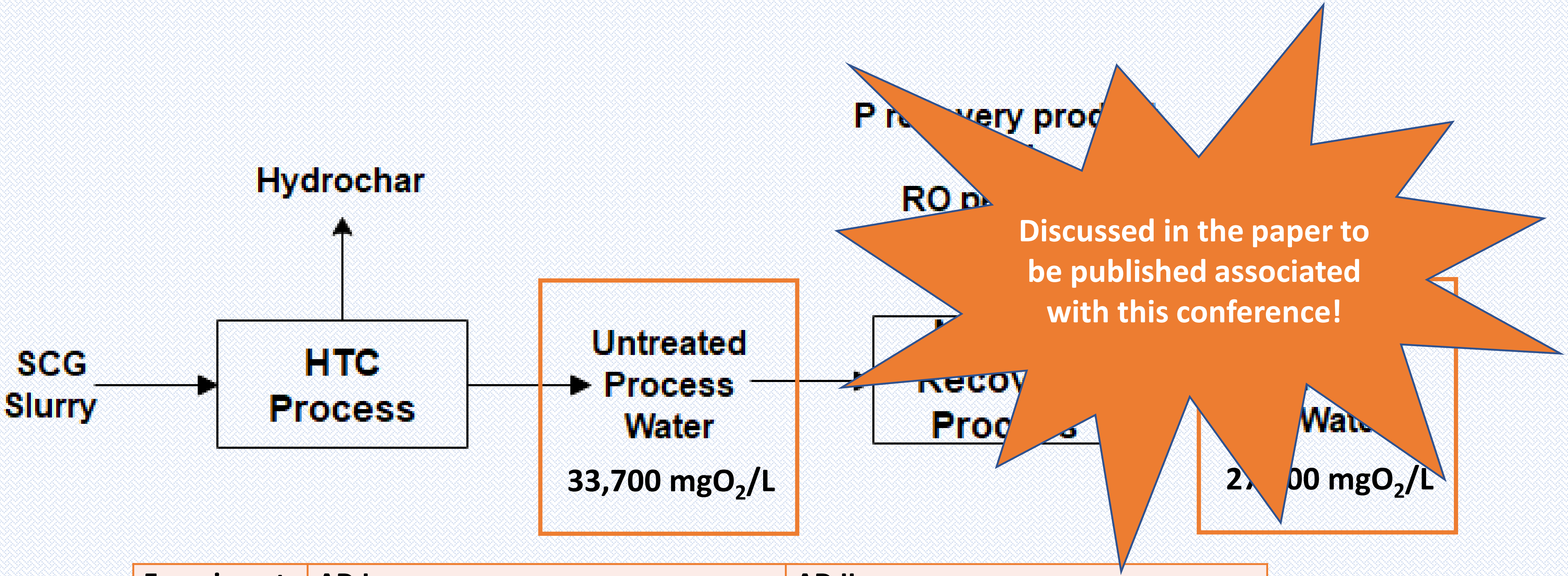
HTC of SCG

Input			
		Value	Error (+/-)
Spent Coffee Grounds	Mass (g)	60	1
	TC (%)	53.6	0.9
	C (g)	**32.2**	**0.8**
Total	**Carbon (g)**	**32.2**	**0.8**

Output			
		Value	Error (+/-)
Char	Mass (g)	33.4	1.1
	TC (%)	79.2	2.7
	Solid C (g)	**26.5**	**1.3**
Liquid	Mass (kg)	0.55	0.00
	TC (g/L)	9.83	0.44
	C (g)	**5.4**	**0.2**
Gas	RHP (bar)	2.8	0.7
	Head vol (ml)	200	20
	CO_2 (mol)	0.023	0.006
	C (g)	**0.276**	**0.006**
Total	**Carbon (g)**	**32.1**	**1.3**

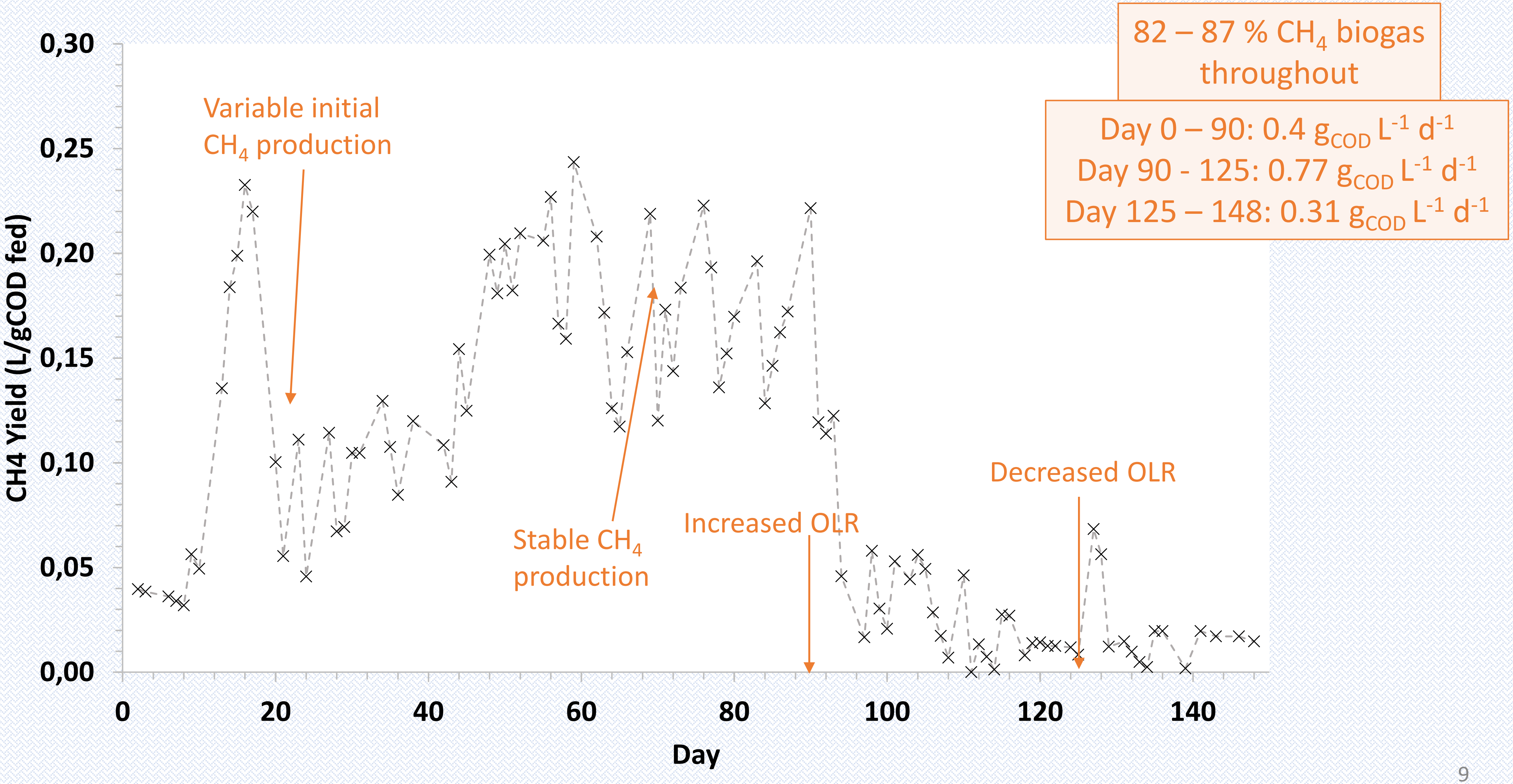
- Solid Yield 56 ± 2 %
- Carbon Yield to Solid 82 ± 4 %
- Carbon Yield to Liquid 17 ± 1 %

Anaerobic Digestion of Treated and Untreated PW

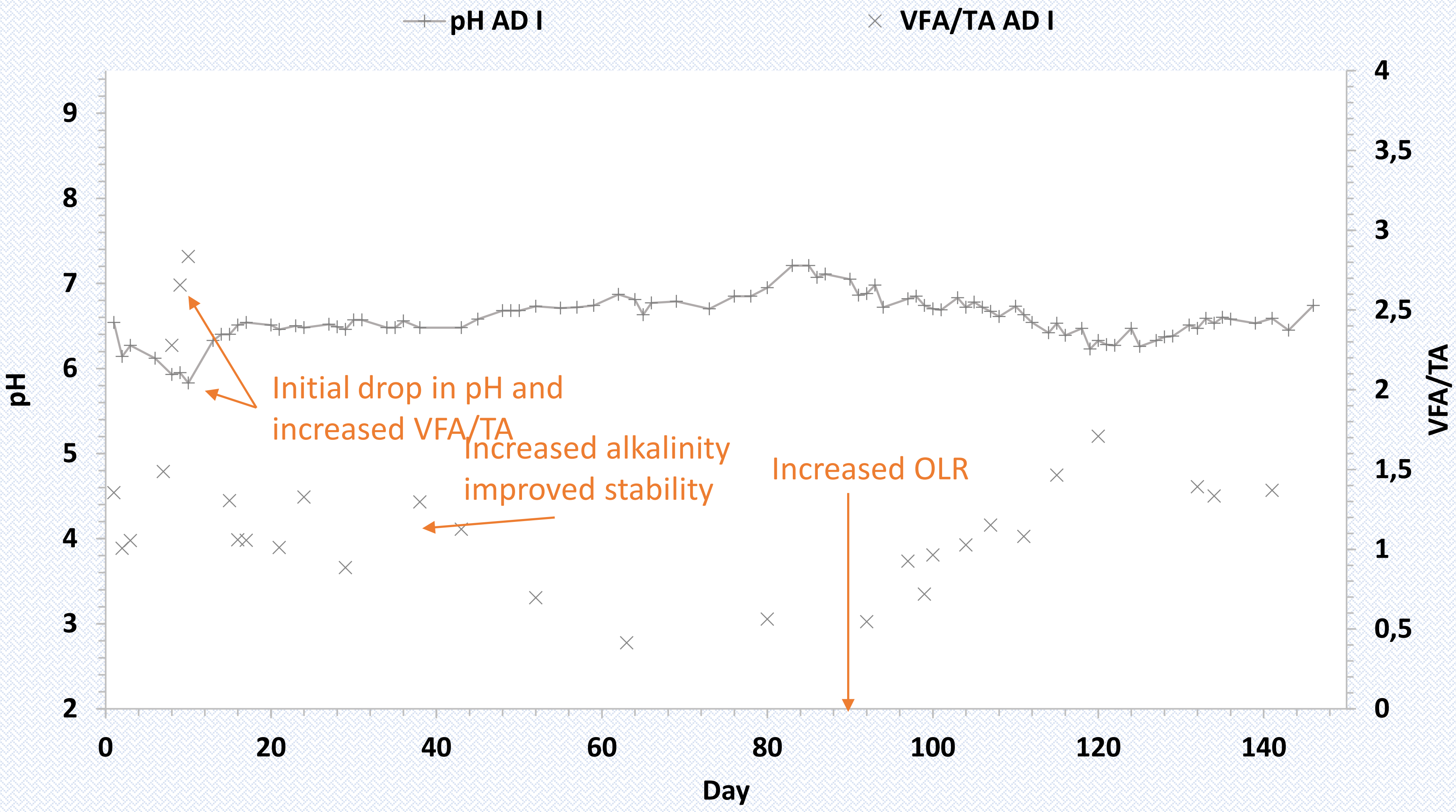


Experiment	AD I	AD II
Feed	Day -14 - 0: glucose Day 1 – 146: untreated process water	Day -14 - 0: glucose Day 1 – 34: untreated process water Day 35 – 77: treated process water

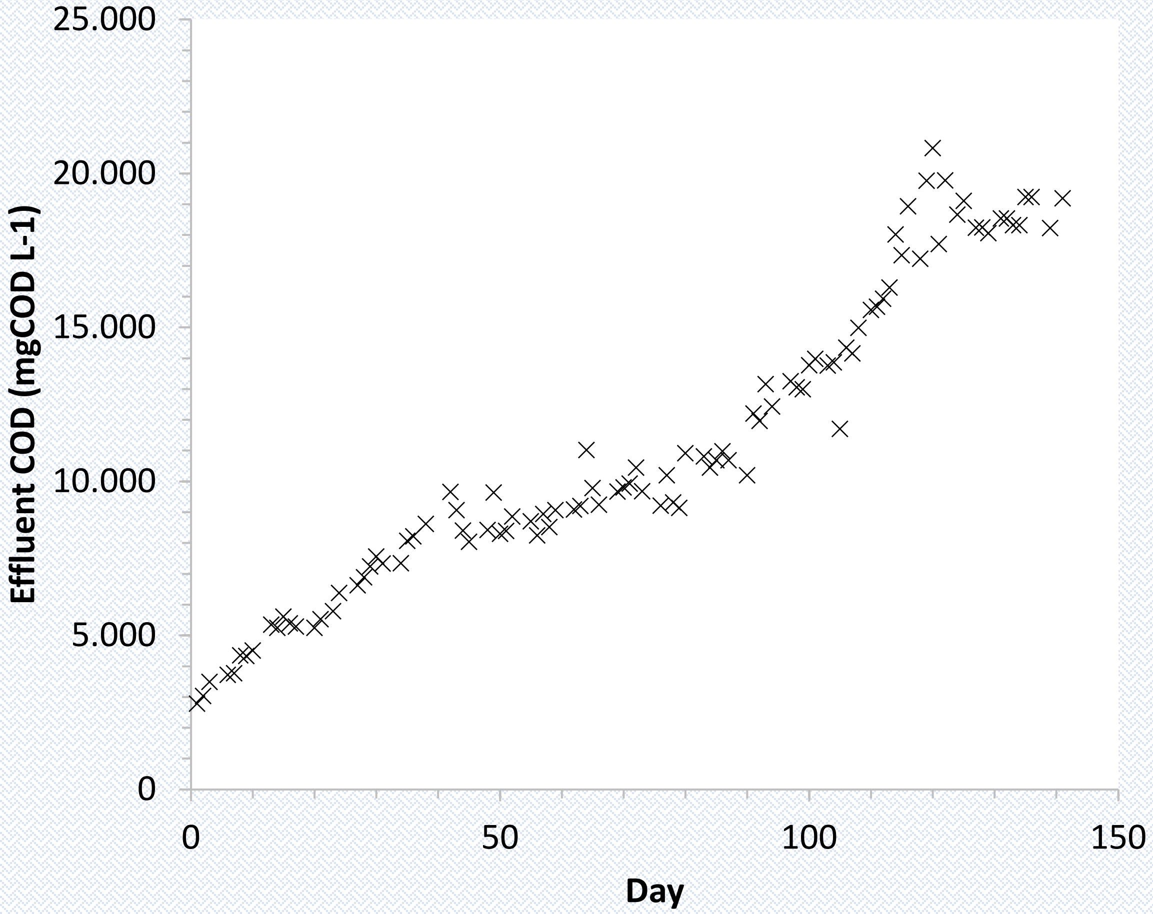
Anaerobic Digestion of Untreated PW

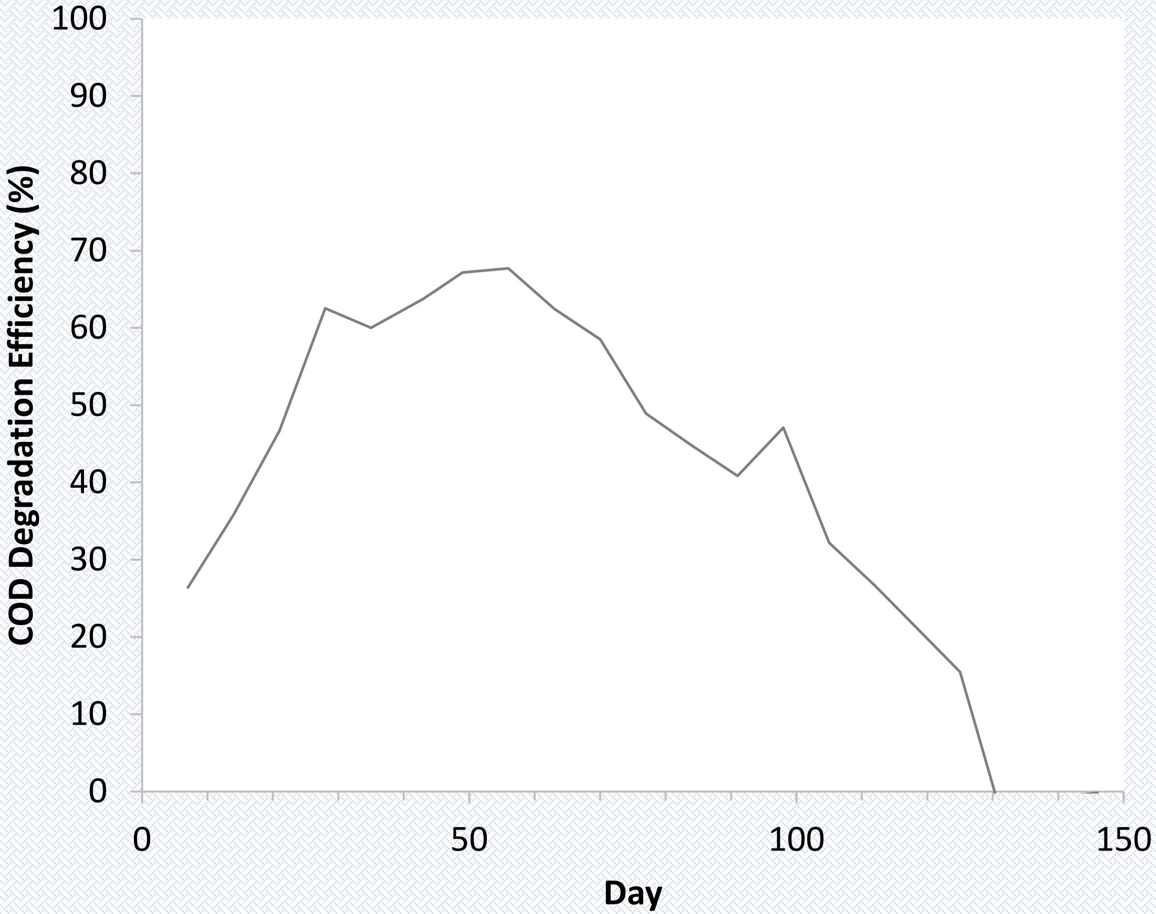


Anaerobic Digestion of Untreated PW



Anaerobic Digestion of Untreated PW





Conclusion

- HTC recovers 82 % of the C from SCG
- Subsequent AD recovers up to 49% of the aqueous COD as CH_4
- Total C recovery as useable fuel = 90%
- No obvious inhibitory compounds
- Issues with stability potentially due to overloading at start of experiment

Thank you – any questions?

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Anaerobic Digestion of Treated and Untreated PW

$$\frac{(yesterday\ absolute\ COD\ (g)after\ addition) - (today\ absolute\ COD\ (g)before\ removal)}{absolute\ COD\ (g)added}$$

$$\textbf{COD degradation efficiency, t} \ (\%) = \frac{COD_{AD,t-1} . V_{AD} - COD_{AD,t} . V_{AD}}{COD_{Inf,t-1} . V_{Inf}}$$