

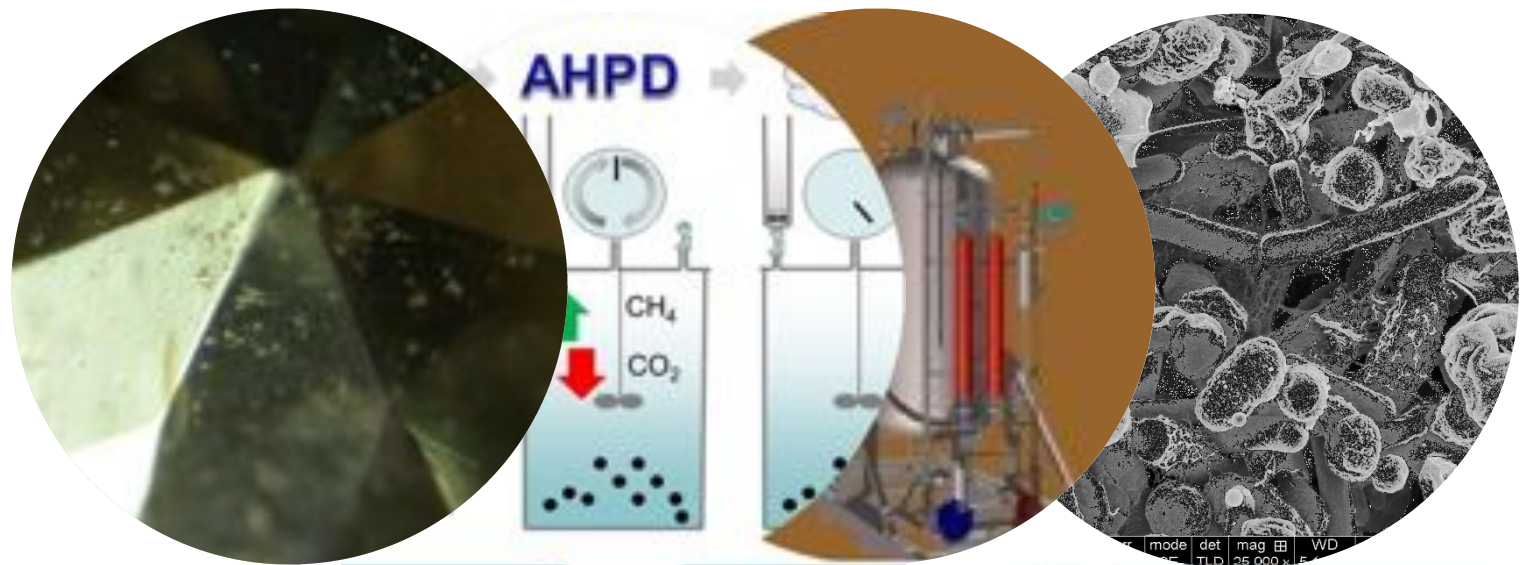
# Autogenerative High Pressure digestion

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28-11-12 Ralph Lindeboom

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In co-operation with Kirsten Zagt (Bareau B.V.)



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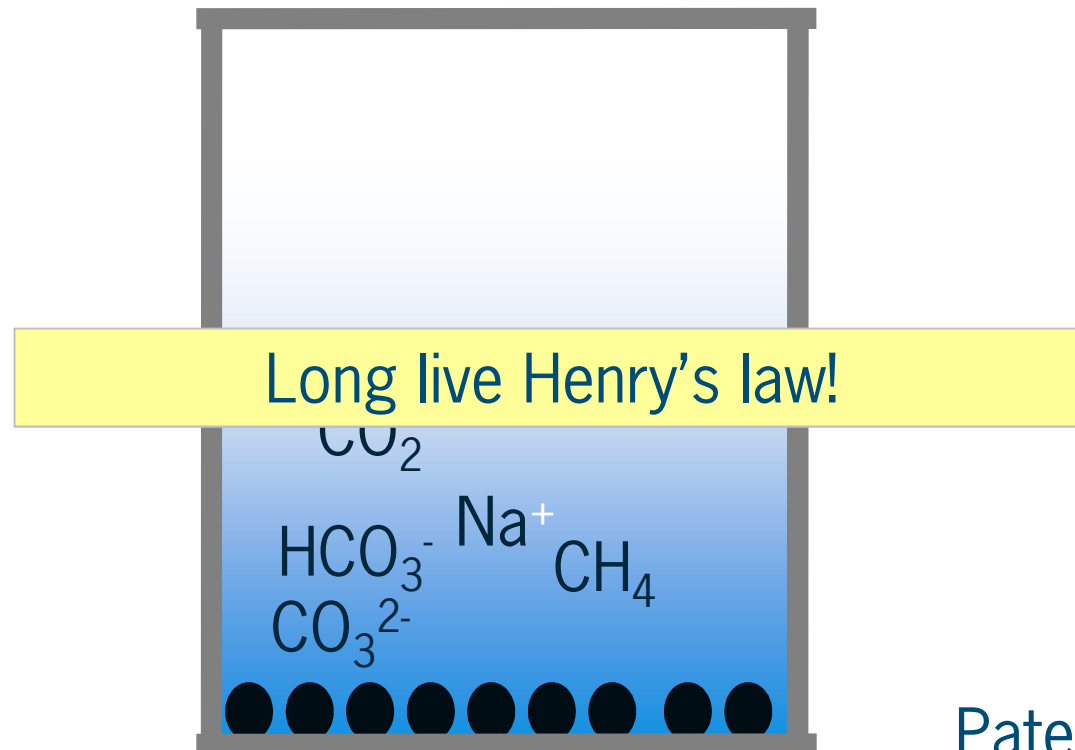
# Background –Biogas quality

State-of-the-art technology is not cost-effective for decentralized biogas upgrading

	Unit	Regional Grid requirement	Natural gas	Biogas
<b>Calorific value</b>	MJ/m <sup>3</sup>	36	33 - 42	21
<b>CH<sub>4</sub> content</b>		80 – 90 %	70 – 90%	55 – 65 %
<b>CO<sub>2</sub> content</b>		< 6 %	0 - 8%	35 – 45 %
<b>H<sub>2</sub>S</b>	mmol/N m <sup>3</sup>	< 0.147	0 - 5%	> 0.147
<b>Dew point</b>	°C	-10	60	58-160
<b>Pressure</b>	bar	40	>300 - <100*	1

\* Slochteren gas pressure; Wempe, 2007; IEA, 2005; Naturalgas.org

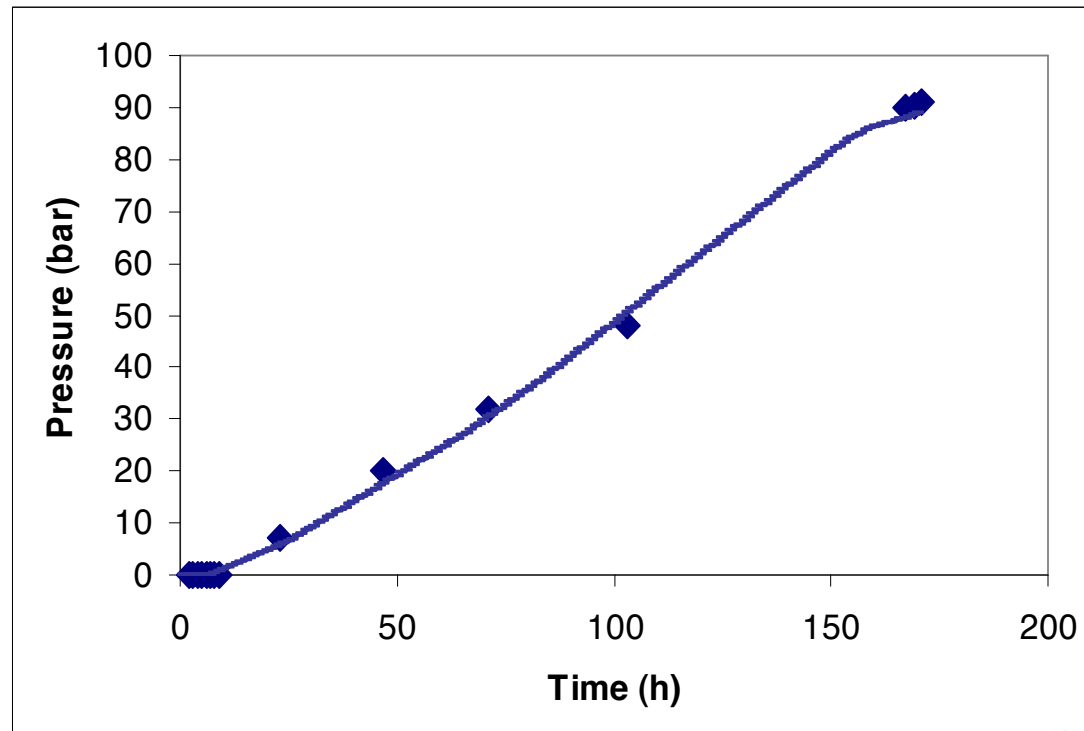
# Goal: integrate gas upgrading into bioreactor



Patented by Bareau

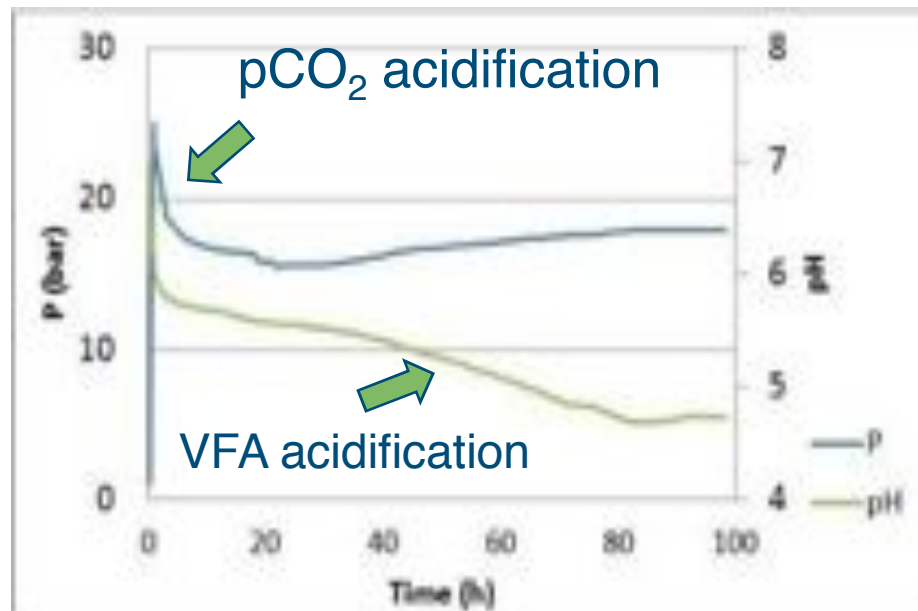
# Verified: production of natural gas-like biogas

- $\text{CH}_4$  follows Henry's law and  $\text{CO}_2^*$  practically follows carbonate equilibrium ( Lindeboom et al. 2012, *ES&T*)
- Methanogens produce 90 bar of pressure >90%  $\text{CH}_4$  out of sodium acetate (Lindeboom, Feroso, Zagt, Weijma, van Lier 2011, *WS&T*)



# Main Problem: Acidification

- Many organisms thrive on glucose, but
  - $C_6H_{12}O_6 + 2H_2O \rightarrow 2CH_3COO^- + 2H^+ + 4H_2 + 2CO_2$
  - $H^+$  and  $CO_2$  production a bad combination



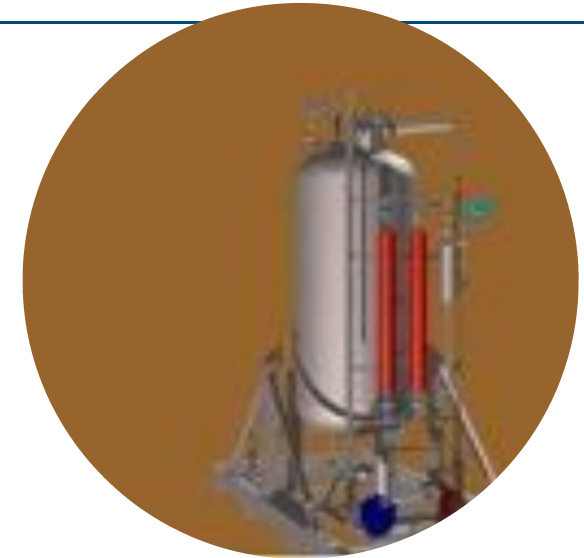
pH between 6-8 is desired for effective methanogenesis!

Lindeboom, Zagt et al. (2011) *IWA-YWP*

# The solutions

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## 1. Reactor design and operation (Bareau)

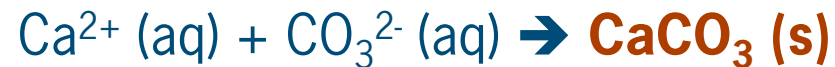


## 2. pH-control by mineral weathering

- Wollastonite – industrial (**good for lab experiments!**)
- Olivine (**better availability!**)
- ***Managing ion toxicity:  $Mg^{2+}$  versus  $Ca^{2+}$***

# Balancing the reaction rates

Acidified



Buried alive



# Take home message

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Autogenerative High Pressure Digestion has the potential to produce natural gas quality biogas in a single step bioreactor

Olivine can improve AHPD performance, but microbe-mineral interactions should be studied to reach full olivine potential!



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# Questions?

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