A Preliminary Investigation of a Specific Methanogenic Activity Test for Quantified the Ammonia Inhibition of Anaerobic Digestion of Faecal Sludge Samples.

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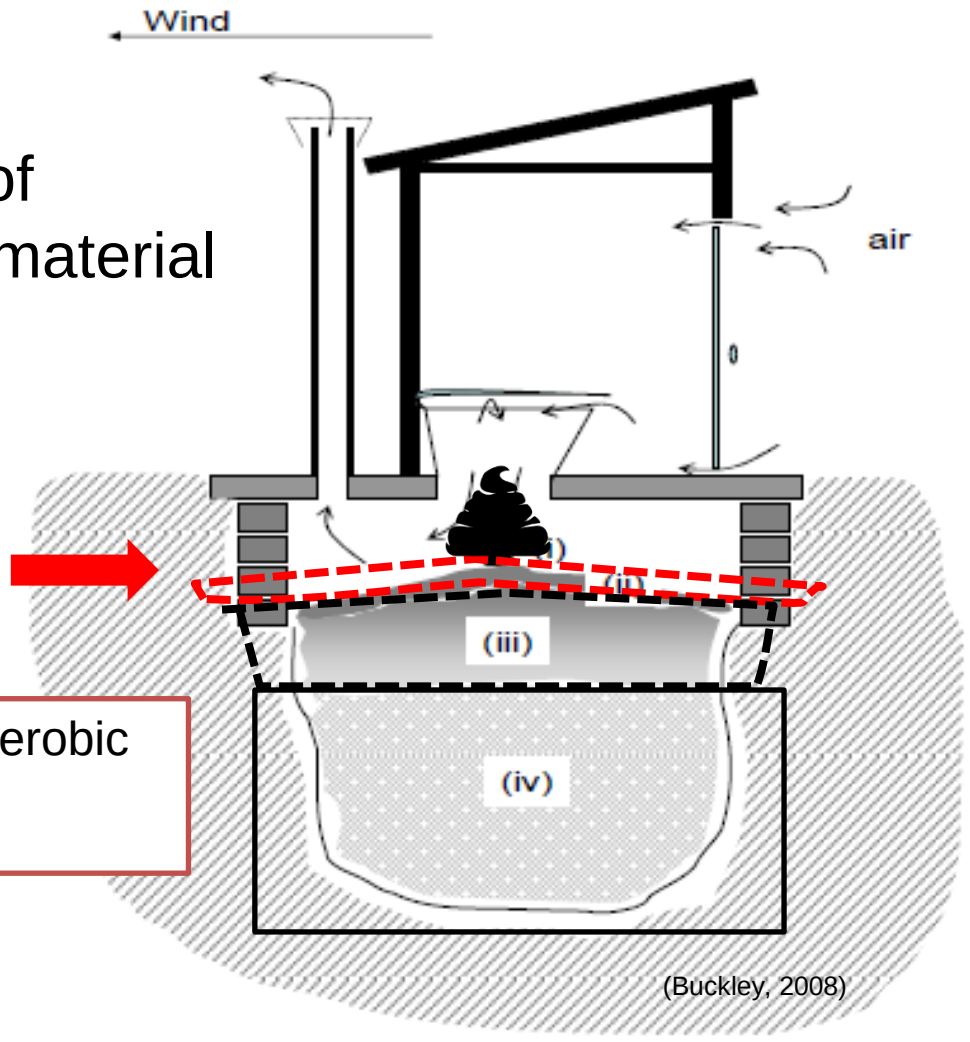
Presentation plan

- Background context
- Methodology
- Results
- Discussion
- Conclusion

Biodegradation mechanisms

i : Fresh faeces
ii : Aerobic degradation of hydrolysable organic material
iii : Anaerobic digestion
iv : Mineralized sludge

VIP Latrines



(Buckley, 2008)

Lack of knowledge on sludge anaerobic degradation kinetics

Operating conditions

Optimized and controlled

Unplanned – uncontrolled

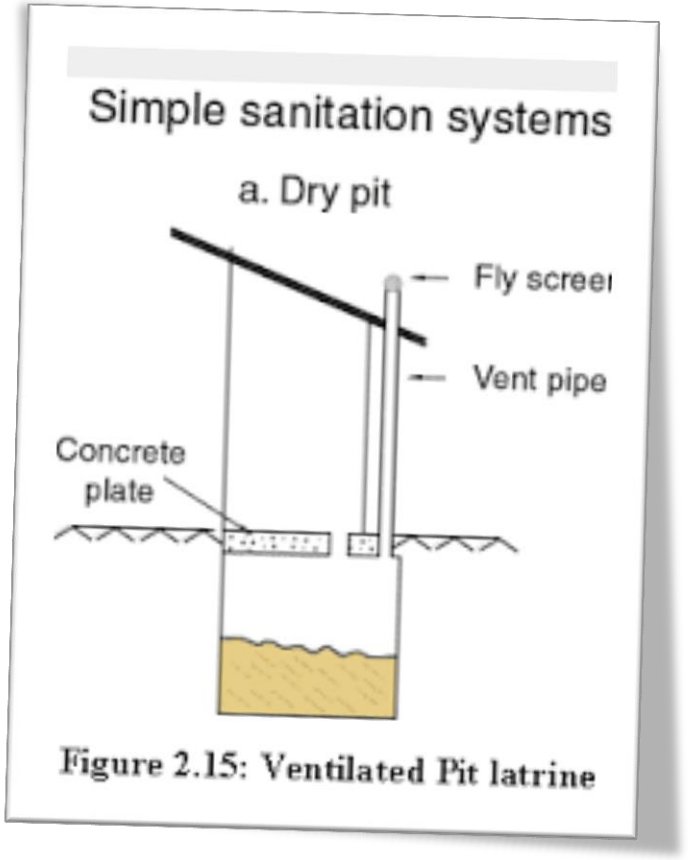


Figure 2.15: Ventilated Pit latrine

Operating conditions

	Anaerobic digestion process	Pit latrine	
Temperature (°C)	PR: 0-20 MR:20 - 45 TR:50 - 65[1]	15 – 30[2]	✓
pH	6,5 - 7,5[1]	5,7 - 8,7[3]	✓
Alkalinity (mg/L)	2 000 - 4 000	-	✓
Inoculation	10% volume[1]	-	✓
Organic loading (g DCO/L)	< 2	20 - 50[4]	✓
N Inhibition (mg N_{TAN}/L)	1 700 - 14 000[5]	2 000 – 15 000[3]	
VFA Inhibition (mg/L)	> 3 000[6]	2 000	✓

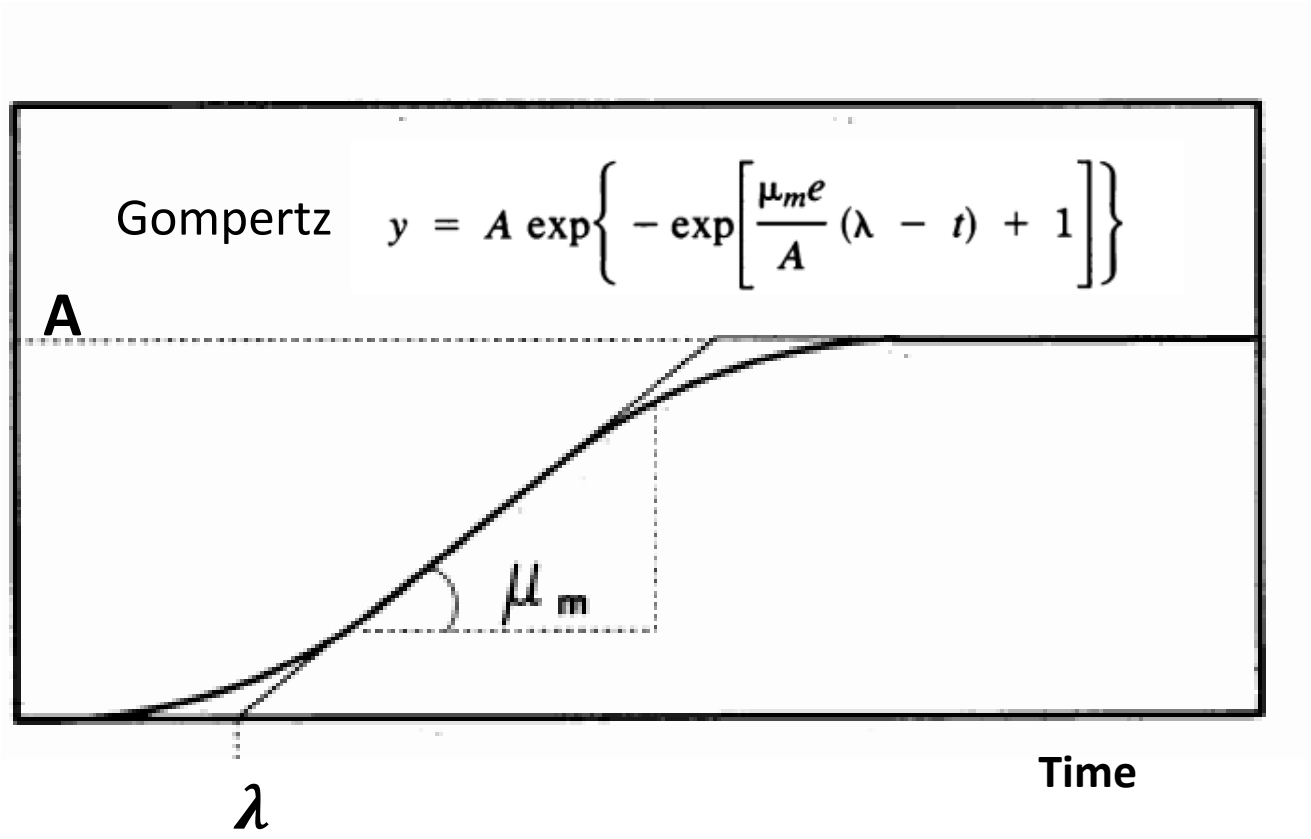
[1]Metclaf and Eddy (2003), [2]Tonrondel and al. (2016), [3]Zuma and al.(2015), [4] Strande and al. (2015) [5]Chen and al (2008), [6]Arhing et al. (1995), UEKI et al. (1988)

Specific methane activity tests (SMA)

Ammonia inhibition can be adequately characterised and modelled by adapted specific methanogenic activity (SMA) tests.

Parameters	
Inoculum sources	Anaerobic sludge
Substrate	Acetate
Inoculum ratio (ISR)	1.33 to 8 g SV / g COD
Temperature	35 ◦C
pH	7
Mixing	Yes
Buffer	Yes
Inhibitive substances	NH_4Cl

SMA – Modelling of the bacterial growth curve



Methane production is growth associated

Zwietering, (1990)

SMA – Modelling of methane production

$$y = A \exp\left\{ -\exp\left[\frac{\mu_m e}{A}(\lambda - t) + 1\right]\right\}$$

$$M = P \cdot \exp\left[-\exp\left(\frac{B \cdot R' \cdot \mathrm{e}}{P}(\gamma - t) + 1\right)\right]$$

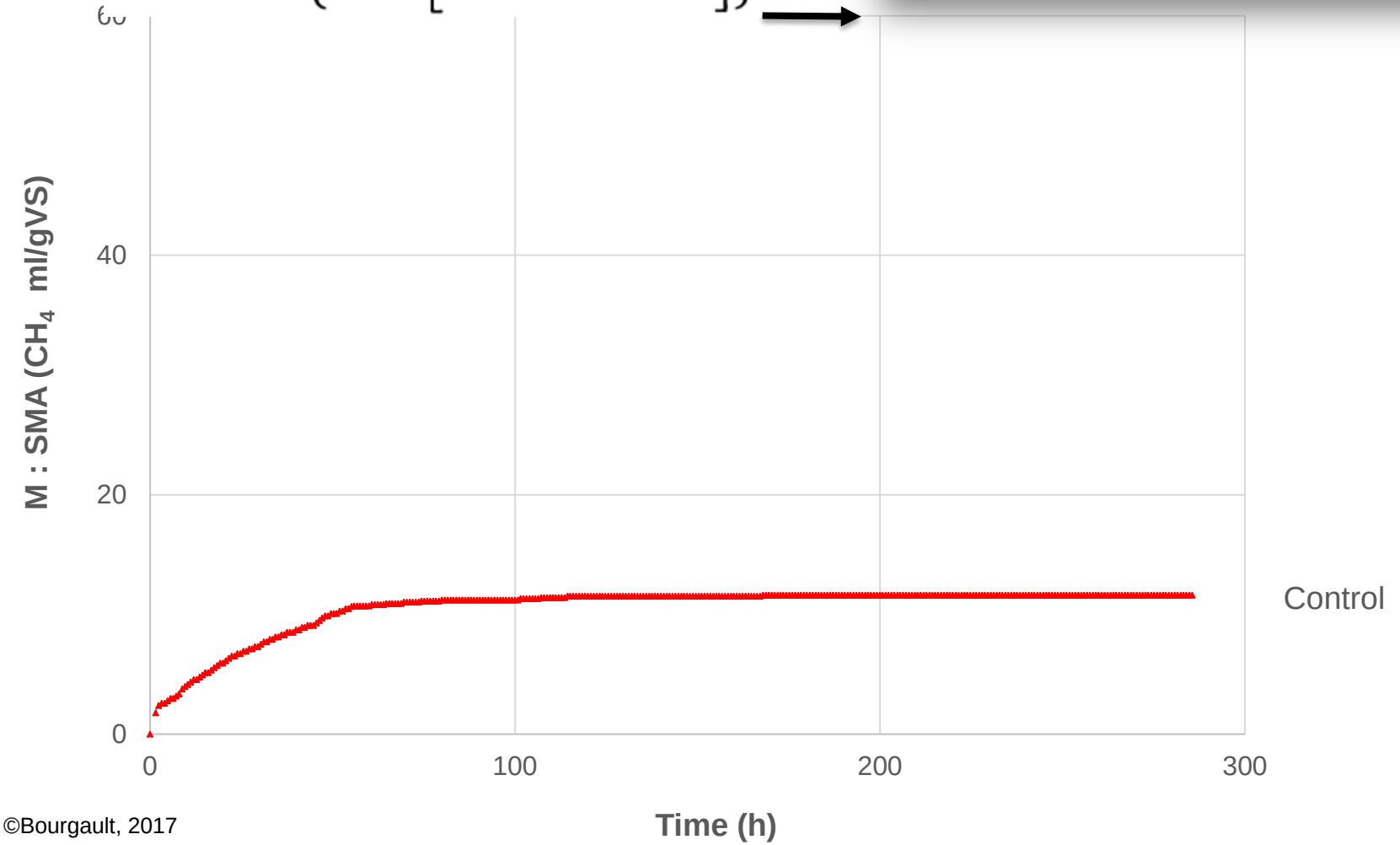
M : Cumulative CH_4 production (ml)
P : Maximum CH_4 production (ml)
B : VS (g)
ɣ : Lag-phase (h)
S : Substrat

Sodium acetate

SMA of anaerobic sludge

$$y = A \exp\left\{ -\exp\left[\frac{\mu_m e}{A}(\lambda - t) + 1\right]\right\}$$

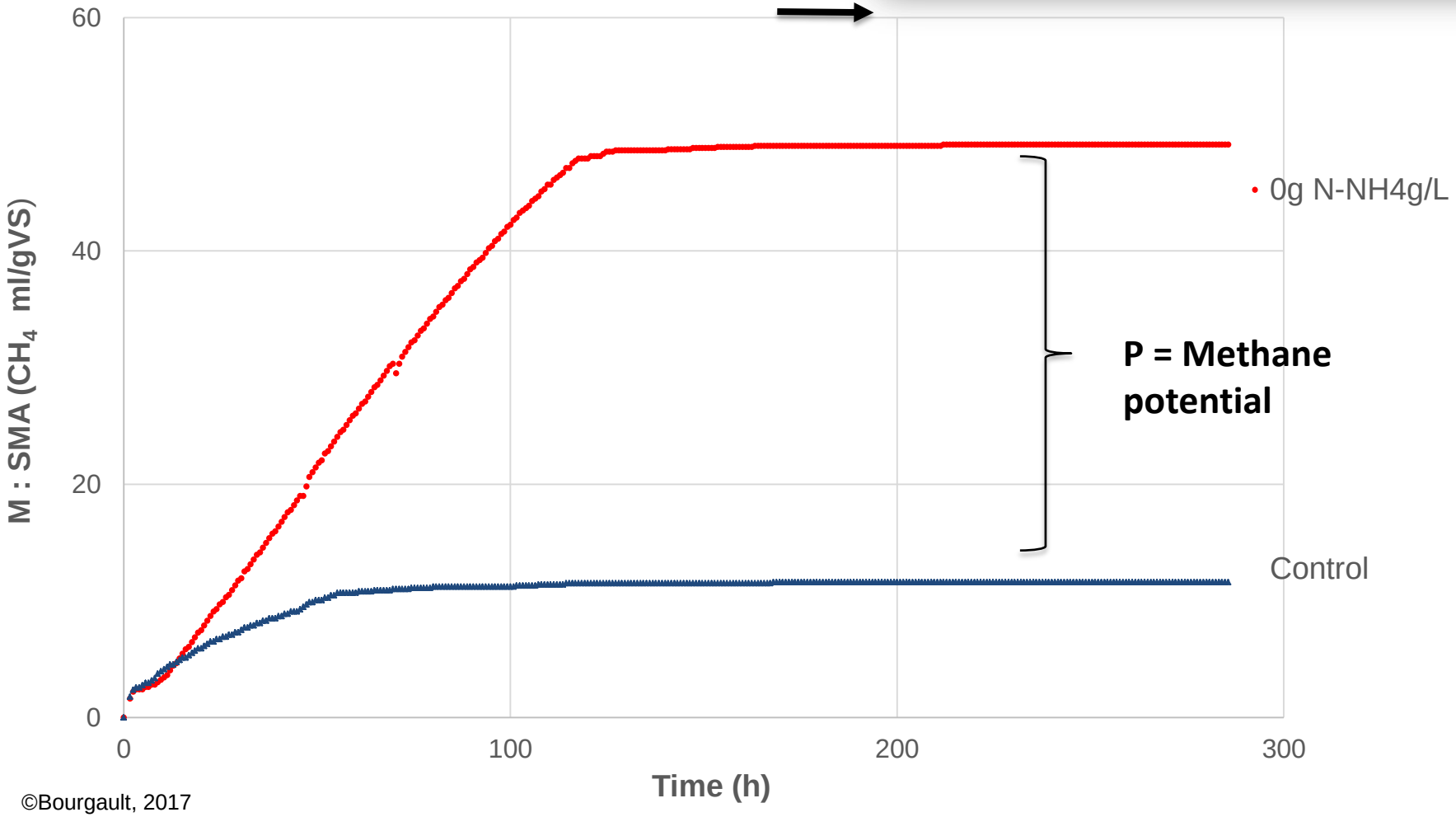
$$M = P \cdot \exp\left[-\exp\left(\frac{B \cdot R' \cdot e}{P}(\gamma - t) + 1\right)\right]$$



SMA of anaerobic sludge + acetate

$$y = A \exp\left\{ -\exp\left[\frac{\mu_m e}{A} (\lambda - t) + 1 \right] \right\}$$

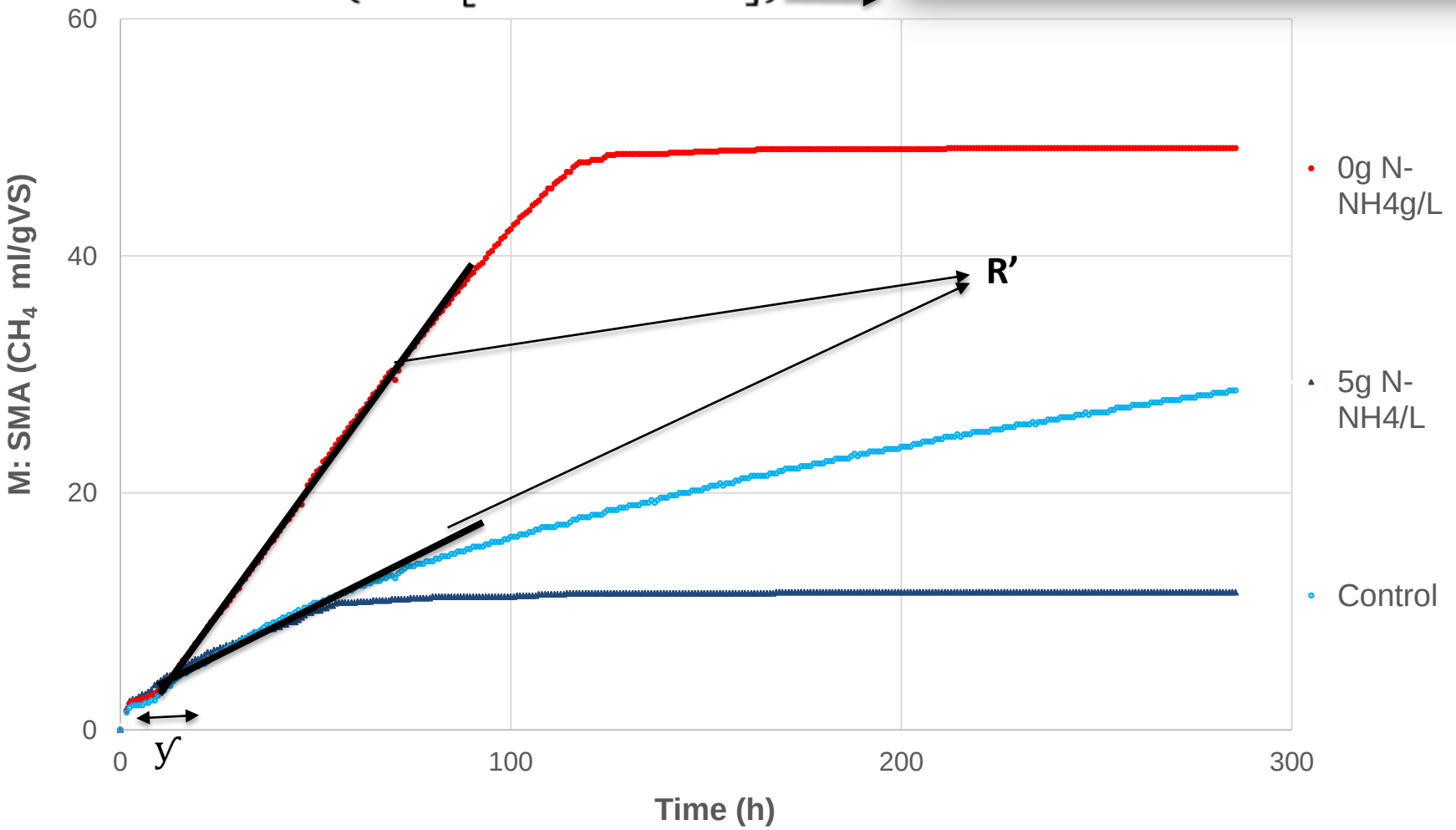
$$M = P \cdot \exp\left[-\exp\left(\frac{B \cdot R' \cdot e}{P} (\gamma - t) + 1 \right) \right]$$



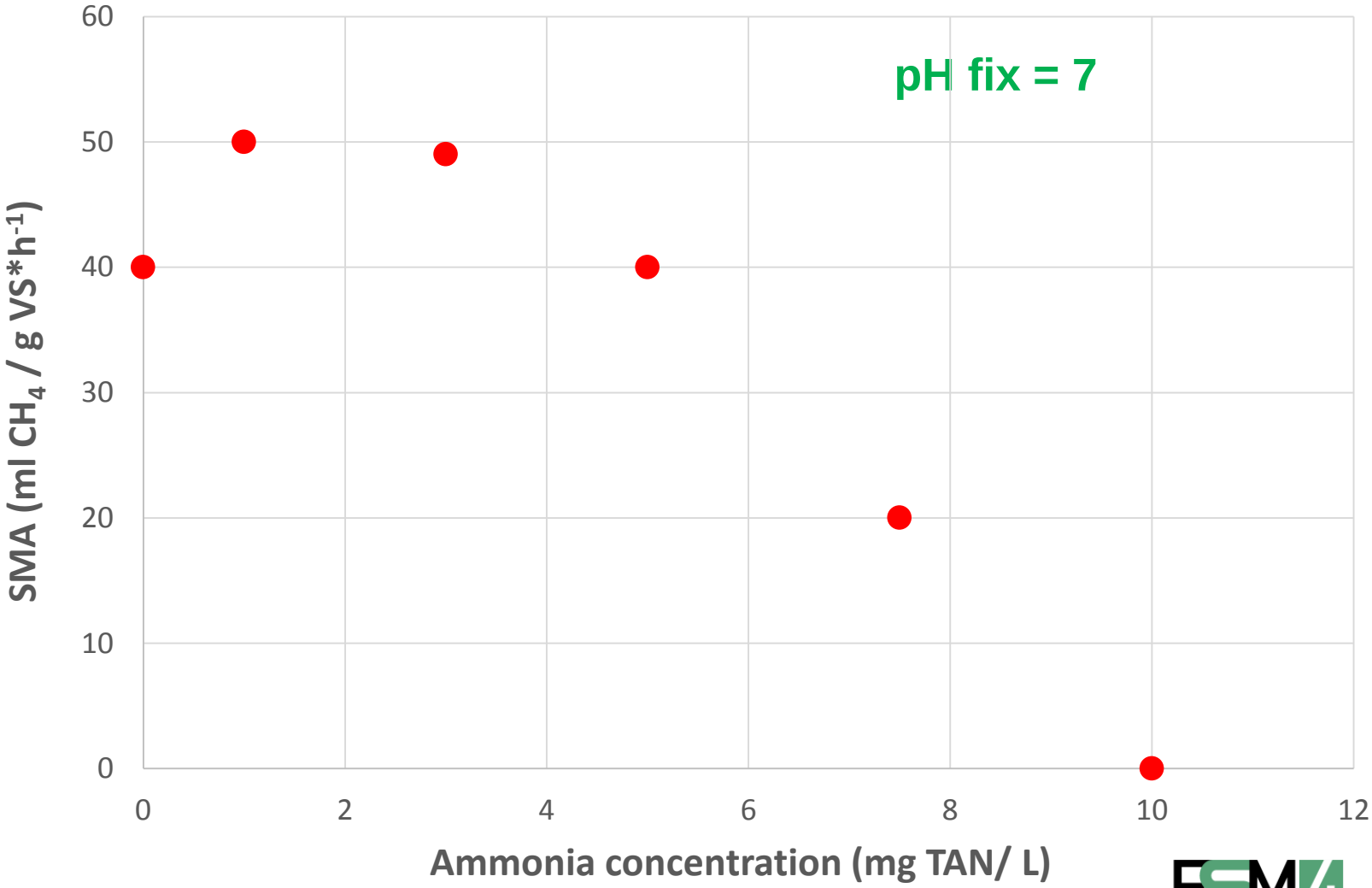
SMA of anaerobic sludge + acetate + NH_4Cl

$$y = A \exp\left\{ -\exp\left[\frac{\mu_m e}{A}(\lambda - t) + 1\right]\right\}$$

$$M = P \cdot \exp\left[-\exp\left(\frac{B \cdot R' \cdot e}{P}(\gamma - t) + 1\right)\right]$$



SMA inhibition of anaerobic sludge + acetate + increasing NH_4Cl



Shihwu Sung a,*, Tao Liu (2003)

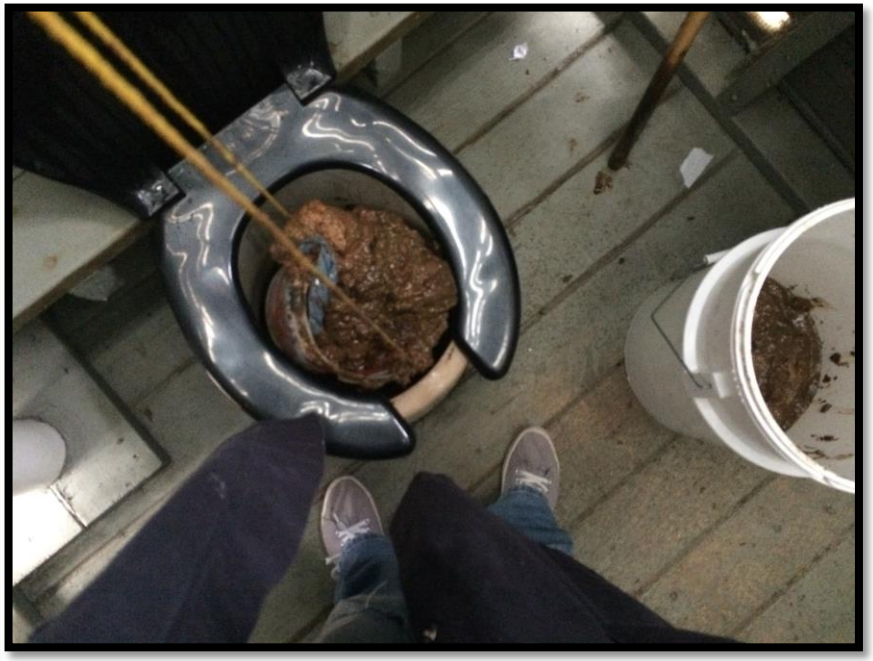
SMA –Experimental system – manometric

Δ hPa

SMA – Feed materials

Fresh Faeces

Faecal sludge



SMA – Protocol

24h at 35 °C

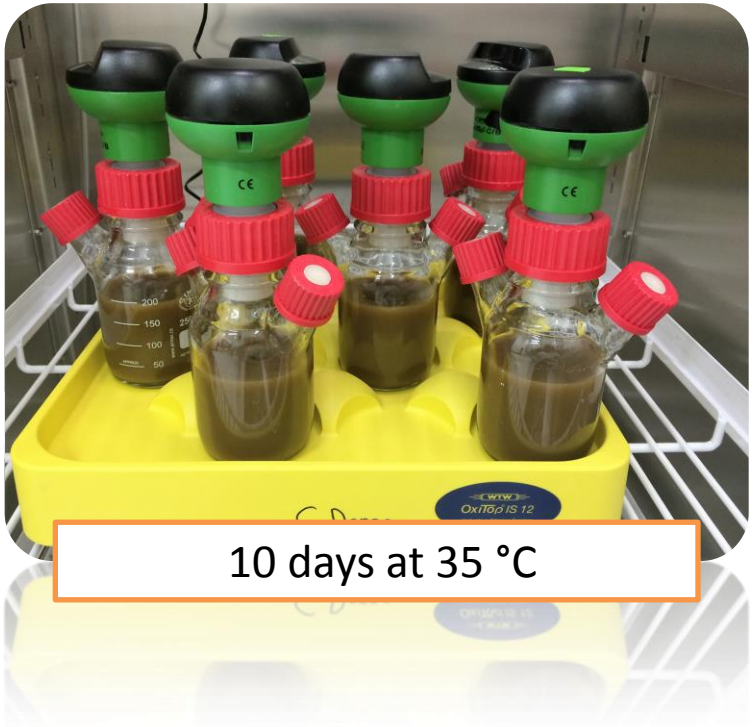
SMA – Protocol

Nitrogen flush

30 min at 35 °C

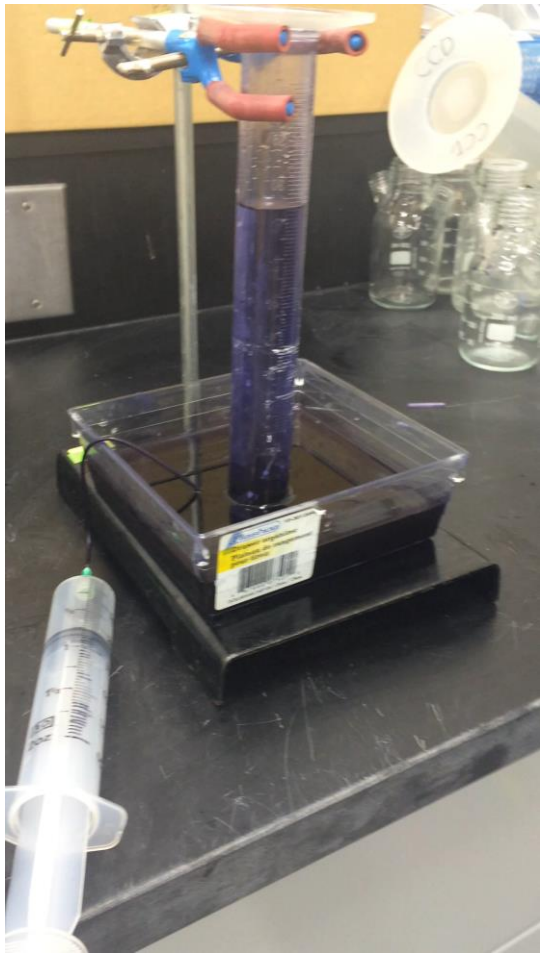
SMA – Protocol

Substrate injection



10 days at 35 °C

SMA – Protocol



SMA – experimental procedure

NH_4CL

- **FF or FS**
- **pH buffer**
- **pH 7**

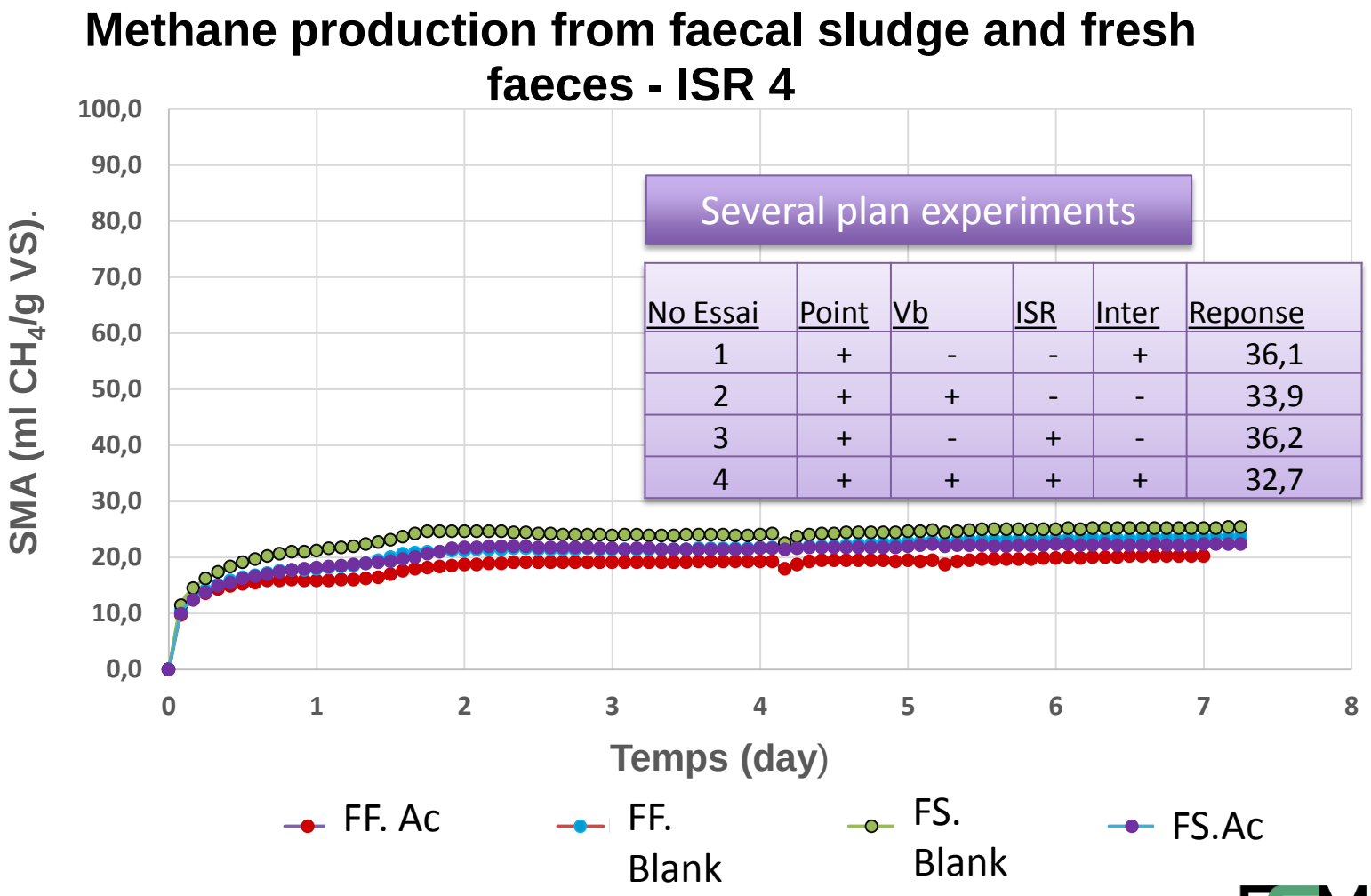
Parameters

- CH_4
- TS/VS
- COD
- pH

0 | **1.5g TAN/l** | **3g TAN /l** | **5g TAN /l** | **7.5g TAN/l** | **10g TAN /l**

Blank | R’

SMA of faecal sludge and fresh Faeces + acetate



Several plan experiments

No Essai	Point	Vb	ISR	Inter	Reponse
1	+	-	-	+	36,1
2	+	+	-	-	33,9
3	+	-	+	-	36,2
4	+	+	+	+	32,7

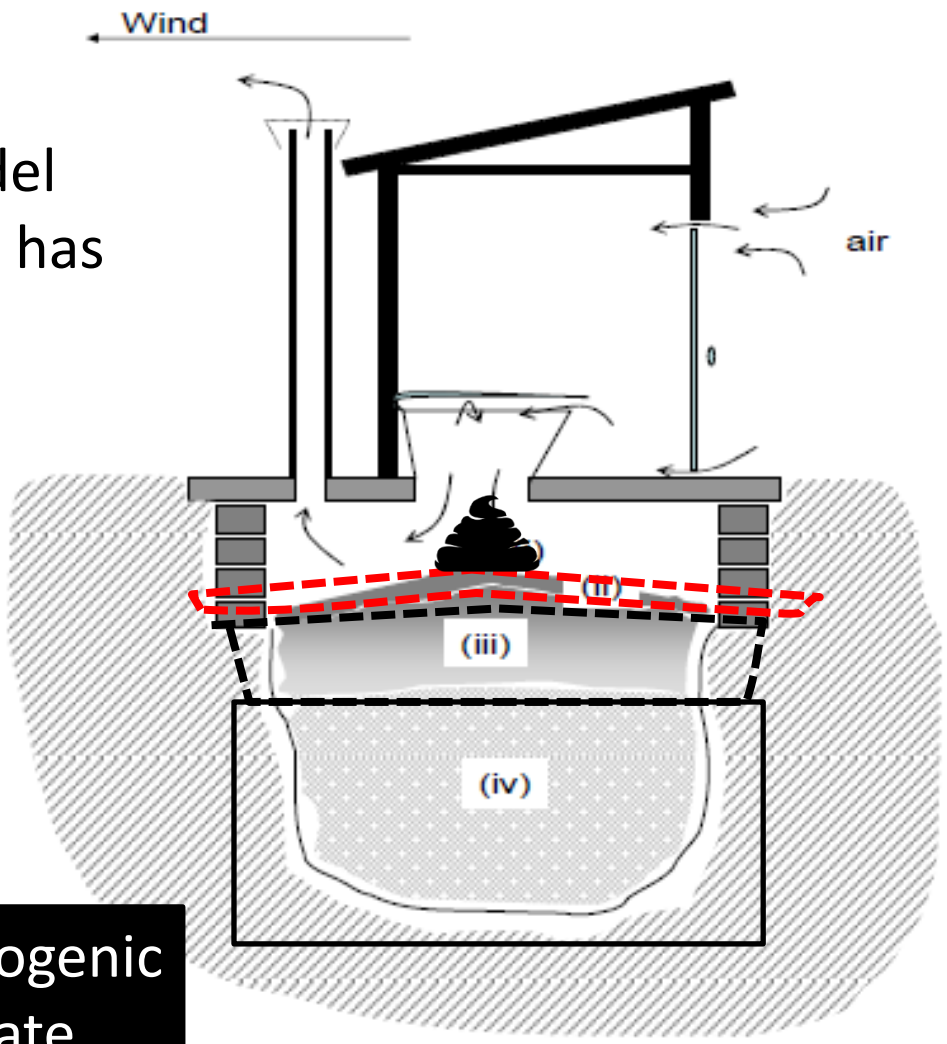
Characteristics of different sludge

Parametres	Fecal sludge	Fresh feces	Anaerobic sludge	References
pH	6.5 - 9.3			Kengne et al. (2011)
		6.6		Rose et al. (2015)
			6.8 - 7	Rodríguez-Méndez (2015)
COD (mg/L)	49,000			Koné and Strauss (2004)
		46 230 – 78 310		Chaggu (2004)
			25 000	Rodríguez-Méndez (2015)
TAN (mg/L)	2 000 – 15 0000			Zuma et al. (2015)
		1 400		Rose et al. (2015)
			690	Rodríguez-Méndez (2015)
VS (% TS)			74	Rodríguez-Méndez (2015)
	85			NWSC (2008)
		89		Rose et al (2015)

Conclusions

SMA tests using Gompertz model and specific substrate (acetate) has not lead to characterize the ammonia toxicity in anaerobic digestion of FF and FS.

Acetate doesn't seem to be an appropriate substrate when performing SMA with FF or FS.



(Buckley, 2008)

Testing the heterogenic methanogenic activity using different substrate.

Thanks !

NSERC
CRSNG

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PRG
pollution research group

CentrEau
Centre de recherche sur l'eau
Water Research Centre