8th INTERNATIONAL CONFERENCE ON SUSTAINABLE SOLID WASTE MANAGEMENT
THESSALONIKI 23-26 JUNE 2021

Thermal and acidic pre-treatments applied to cow manure: effects on pathogenic bacteria persistence and on biogas production during thermophilic anaerobic digestion

C. Delmon, A. Prorot, C. Maftah, M. Casellas-Français

Université de Limoges

Laboratoire Peirene Eau

Anaerobic digestion

H. Salsali *et al.* (2006); H. Salsali *et al.* (2008); Scaglia *et al.* (2014); Orzi *et al.* (2015); Liu *et al.* (2019)

« Green » energy

Agricultural anaerobic digestion

Biogas

Digestate

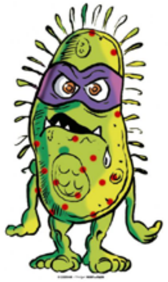
Anaerobic digestion

H. Salsali *et al.* (2006); H. Salsali *et al.* (2008); Scaglia *et al.* (2014); Orzi *et al.* (2015); Liu *et al.* (2019)

Hygienization

but

Pathogenic bacteria persistence



Pre-treatments

Acidic pre-treatment

Thermal pre-treatment

Combination between 2 pre-treatments

Objectives

Evaluate impact of pre-treatments on cow manure

1) Ability to reduce pathogen survival

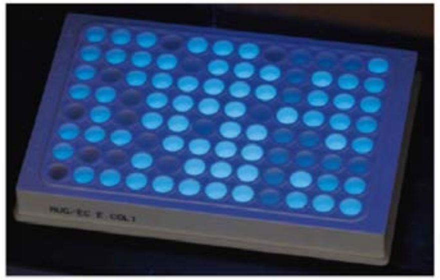
2) Impact on biogas production

Types of pre-treatments and bacteria enumeration

Acidic pre-treatments : equimolar mixture of acetic, propionic and butyric acids

	Acidic pre-treatments	**Thermal pre-treatment**	**Acido-thermal pre-treatments**
Pre-treatments	1.5 g/L	1 hour at 70°C	1.5 g/L + 1 hour at 70°C
	3 g/L		3 g/L + 1 hour at 70°C
	6 g/L		6 g/L + 1 hour at 70°C

Cow manure



Clostridium perfringens (spores)

Enterococcus sp. and *Escherichia coli*

Biochemical methane potential (BMP) production assessment

Inoculum = agricultural anaerobic digester

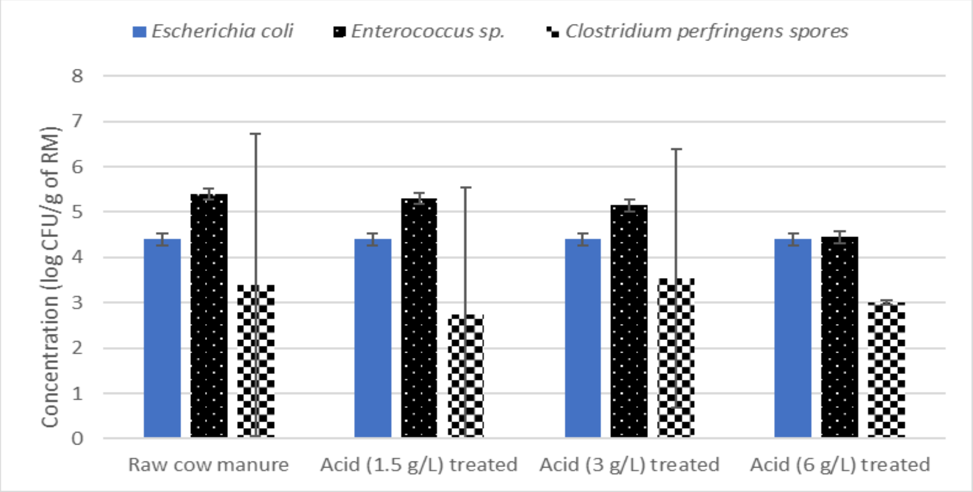
4/5 inoculum
(Volatile Solids basis)

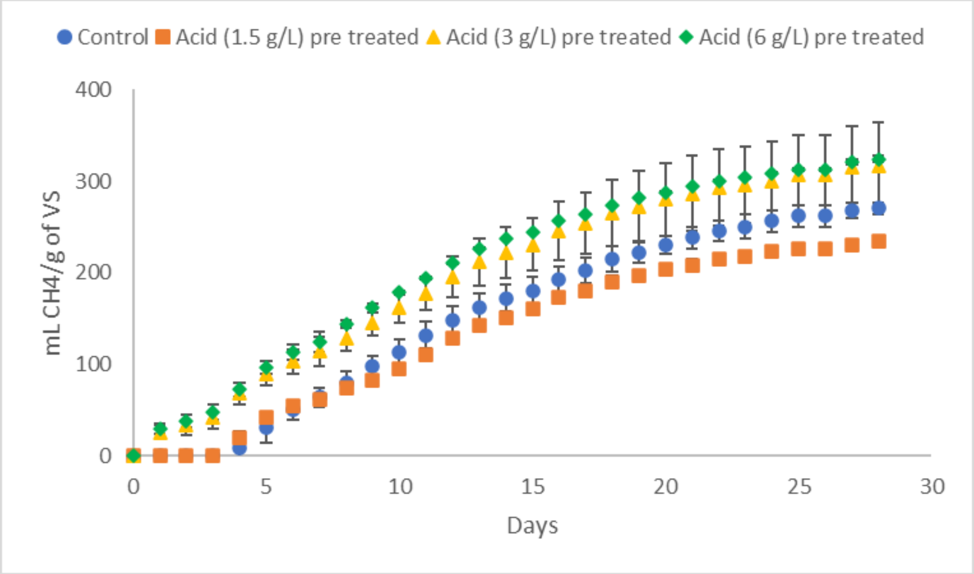
Substrate = cow manure

1/5 substrate
(Volatile Solids basis)

Thermophilic conditions
(55°C)

Acidic pre-treatments





Bacteria	Acidic pre-treatments
Escherichia coli	No influence
Enterococcus sp.	1-log reduction at 6 g/L
***Clostridium perfringens* spores**	No influence ?

Substrate	Influence on overall CH4 production
Pre-treated (1.5 g/L) cow manure	No influence
Pre-treated (3 g/L) cow manure	Slight increase
Pre-treated (6 g/L) cow manure	

Acidic pre-treatments

D. C. Devlin *et al.* (2011); T. Tommasi et al. (2008); Y. Li *et al.* (2021)

Bacteria	Acidic pre-treatments
Escherichia coli	No influence
Enterococcus sp.	1-log reduction at 6 g/L
***Clostridium perfringens* spores**	No influence ?

Substrate	Influence on overall CH4 production
Pre-treated (1.5 g/L) cow manure	No influence
Pre-treated (3 g/L) cow manure	Slight increase
Pre-treated (6 g/L) cow manure	

Faecal contamination indicators

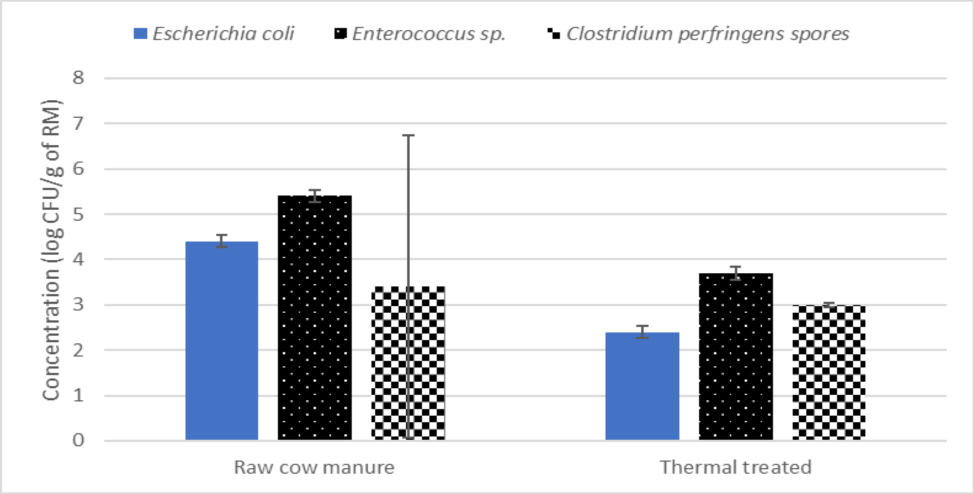
Influence of matrix type

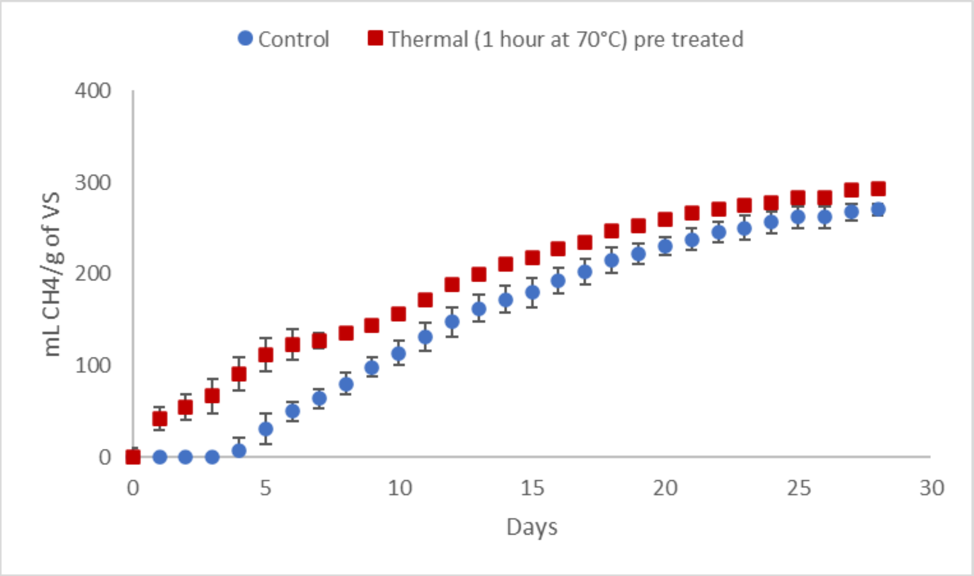
Sporulating bacteria

Only acid : no effect

Ease the anaerobic digestion's first step

Thermal pre-treatment





Bacteria	Thermal pre-treatment
Escherichia coli	2-log reduction
Enterococcus sp.	
Clostridium perfringens **spores**	No influence ?

Substrate	Influence on overall CH_4 production
Thermal pre-treated cow manure	No real influence

Thermal pre-treatment

A.-M. Pourcher *et al.* (2009); X. Liu *et al.* (2019); Y. Li *et al.* (2021)

Bacteria	Thermal pre-treatment
Escherichia coli	2-log reduction
Enterococcus sp.	
***Clostridium perfringens* spores**	No influence ?

Substrate	Influence on overall CH4 production
Thermal pre-treated cow manure	No real influence

Faecal contamination indicators

« Jumbled matrix »

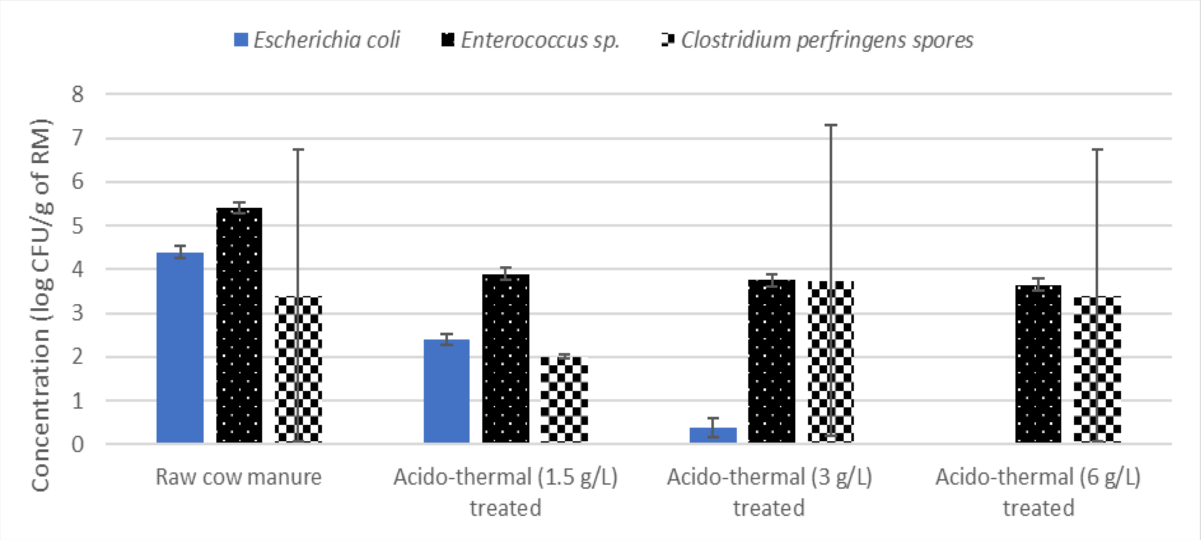
Not a pure culture

Organic matter solubilisation

Sporulating bacteria

Weak effect on spores

Acido-thermal pre-treatments
H. Salsali *et al.* (2008)



Bacteria	Acido-thermal pre-treatment (1.5 g/L)	Acido-thermal pre-treatment (3 g/L)	Acido-thermal pre-treatment (6 g/L)
Escherichia coli	2-log reduction	4-log reduction	total reduction
Enterococcus sp.	1.5-log reduction	1.6-log reduction	1.7-log reduction
***Clostridium perfringens* spores**	High standard deviation		

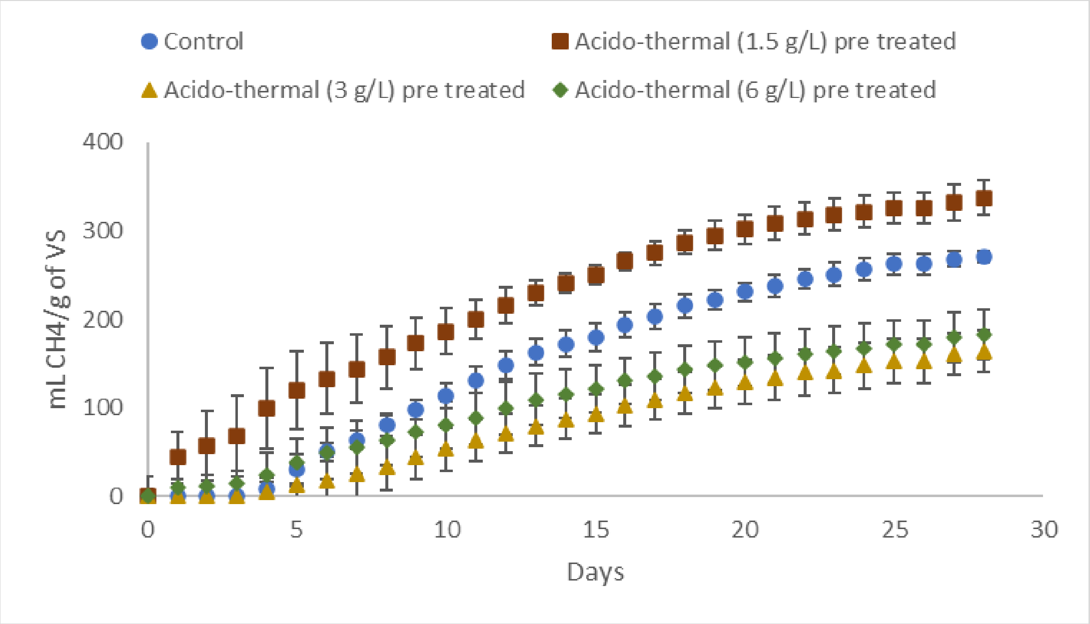
Faecal contamination indicators

Synergistic effect

Sporulating bacteria

Effect on *C. perfringens* but both vegetative and spores
H. Salsali et al. (2008)

Acido-thermal pre-treatments
F. Passos *et al.* (2017)



Substrate	Influence on overall CH4 production
Acido-thermal (1.5 g/L + 1 hour at 70°C) pre-treated cow manure	No real influence
Acido-thermal (3 g/L + 1 hour at 70°C) pre-treated cow manure	Lower methane production
Acido-thermal (6 g/L + 1 hour at 70°C) pre-treated cow manure	

Higher methane production F. Passos *et al.* (2017)

Reduce pathogen survival

Deep impact on *Escherichia coli* and *Enterococcus sp.*

No real impact on spores

Synergistic effects between two pre-treatments

Impact on biogas production

Lower methane production with acido-thermal pre-treatments

How could we explain persistence of spores ?

Why a lower methane production ?

Thank you for your attention

Bibliography

D. C. Devlin, S. R. R. Esteves, R. M. Dinsdale, and A. J. Guwy, ‘The effect of acid pretreatment on the anaerobic digestion and dewatering of waste activated sludge’, Bioresource Technology, vol. 102, no. 5, pp. 4076–4082, Mar. 2011, doi: 10.1016/j.biortech.2010.12.043

Y. Li, J. Zhao, J. Krooneman, and G. J. W. Euverink, ‘Strategies to boost anaerobic digestion performance of cow manure: Laboratory achievements and their full-scale application potential’, Science of the Total Environment, p. 25, 2021.

X. Liu, T. Lendormi, M. Le Fellic, Y. Lemée, and J.-L. Lanoisellé, ‘Hygienization of mixed animal by-product using Pulsed Electric Field: Inactivation kinetics modeling and recovery of indicator bacteria’, Chemical Engineering Journal, vol. 368, pp. 1–9, Jul. 2019, doi: 10.1016/j.cej.2019.02.158

V. Orzi *et al.*, ‘The role of biological processes in reducing both odor impact and pathogen content during mesophilic anaerobic digestion’, *Science of The Total Environment*, vol. 526, pp. 116–126, Sep. 2015, doi: 10.1016/j.scitotenv.2015.04.038.

F. Passos, V. Ortega, and A. Donoso-Bravo, ‘Thermochemical pretreatment and anaerobic digestion of dairy cow manure: Experimental and economic evaluation’, Bioresource Technology, vol. 227, pp. 239–246, Mar. 2017, doi: 10.1016/j.biortech.2016.12.034.

A.-M. Pourcher, C. Burton, C. Ziebal, and A. De-Guardia, ‘Impact of temperature-time combinations on enteric bacteria in separated solids from pig manure’, p. 5.

H. R. Salsali, W. J. Parker, and S. A. Sattar, ‘Impact of concentration, temperature, and pH on inactivation of *Salmonella* spp. by volatile fatty acids in anaerobic digestion’, *Can. J. Microbiol.*, vol. 52, no. 4, pp. 279–286, Apr. 2006, doi: 10.1139/w05-125.

H. Salsali, W. J. Parker, and S. A. Sattar, ‘The effect of volatile fatty acids on the inactivation of Clostridium perfringens in anaerobic digestion’, World J Microbiol Biotechnol, vol. 24, no. 5, pp. 659–665, May 2008, doi: 10.1007/s11274-007-9514-4

B. Scaglia, G. D’Imporzano, G. Garuti, M. Negri, and F. Adani, ‘Sanitation ability of anaerobic digestion performed at different temperature on sewage sludge’, *Science of The Total Environment*, vol. 466–467, pp. 888–897, Jan. 2014, doi: 10.1016/j.scitotenv.2013.07.114.

T. Tommasi, G. Sassi, and B. Ruggeri, ‘Acid pre-treatment of sewage anaerobic sludge to increase hydrogen producing bacteria HPB: effectiveness and reproducibility’, Water Science, p. 6, 2008