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TRACE ELEMENT REQUIREMENTS FOR THE ANAEROBIC DIGESTION OF LIPID-RICH SLAUGHTERHOUSE WASTES

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Introduction

Fat, Oil and Grease (FOG)

- Clogging of pipes
- Increase the organic load to waste water treatment plants

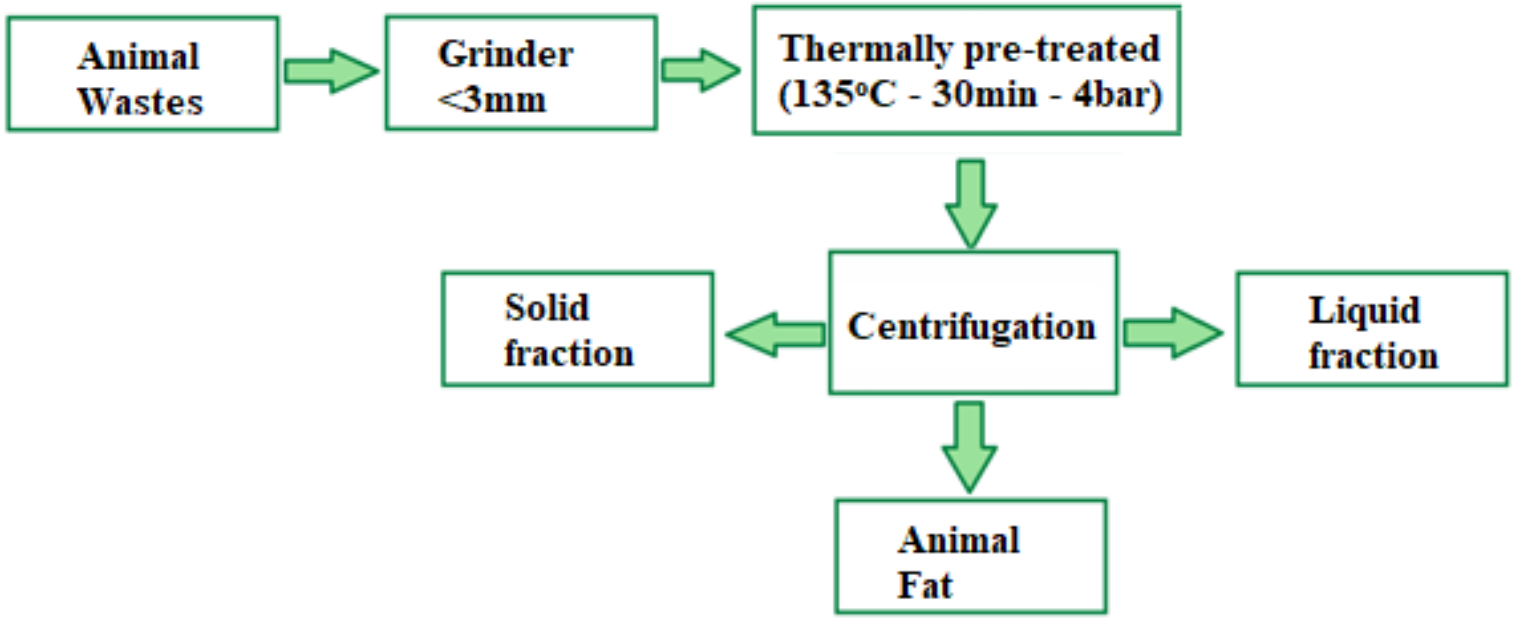
Anaerobic digestion of lipid-rich wastes

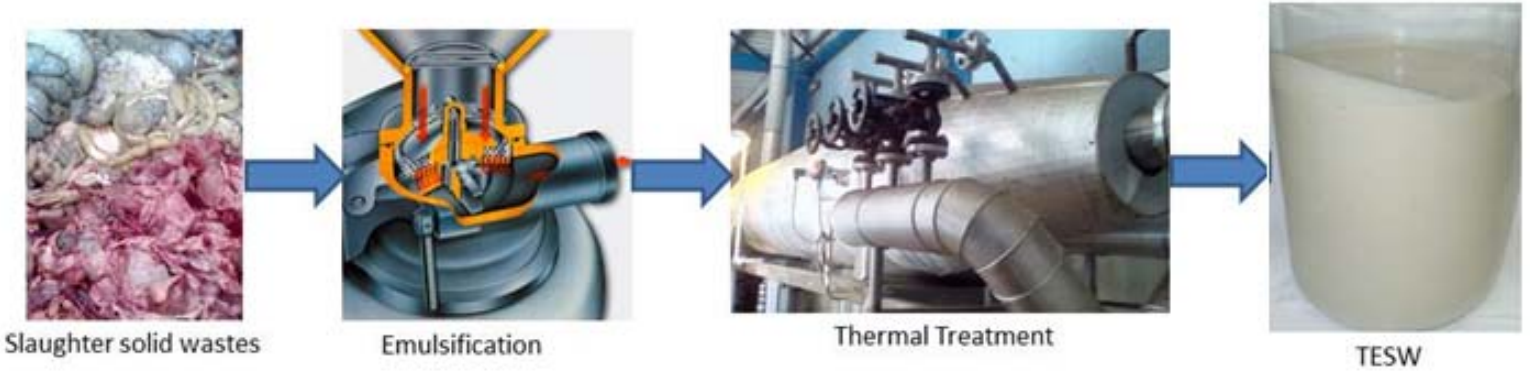
- Foaming
- Sludge flotation
- Accumulation of LCFA
- Low biogas yield
- Complete digester failure

Anaerobic digestion of lipid-rich wastes

- Trace elements (such as Ni, Co and Mo) are major importance for the optimum growth conditions of Methanogenic archaea
  - Enzyme Systems
  - Respiratory Processes
  - Cell Structural Stability
- Limited transport of trace elements across the cell membrane lead
  - Low conversion of acetic acid to methane
  - Inhibition of LCFA
  - Accumulate inside the digester cause sludge disintegration, flotation and digester failure

Wastewater Origin





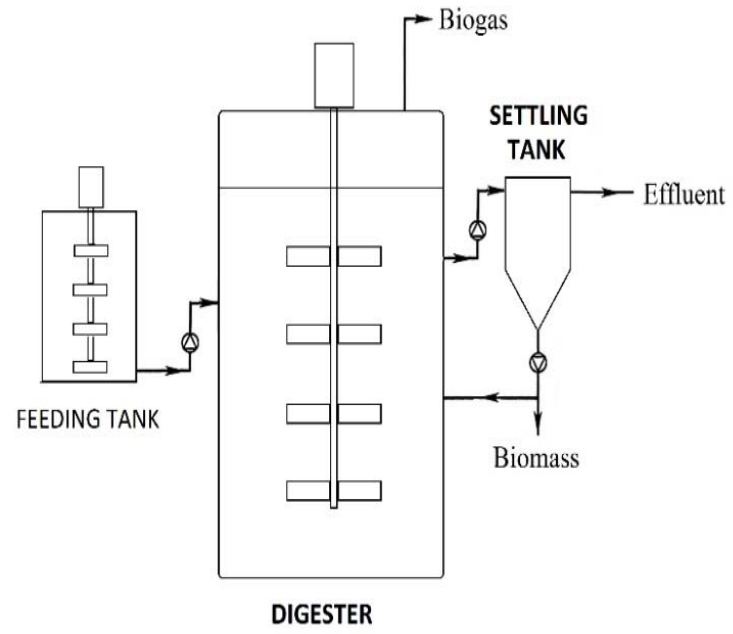
Waste Characteristics

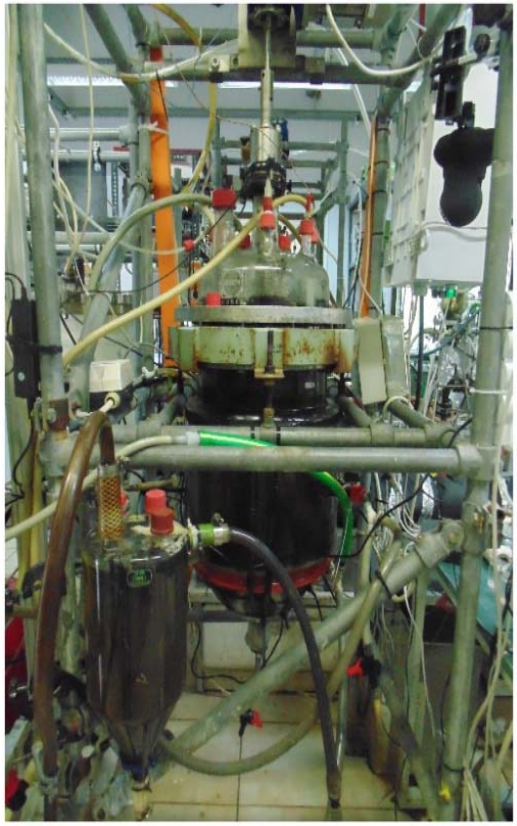
Parameter	Average (±stdev)
pH	6.33 (±0.19)
EC (mS cm^{-1})	16.8 (±4.7)
TS (g L^{-1})	96 (±24)
VS (g L^{-1})	81.3 (±20.3)
NH_4-N (g L^{-1})	1.12 (±0.48)
TKN (g L^{-1})	9.02 (±1.23)
COD total (g L^{-1})	180 (±37)
COD proteins (g L^{-1})	70 (±9)
COD lipids (g L^{-1})	110 (±27)
COD carbohydrates (g L^{-1})	<5

Lipid fraction properties	Average (±stdev)
COD coefficient (g COD g^{-1} FOG)	2.65
Acid value (mgKOH g^{-1} FOG)	22.8 (±7.2)
Saponification value (mgHCl g^{-1} FOG)	193.2 (±44.7)
Iodine value (g I 100 g^{-1} FOG)	44.9 (±9.9)
Density (g mL^{-1})	0.90 (±0.09)

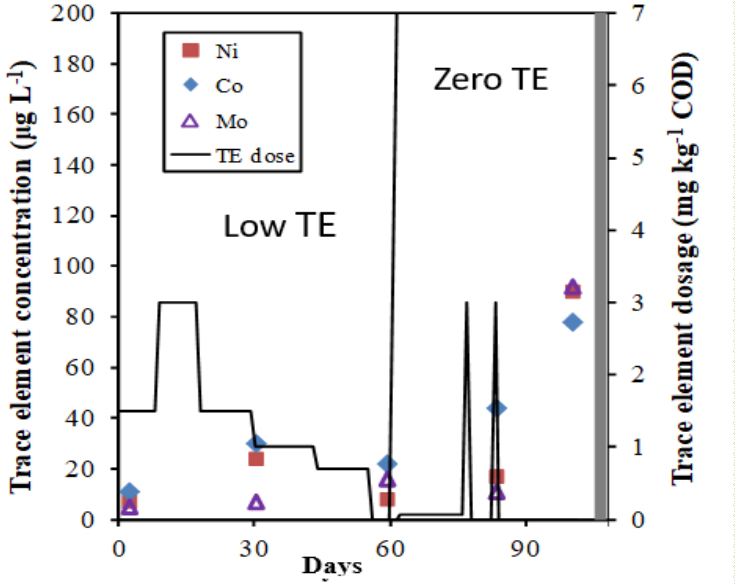
Anaerobic Digester Design & Operation

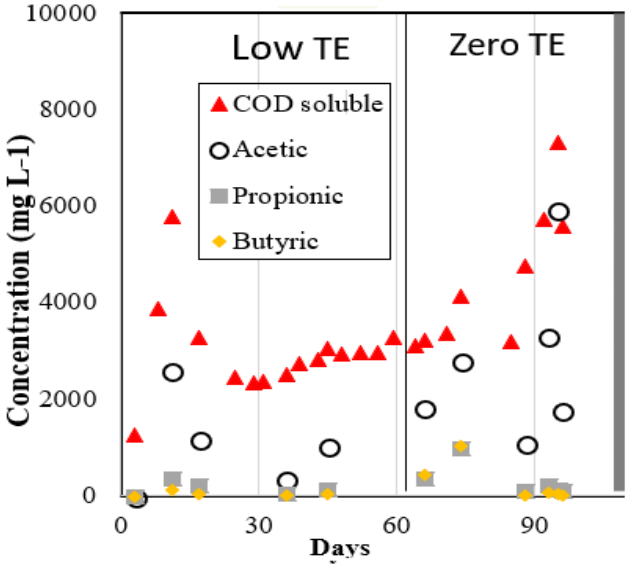
Parameters	
Digester type	CSTR
Digester volume	42 L
Temperature	Mesophilic ~ 38 ^{o}C
Mixing velocity	40 rpm
Feeding type	Intermittent
Period I	Low - Zero TE dosage
Period II	High TE dosage
Sludge recirculation	
Biogas production	
Methane Content	
Chemical Analysis	

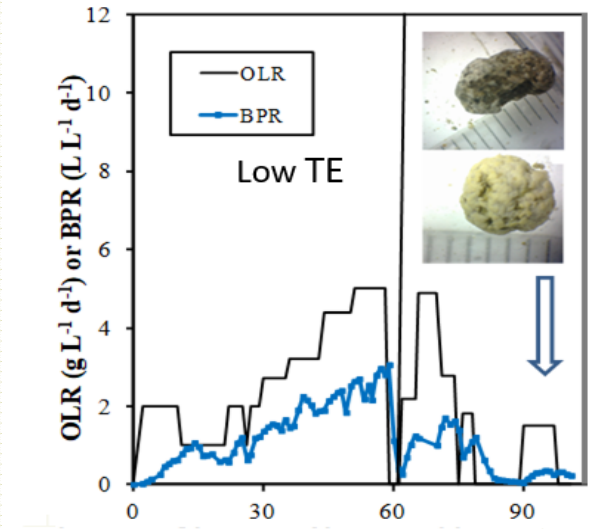


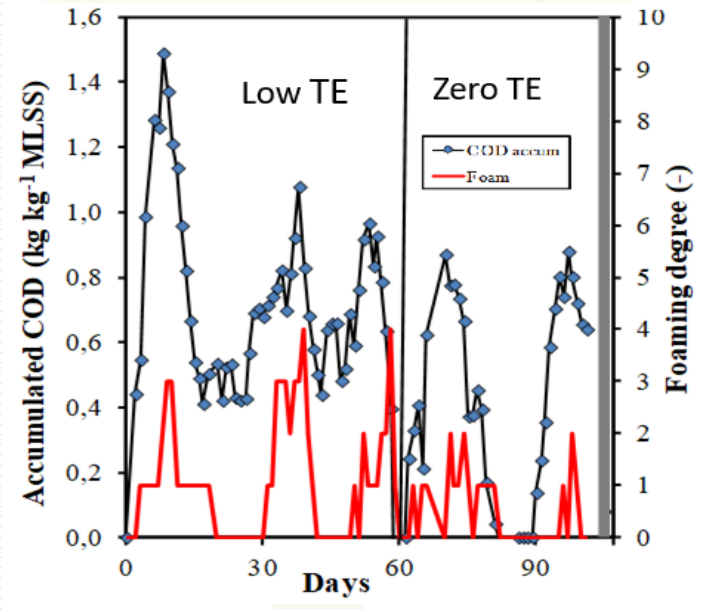


Digester performance under low - zero trace element dosa

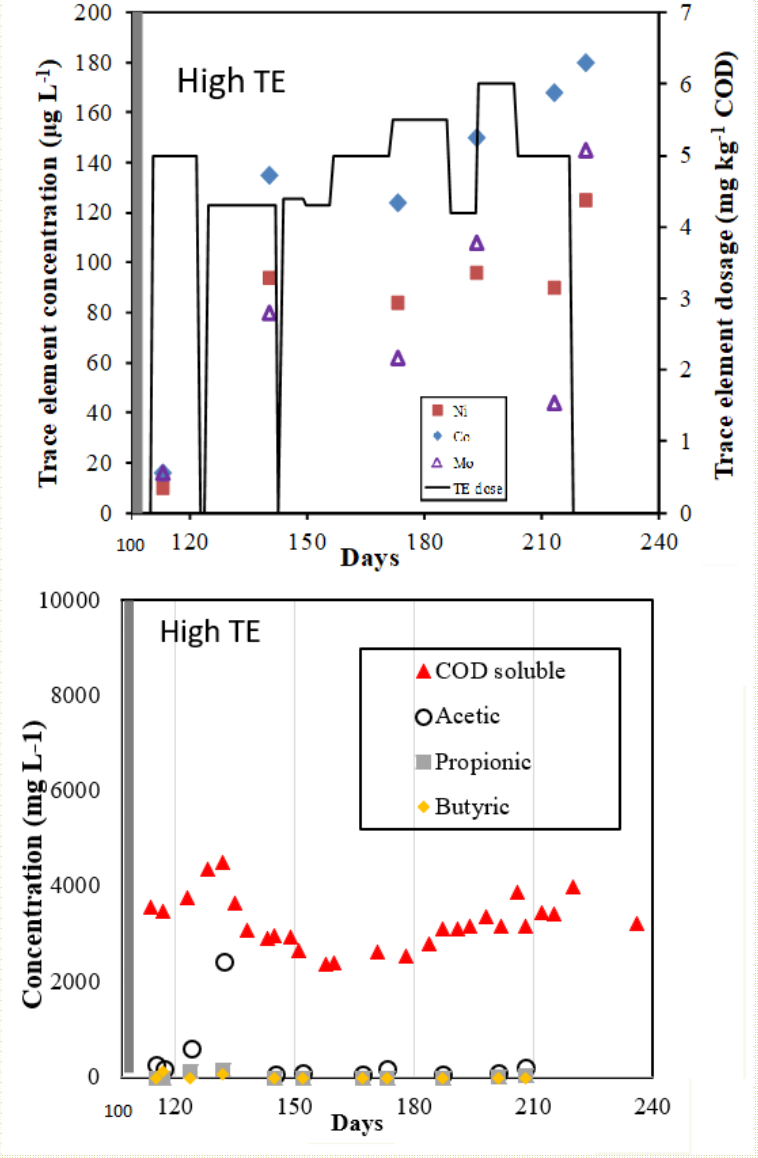


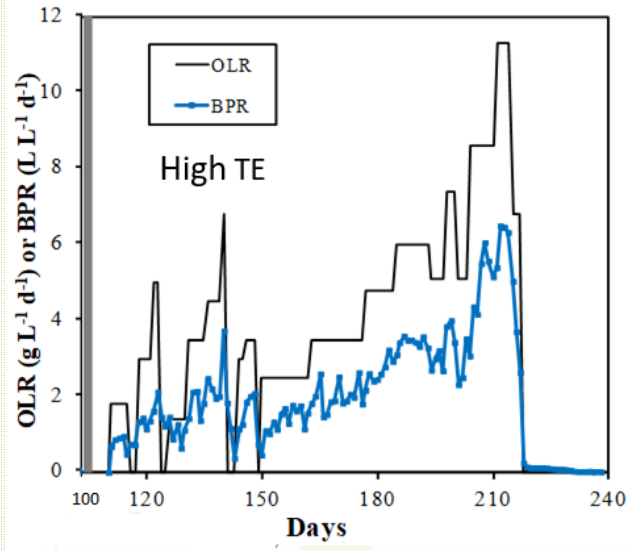


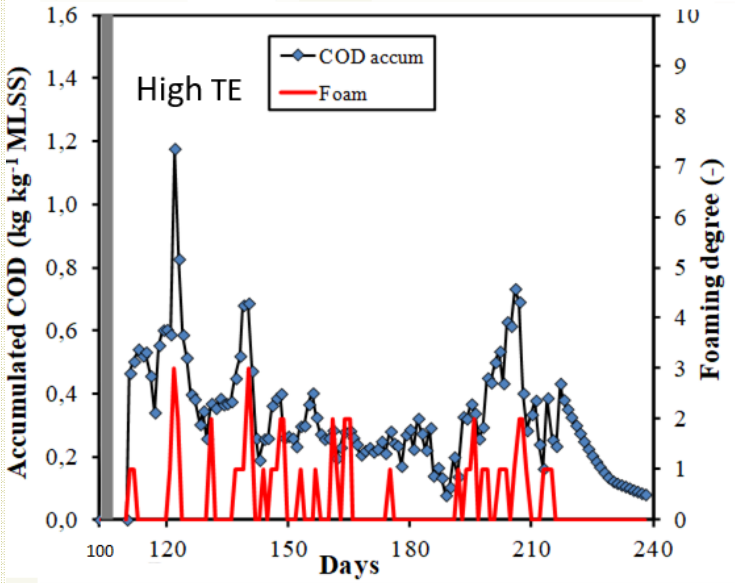




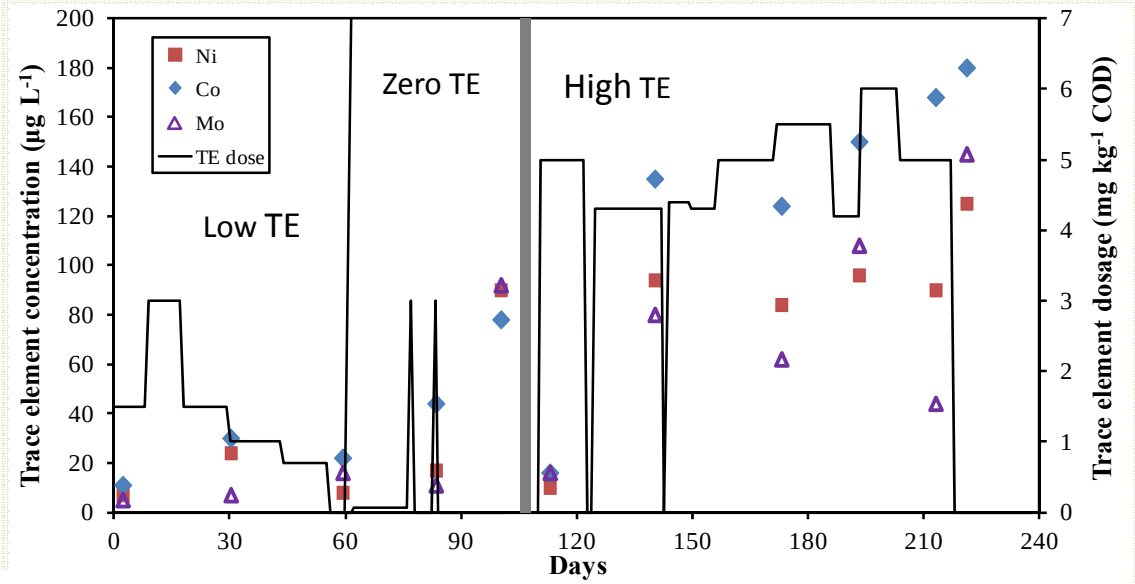
Digester performance under high trace element dosage

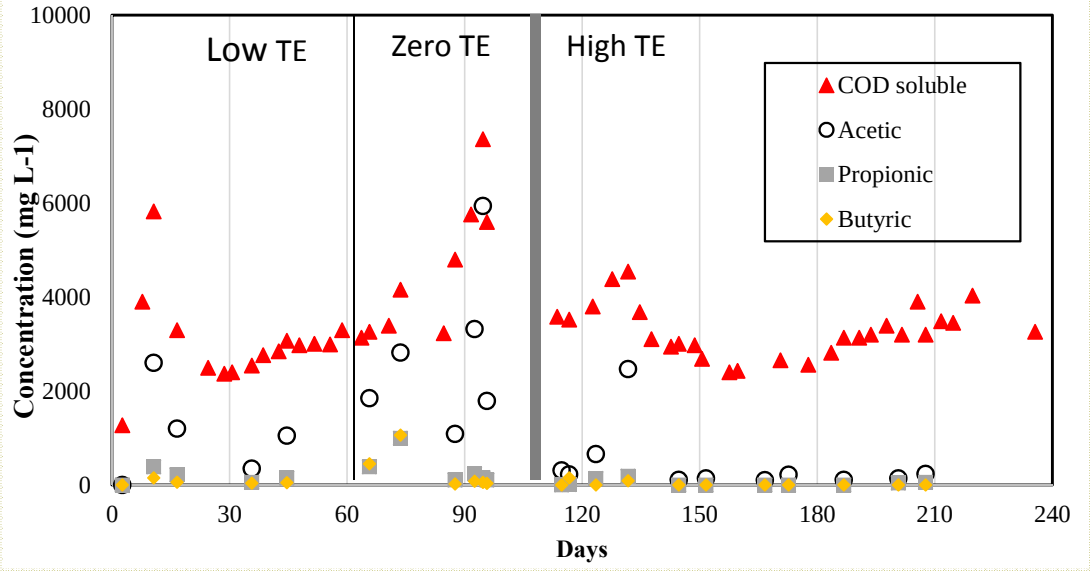




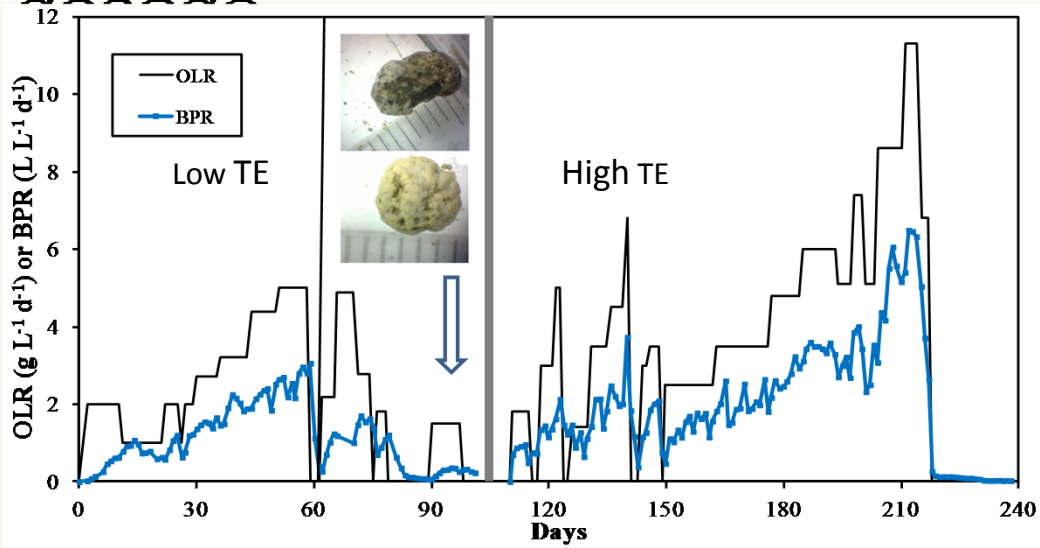


Digester performance under low & high trace element dosage

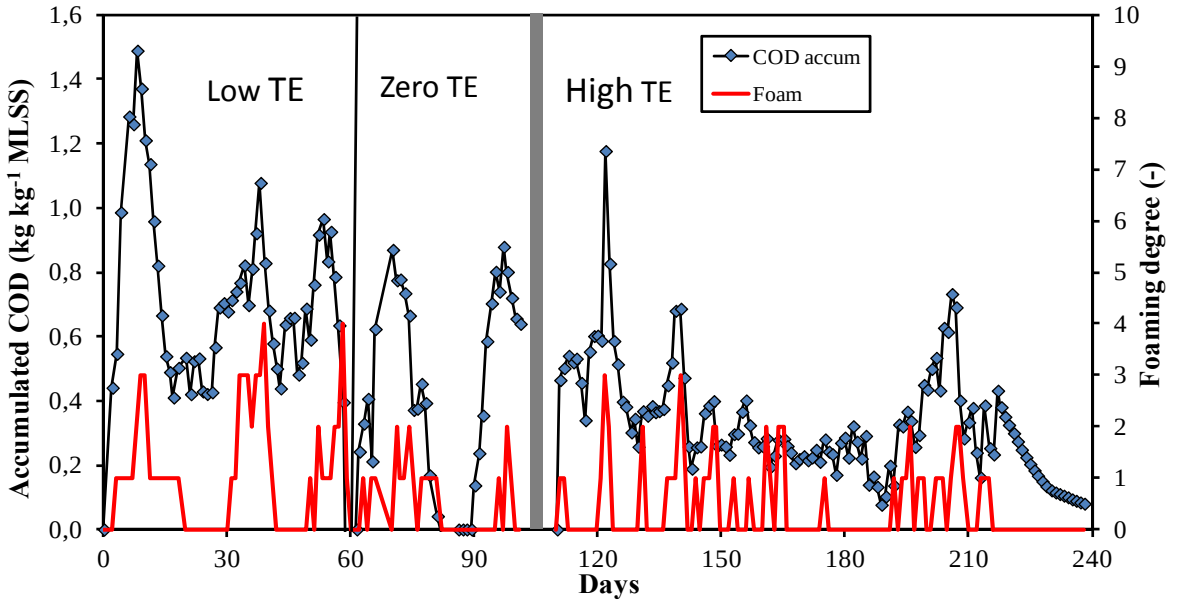




Digester performance under low & high trace element

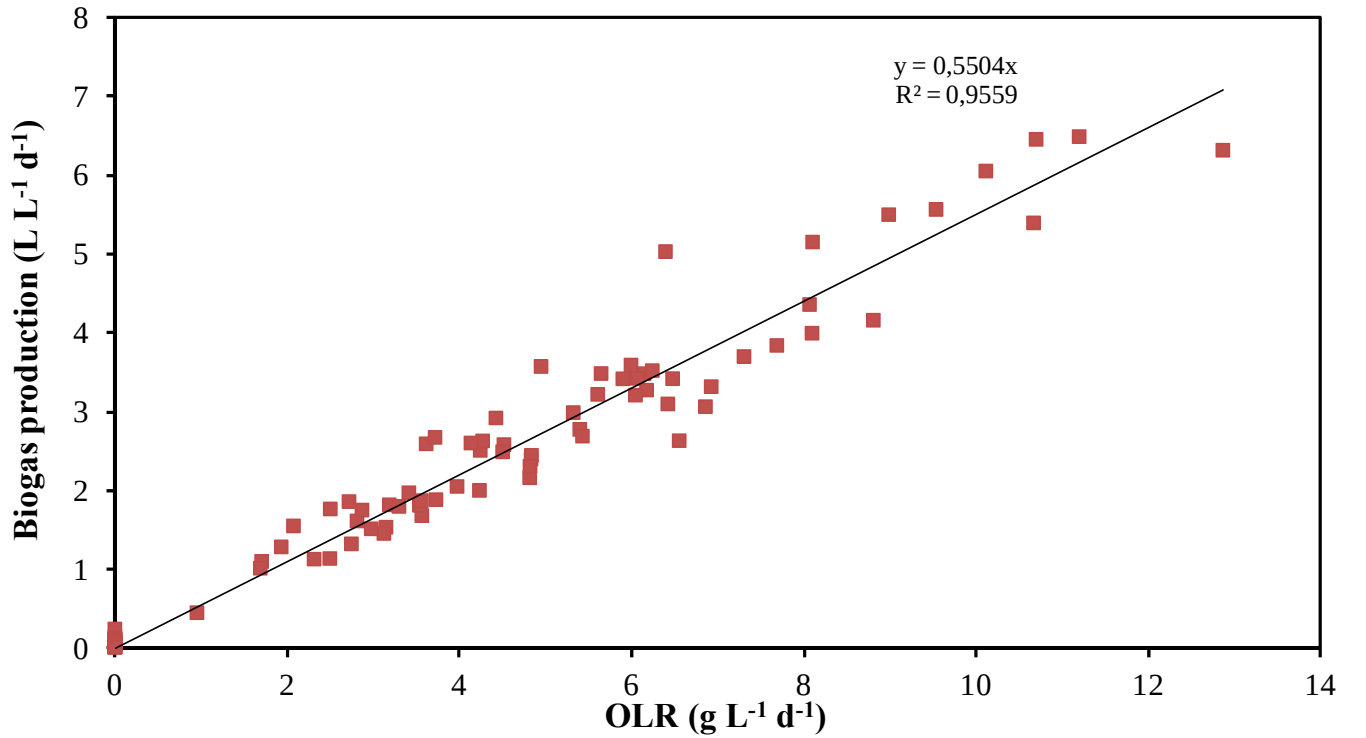


Source of photos: Eftaxias A., Diamantis V., Aivasidis A.: Anaerobic digestion of thermal pre-treated emulsified slaughterhouse wastes (TESW): Effect of trace element limitation on process efficiency and sludge metabolic properties. Waste management (2018).



Digester performance under high trace element dosage

- Yield coefficient ($m^3_{BG}/kgCOD_{removed}$)



Trace elements concentrations

Trace element ($\mu g\ L^{-1}$)	Raw waste (n=3) (COD 180 $g\ L^{-1}$)	Seed sludge (n=8)	Period I (n=4)	Period II (n=4)
Co	5 (±3)	12 (±5)	28 (±12)	130 (±39)
Ni	8 (±1)	6 (±1)	15 (±7)	100 (±23)
Mo	3 (±1)	5 (±2)	12 (±4)	100 (±58)
Fe	430 (±230)	490 (±110)	560 (±323)	852 (±312)
Cu	135 (±77)	13 (±9)	9 (±5)	<10
Zn	2300 (±1230)	118 (±70)	80 (±76)	85 (±13)
Mn	127 (±103)	24 (±5)	14 (±4)	29 (±21)
Se	0.5 (±0)	1 (±0.5)	3 (±1)	1 (±0.3)
B	713 (±137)	190 (±90)	250 (±85)	286 (±55)

Conclusions

- Trace elements play a critical role in anaerobic digestion since they affect the function and activity of methanogenic archaea.
- Under a low trace element dosage, the anaerobic digestion process encountered major instabilities as evidenced by severe sludge flotation, accumulation of COD and VFA and the formation of white precipitates inside the mixed liquor.
- Implementing a high trace element dosage proportional to the applied OLR (4 µg Co, 4 µg Ni and 6 µg Mo per g COD feed) resulted stable digester performance at high OLR (up to 10-12 g L^{-1} d^{-1}).
- COD accumulation remained low, VFA concentrations were negligible and high biogas production (up to 6.5 L^{-1} L^{-1} d) and methane content (77%) were achieved.

Acknowledgements

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Thank you