Valorization of food waste by hydrothermal carbonization and anaerobic digestion

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Introduction

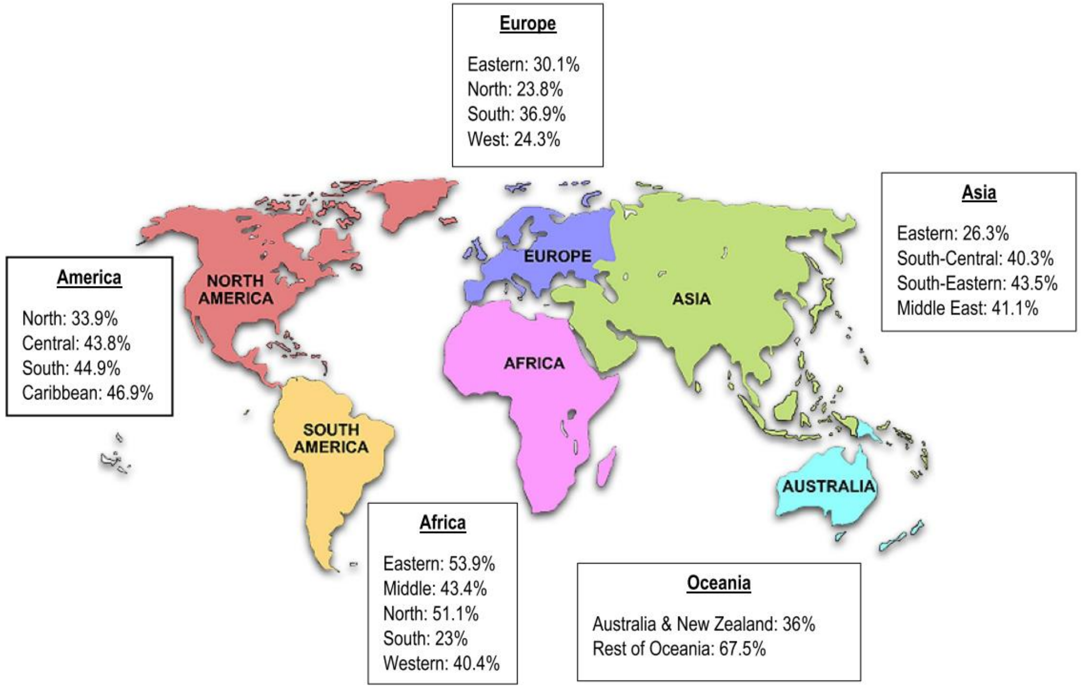
Food waste

*"**Food waste is any food, and inedible parts of food, removed from the food supply chain to be recovered or disposed** (including composted, crops ploughed in/not harvested, anaerobic digestion, bio-energy production, co-generation, incineration, disposal to sewer, landfill or discarded to sea)".* (EU Fusion)

Food loss - Food waste - Food wastage (FAO, 2013)

- In Europe, 88 million of tonnes of food waste are produced annually;
- Costs are estimated to reach up to 143 billion euros.

(European Commission, 2016)



Ul Saqib et al. (2019)

Introduction

Food waste

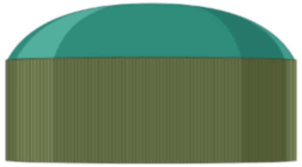
Common treatment technologies can be applied:

Landfilling

Anaerobic digestion

Composting

Incineration



Do these technologies have limits?

Pre-treatments

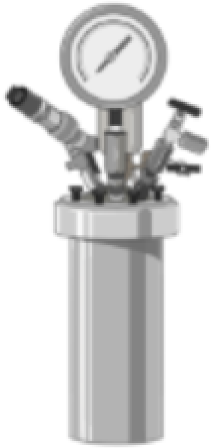
Inhibition

Pollution

Time

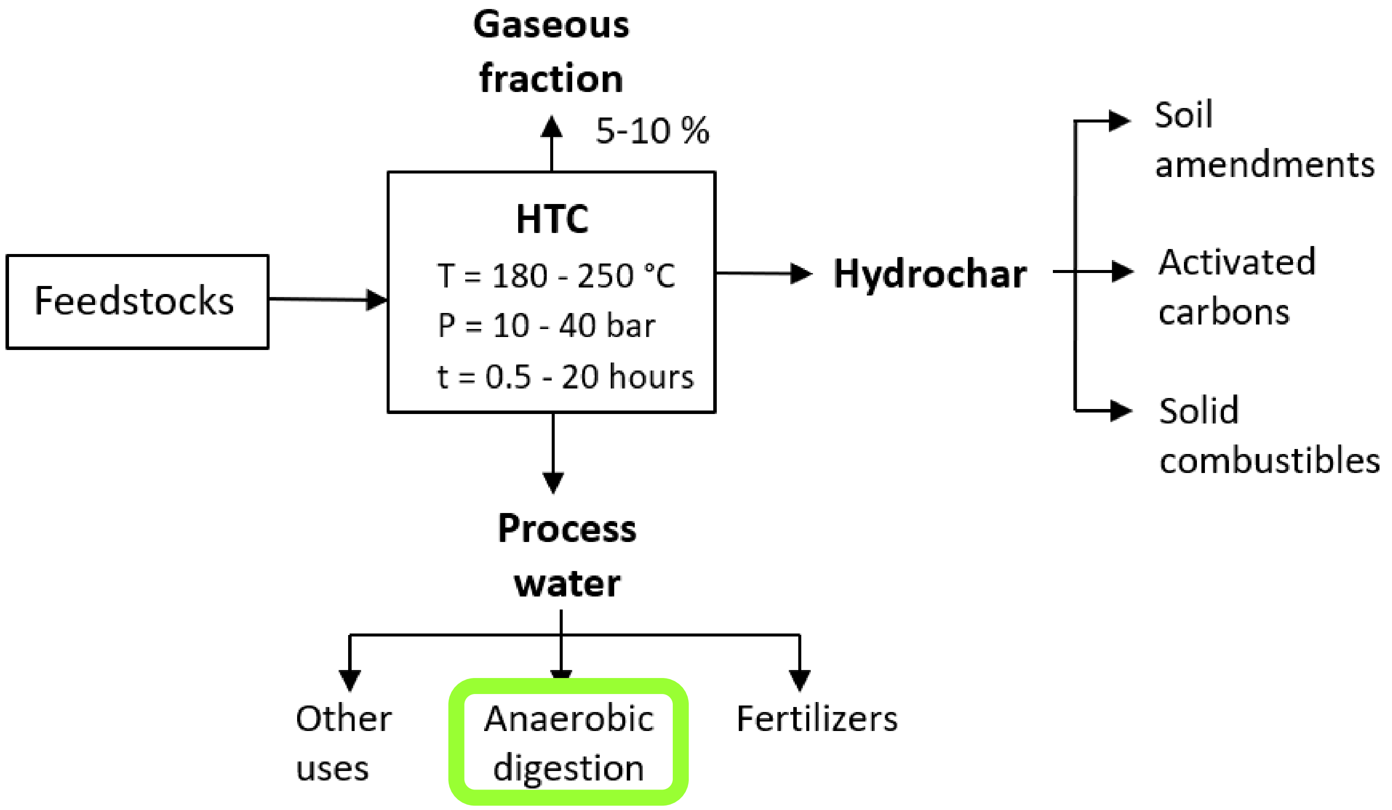
Costs

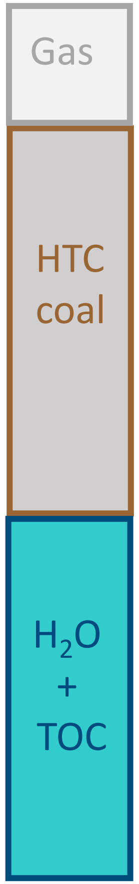
Hydrothermal carbonization (HTC)



Hydrothermal carbonization (HTC)

In this framework, hydrothermal carbonization (HTC) is gaining attention as treatment technology for food waste.





Mainly CO_2
Some CH_4 and CO

Lignite-like material

H_2O and TOC
Sugars and derivatives
Organic acids
Furanoid and phenolic compounds

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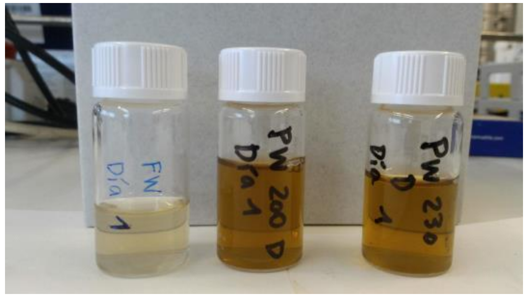
Materials and methods – Process water

Process water (PW) from food waste (200 °C, and 230 °C for 1 hour)

	PW200	PW230
TS (g L^{-1})	38.8 (0.8)	35.9 (0.3)
VS (g L^{-1})	30.4 (0.9)	28.0 (0.4)
SCOD (g O_2 L^{-1})	68.2 (1.5)	62.4 (1.5)
TC (g L^{-1})	24.3 (0.5)	23.6 (0.5)
TN (g L^{-1})	1.8 (0.1)	1.8 (0.1)
TP (mg L^{-1})	40.7 (0.1)	12.6 (0.1)
pH	3.9 (0.1)	3.8 (0.1)

Average values with standard deviation in parenthesis

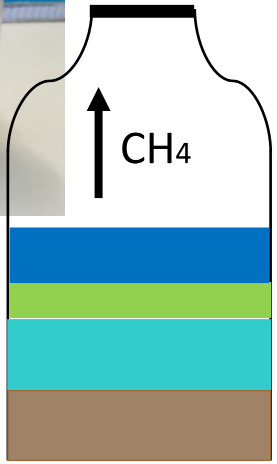


Food waste: TS = 88.2 (2.8) g kg^{-1}, VS/TS = 87.6 (0.2) % and TCOD wet basis 102.2 (2.0) g O_2 kg^{-1}.

Materials and methods – Anaerobic digestion

<u>**Process water (PW) from food waste**</u> (200 °C, and 230 °C for 1 hour)

ANAEROBIC DIGESTION TEST

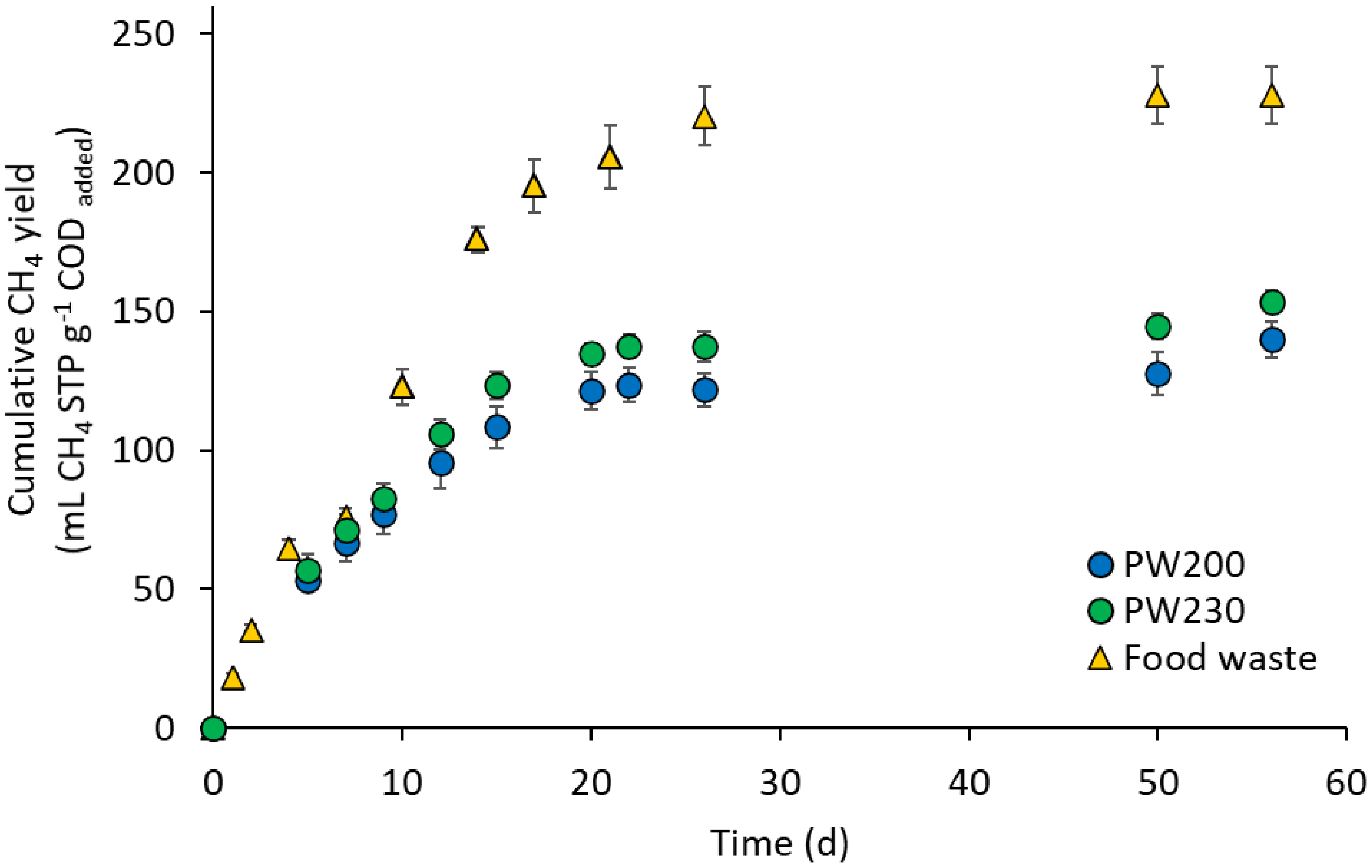


- ISR = 2 on COD basis;
- Tests lasted until no significant changes were observed in CH4 production;
- Monitoring of AD evolution during the experiments;
- Biogas production was determined by manometric method;
- The biogas composition was determined by GC.

- Monitored parameters:
  - Biogas volume and composition
  - Chemical oxygen demand (COD)
  - Volatile fatty acids (VFA)
  - Total ammonia nitrogen (TAN)
  - Alkalinity
  - pH
  - Recalcitrant compounds

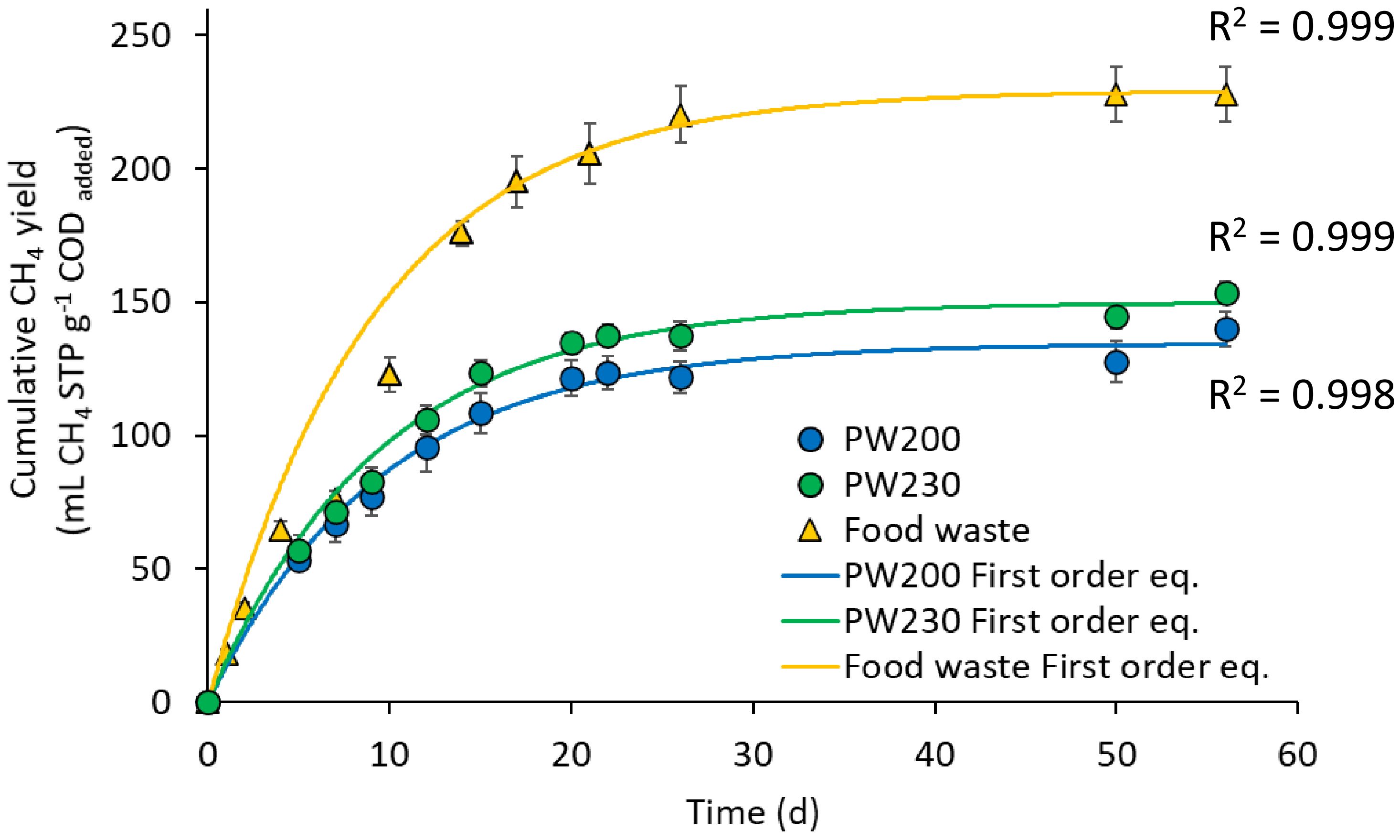
Results – CH_4 specific production

Experimental values



Results – CH_4 specific production

Experimental values and fitted data



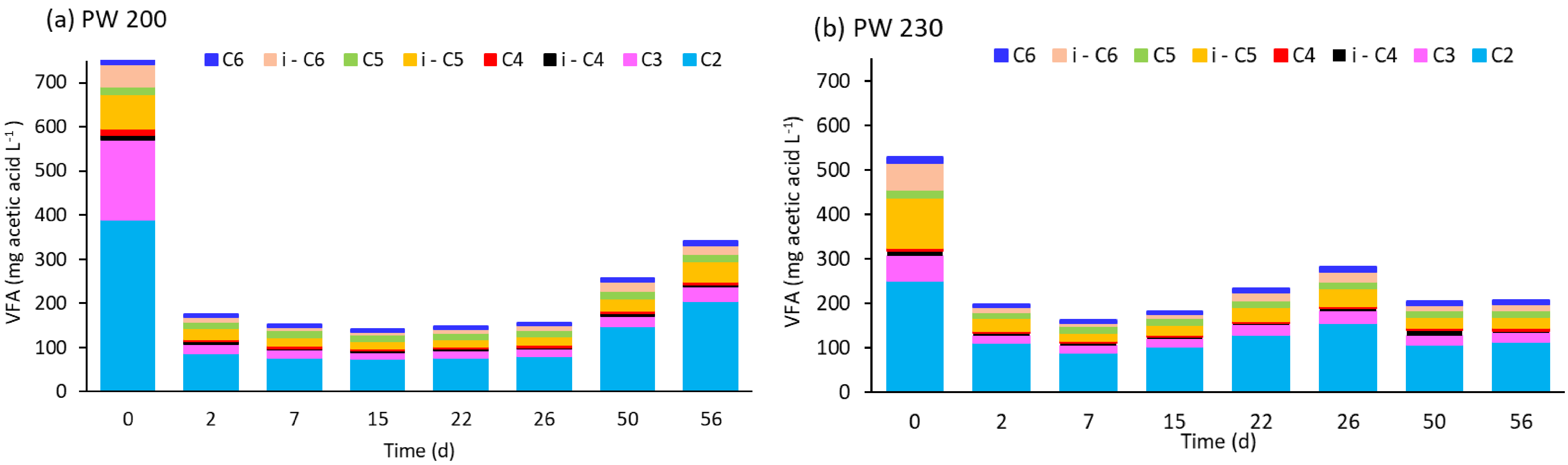
First order equation:

$$G(t) = G_{max} \cdot [1 - \exp(-k \cdot t)]$$

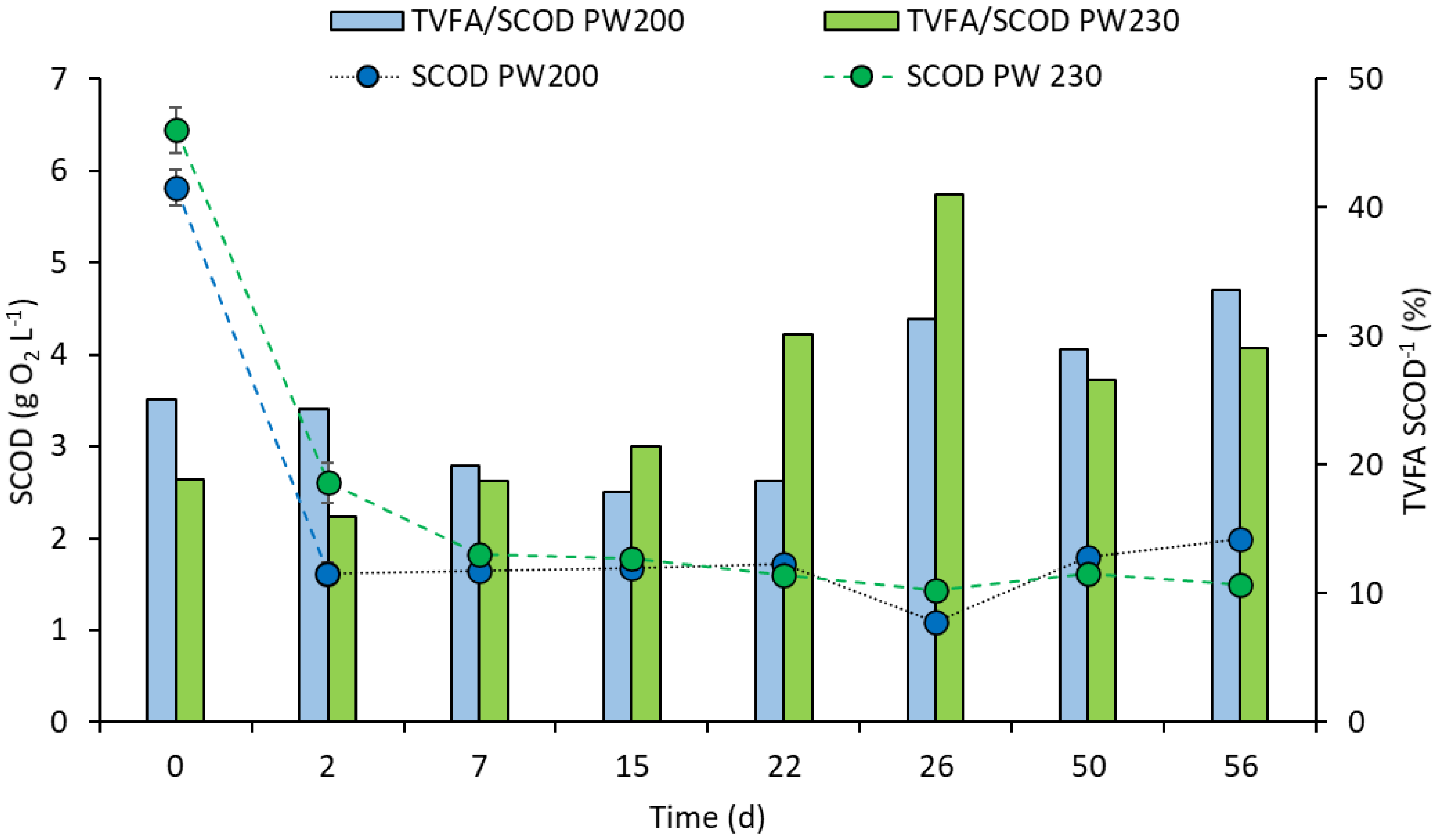
Sample	Gmax (mL CH_4 STP g^{-1} COD_{added})	k (d^{-1})
Food waste	229 ± 1	0.110 ± 0.006
PW200	135 ± 2	0.105 ± 0.011
PW230	150 ± 2	0.106 ± 0.008

Modelled values ± standard error

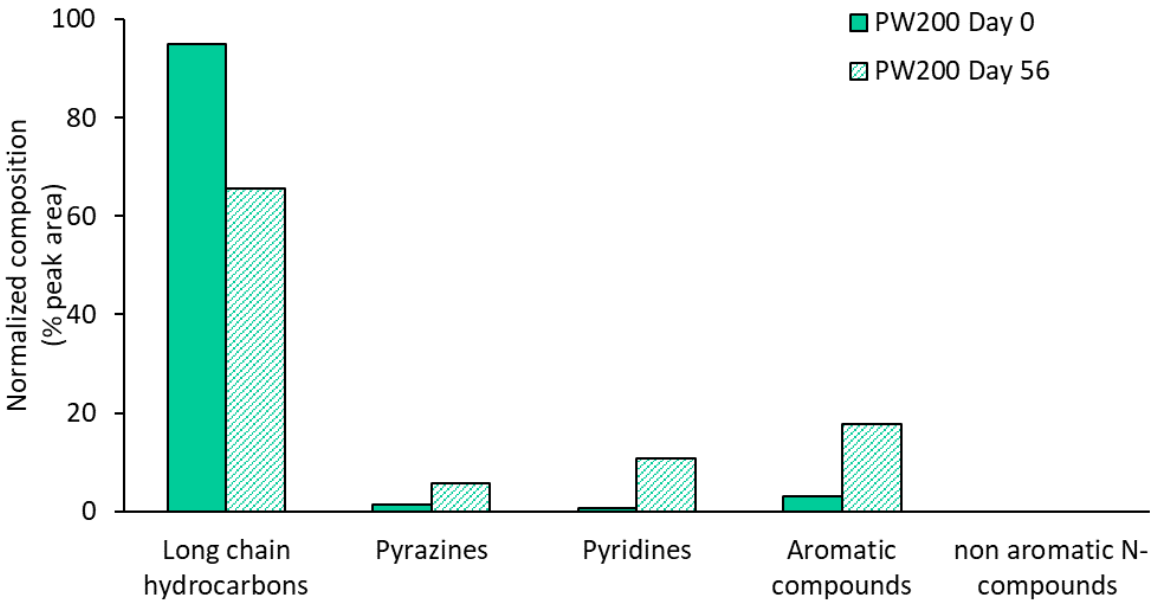
Results – Volatile fatty acid (VFA) evolution

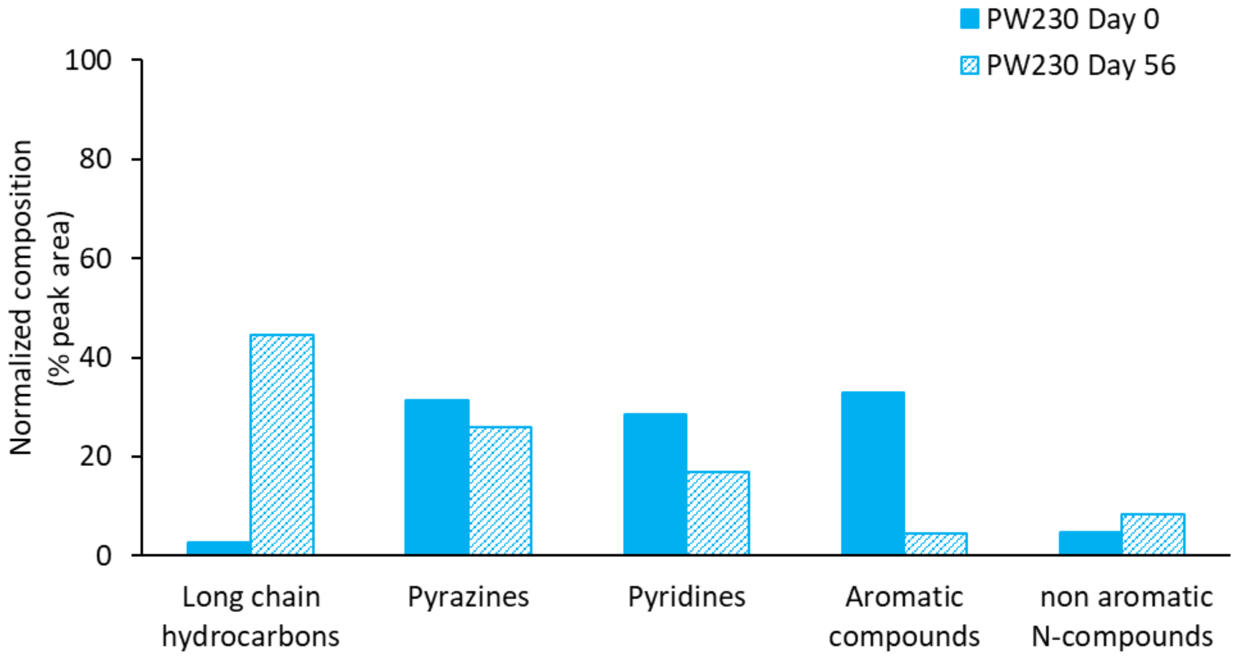


Results – COD and TVFA/COD ratio evolution



Results – Recalcitrant compounds





- Removal of specific recalcitrant compounds (e.g. 2-methylpyridine and 2-ethyl-3-methylpyrazine)!

Conclusions

- PW200, and PW230 resulted in comparable specific CH_4 yields ($\cong$ 150 mL CH_4 STP g^{-1} COD_{added}), while food waste resulted in higher CH_4 production than PW (228 mL CH_4 STP g^{-1} COD_{added});
- Overall, anaerobic digestion test resulted to be efficient (effective conversion of both VFA and COD);
- Stability of pH (7.4 – 7.9), alkalinity (> 4.0 g $CaCO_3$ L^{-1} at the end of anaerobic digestion), and TAN (< 1 g N L^{-1} at the end of anaerobic digestion);
- Removal of specific recalcitrant compounds during anaerobic digestion occurred;
- To fully understand the real advantage of this technology in food waste management, hydrochar valorization through combustion has to be included!

Thank you for your attention!

… any questions?

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