Ammonia recovery from acidogenic fermentation effluents using a gas-permeable membrane

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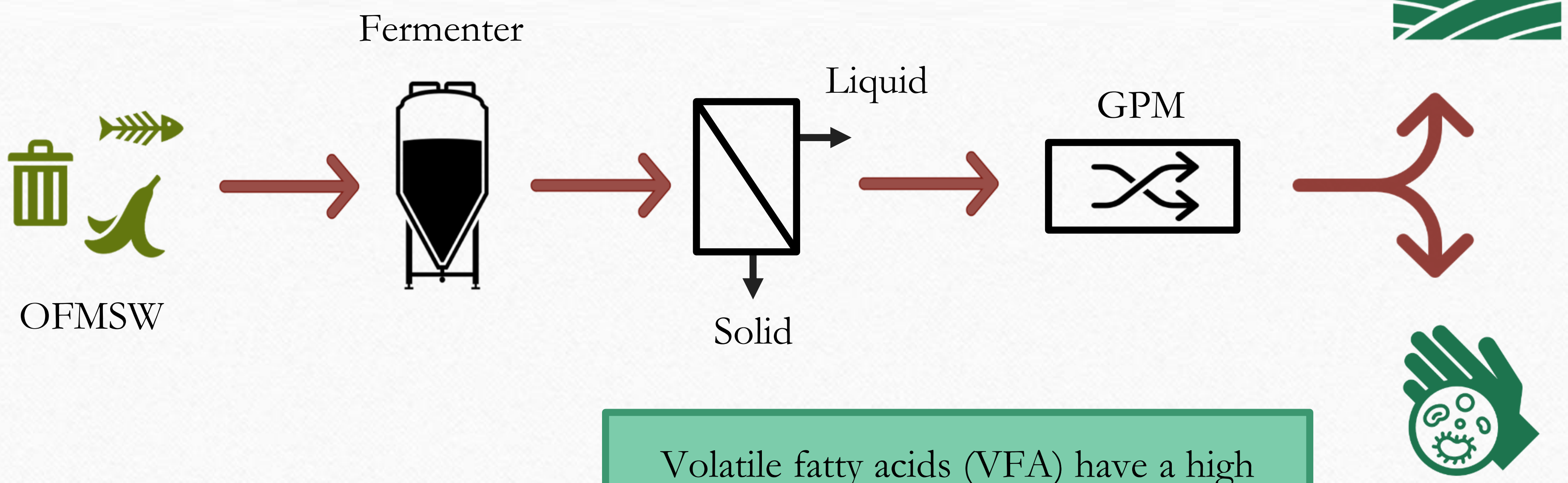
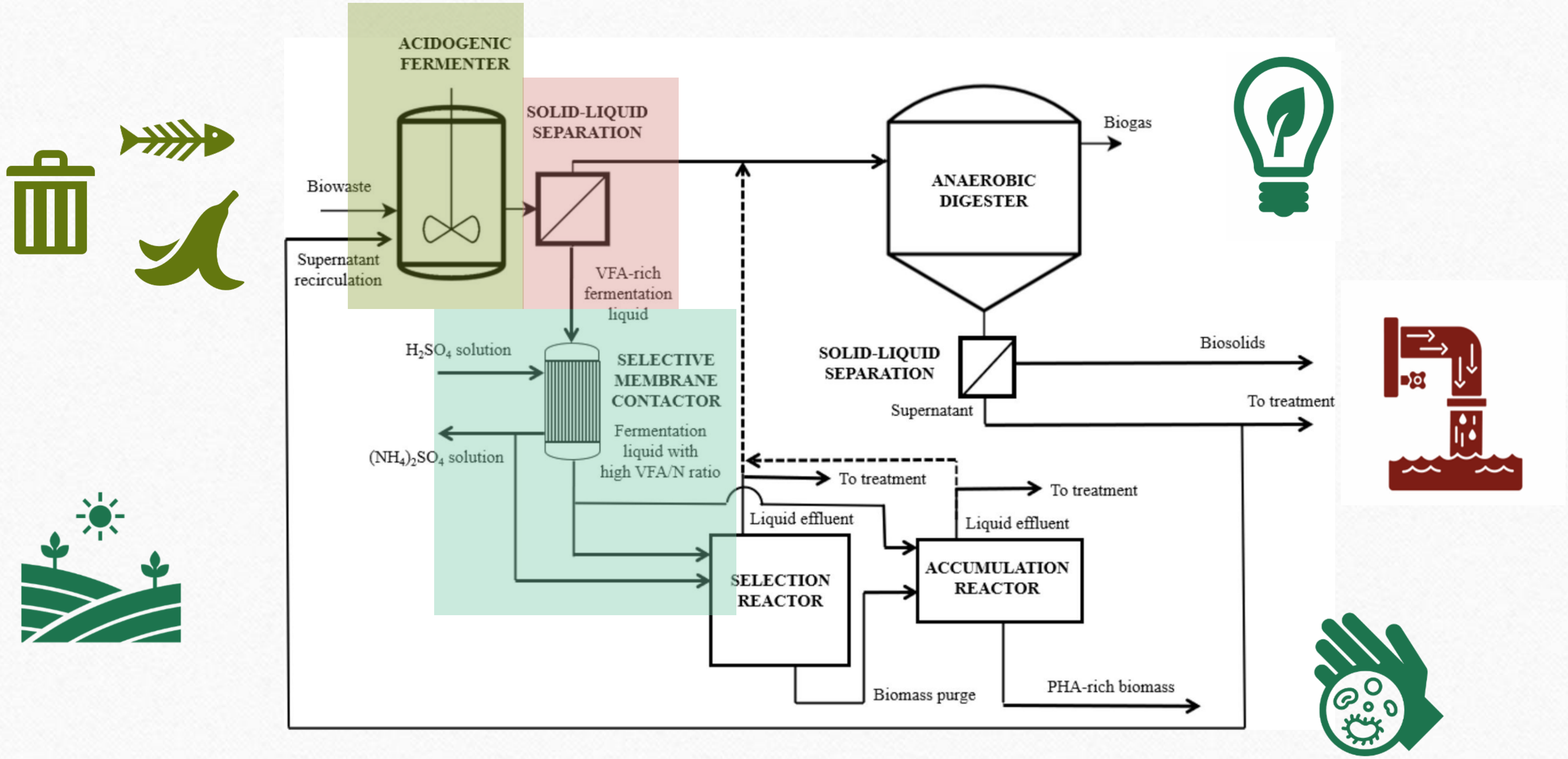
Introduction

Gas-permeable membrane (GPM) contactors are a potential technology to recover N-NH_4^+ from **fermentation liquids**.



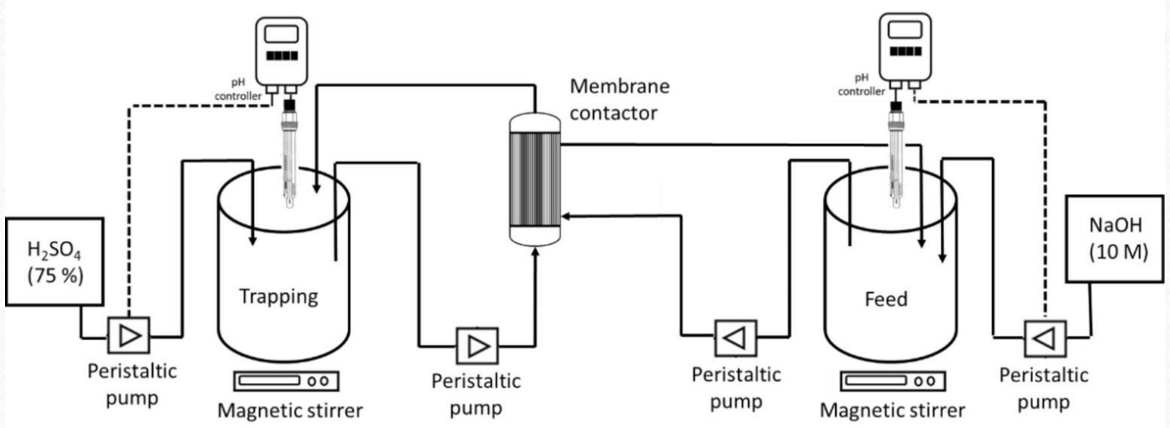
Volatile fatty acids (VFA) have a high added value and can be generated from **fermentation effluents**.

Introduction



Materials and Methods

Ammonia removal took place in a **nanoperforated hollow fibre membrane contactor** that put in contact the feed solution and the trapping acidic solution.



The **acidogenic fermentation** of OFMSW was carried out in a 30 L reactor and lasted 8 days.

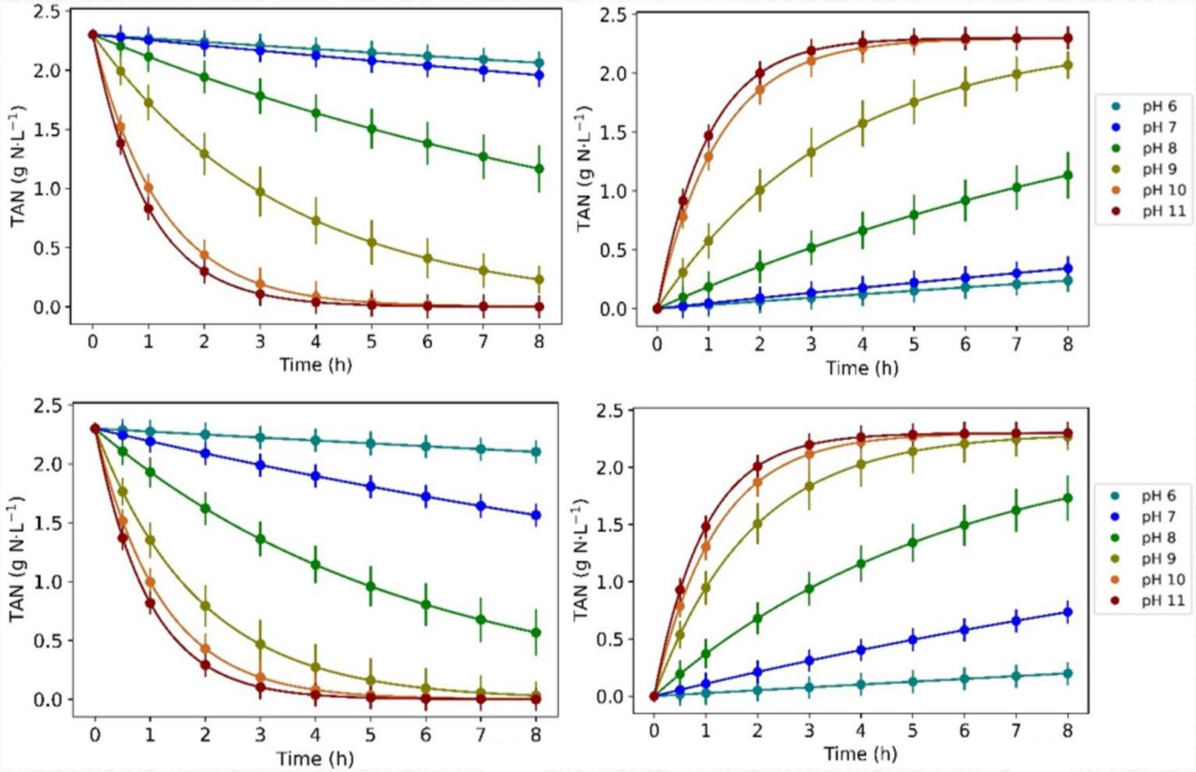
Feed solution	pH (-)	T (°C)
Synthetic fermentation liquid (2.5 g N/L 3.0 g HAc/L)	6.0	35
	7.0	35
	8.0	35
	9.0	35
	10.0	35
	11.0	35
	6.0	55
	7.0	55
	8.0	55
	9.0	55
	10.0	55
	11.0	55
OFMSW fermentation liquid	9.0	35
	10.0	35
	9.0	55
	10.0	55

Nitrogen recovery with synthetic solution

Feed solution | Trapping solution

T = 35 °C

T = 55 °C



NH_4^+-N recovery increased as the feed solution pH was raised.

Higher temperature lead to improved NH_4^+-N transfers.

Nitrogen recovery with synthetic solution

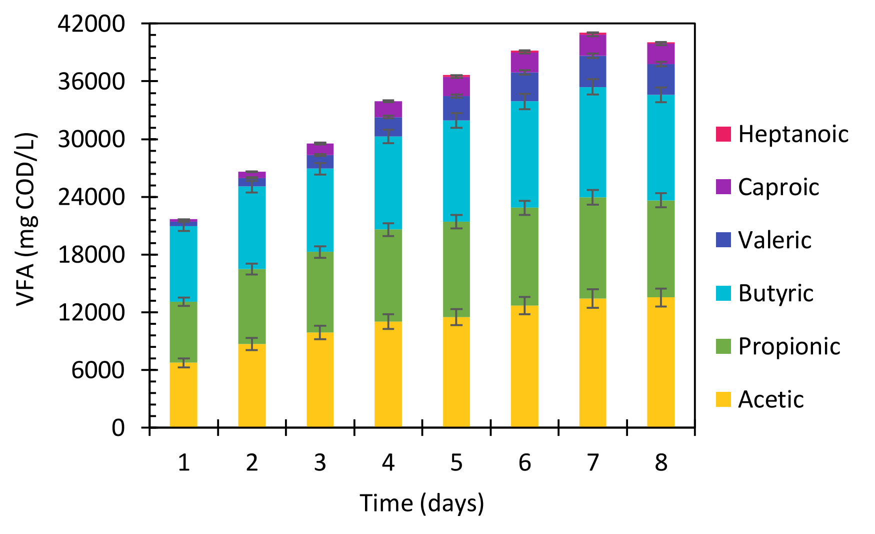
Exp.	T	pH	TAN recovery at 8h	Average flux at 8h	K_m
	ºC	-	%	$g\ N \cdot day^{-1} \cdot m^{-2}$	$m \cdot s^{-1}$
1A	35	6.0	8	2.5 ± 0.3	$(2.2 \pm 0.5) \cdot 10^{-8}$
1B		7.0	16	4.3 ± 0.6	$(2.8 \pm 0.4) \cdot 10^{-8}$
1C		8.0	65	17 ± 3	$(9.5 \pm 1.3) \cdot 10^{-8}$
1D		9.0	91	62 ± 10	$(3.2 \pm 0.3) \cdot 10^{-7}$
1E		10.0	100	115 ± 16	$(9.2 \pm 0.4) \cdot 10^{-7}$
1F		11.0	100	138 ± 17	$(1.13 \pm 0.03) \cdot 10^{-6}$
2A	55	6.0	10	2.8 ± 0.3	$(1.3 \pm 0.3) \cdot 10^{-8}$
2B		7.0	36	10 ± 2	$(5.8 \pm 1.0) \cdot 10^{-8}$
2C		8.0	73	32 ± 5	$(1.9 \pm 0.1) \cdot 10^{-7}$
2D		9.0	99	84 ± 11	$(5.9 \pm 0.5) \cdot 10^{-7}$
2E		10.0	100	121 ± 16	$(9.3 \pm 0.3) \cdot 10^{-7}$
2F		11.0	100	133 ± 16	$(1.15 \pm 0.04) \cdot 10^{-6}$

NaOH consumption decreased as the feed solution pH was raised.

H_2SO_4 consumption decreased as the feed solution pH was raised (minimum at pH 10).

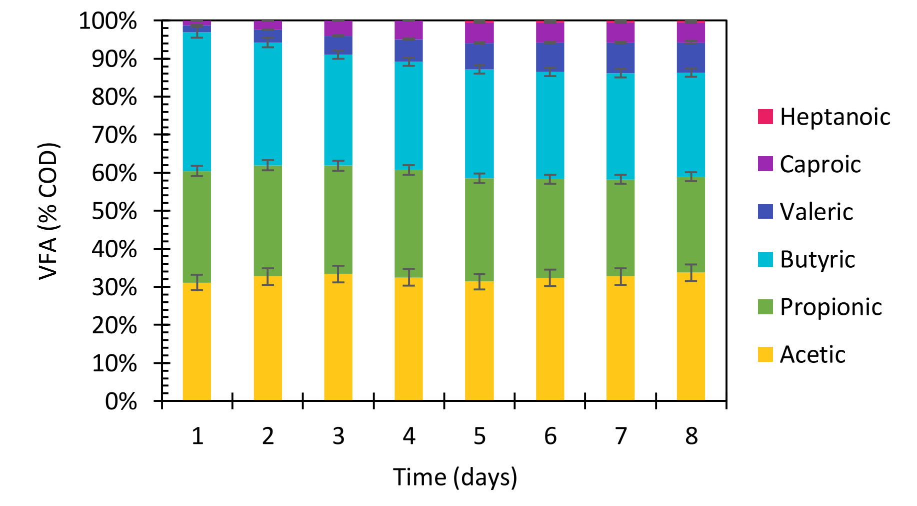
The best operation pH was determined to be 10.

Acidogenic fermentation



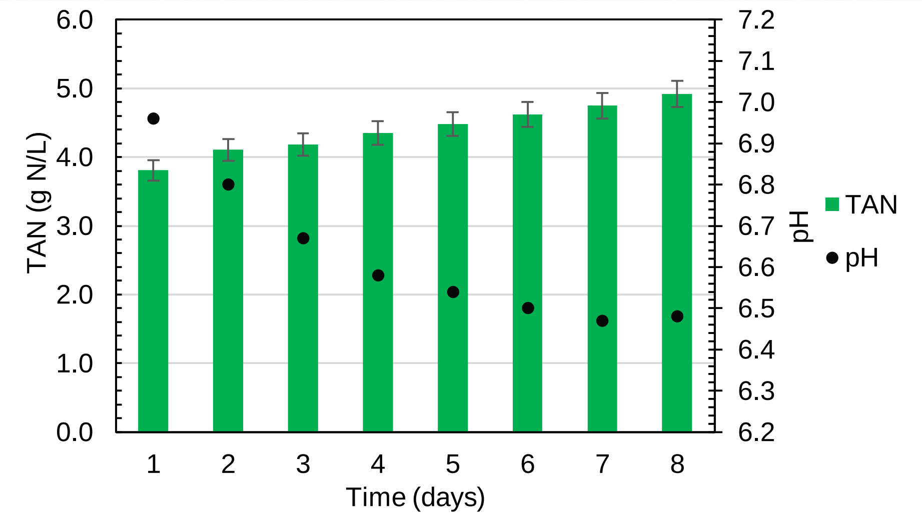
VFA proportion was constant amongst the fermentation.

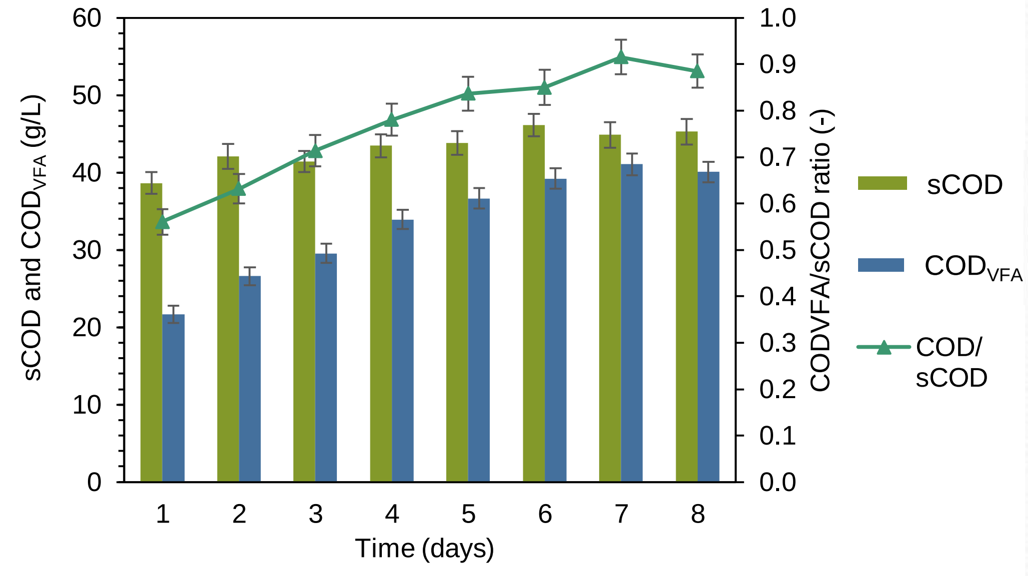
VFA concentration reached 41 g COD_{VFA}/L at the 7^{th} day.



Acidogenic fermentation

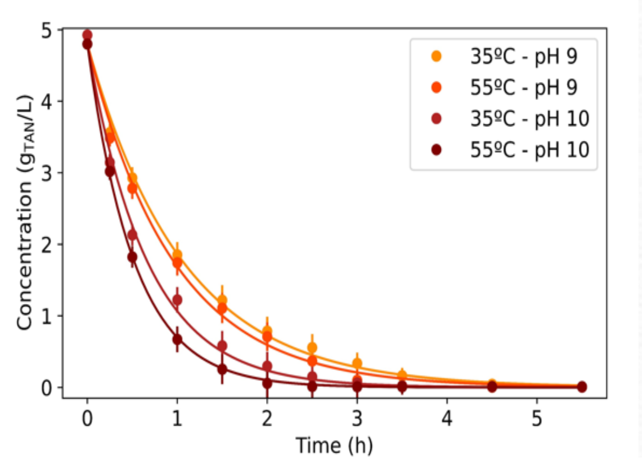
$N\text{-}NH_4^+$ concentration reached 4.9 g N/L.

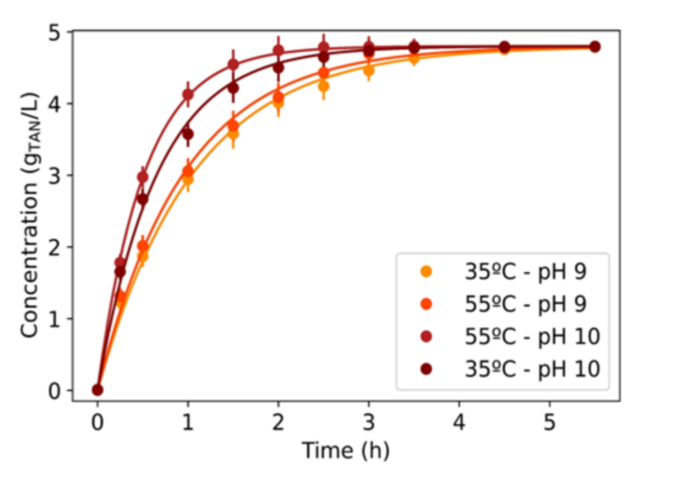




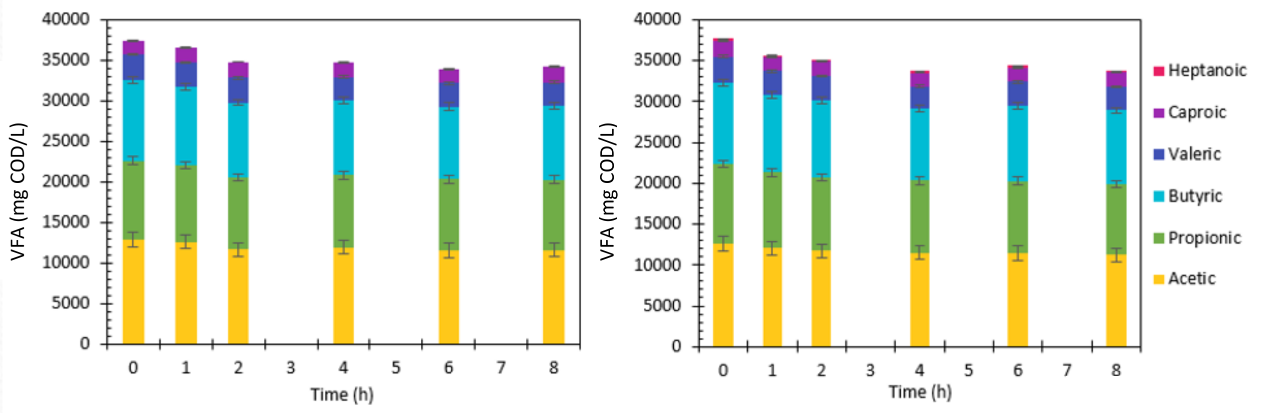
COD_{VFA} increased due to the acidogenic fermentation.

Nitrogen recovery with fermentation liquid





The GPM allowed a complete recovery of $N\text{-}NH_4^+$ with a minimum loss of VFA.



Nitrogen recovery with fermentation liquid

Exp.	T	pH	TAN recovery at 8h	Average flux at 8h	K_m	Synthetic K_m
	ºC	-	%	$g\ N \cdot day^{-1} \cdot m^{-2}$	$m \cdot s^{-1}$	$m \cdot s^{-1}$
3A	35	9.0	100	78.4 ± 11.0	$(2.8 \pm 6.0) \cdot 10^{-7}$	$(3.2 \pm 0.3) \cdot 10^{-7}$
3B		10.0	100	120.1 ± 14.4	$(5.0 \pm 9.2) \cdot 10^{-7}$	$(9.2 \pm 0.4) \cdot 10^{-7}$
3C	55	9.0	100	91.0 ± 12.7	$(3.3 \pm 6.3) \cdot 10^{-7}$	$(5.9 \pm 0.5) \cdot 10^{-7}$
3D		10.0	100	138.8 ± 16.7	$(5.4 \pm 5.7) \cdot 10^{-7}$	$(9.3 \pm 0.3) \cdot 10^{-7}$

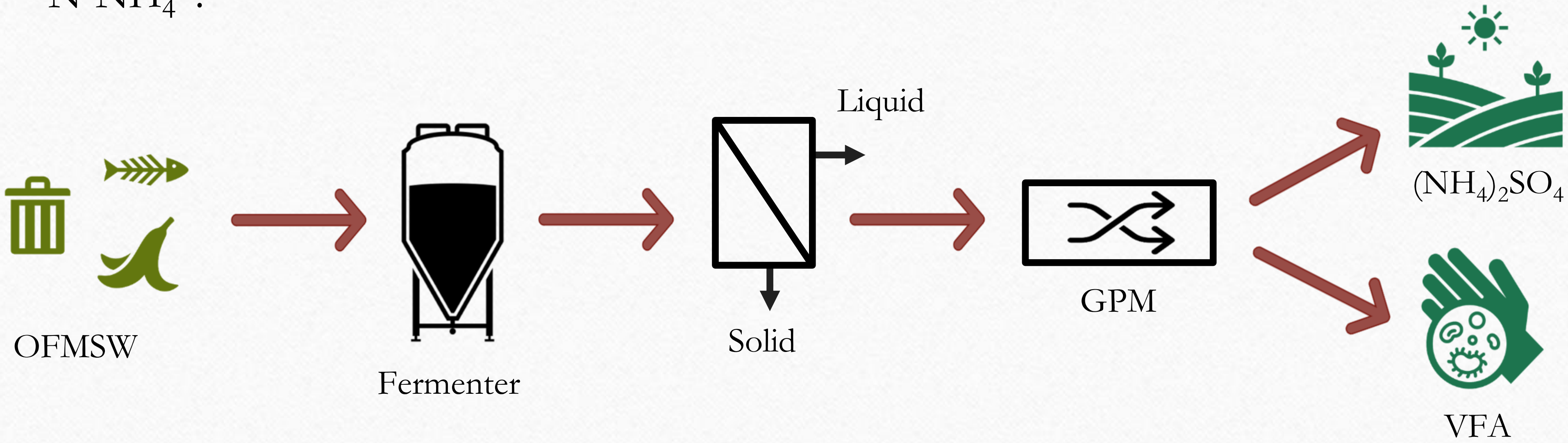
$N\text{-}NH_4^+$ transfer decreased when we operated with fermentation liquid.

The K_m improve from pH 9 to 10 were lower in fermentation liquid.

Conclusions

- The **N-NH_4^+ can be completely recovered** from fermentation effluents at 35 and 55 °C and pH values above 9 efficiently.

- The process produce a **$(NH_4)_2SO_4$ solution** suitable as fertiliser and a **rich VFA liquid** free of N-NH_4^+.



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