HERAKLION 2019

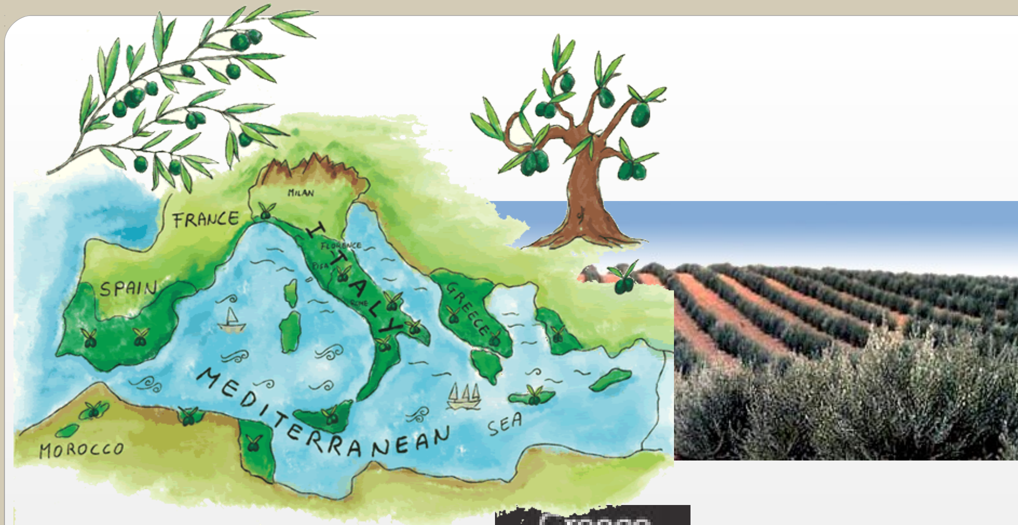
7th International Conference on Sustainable Solid Waste Management

Biogas production in pilot digesters treating a mixture of olive mill wastewater and agro-industrial by-products

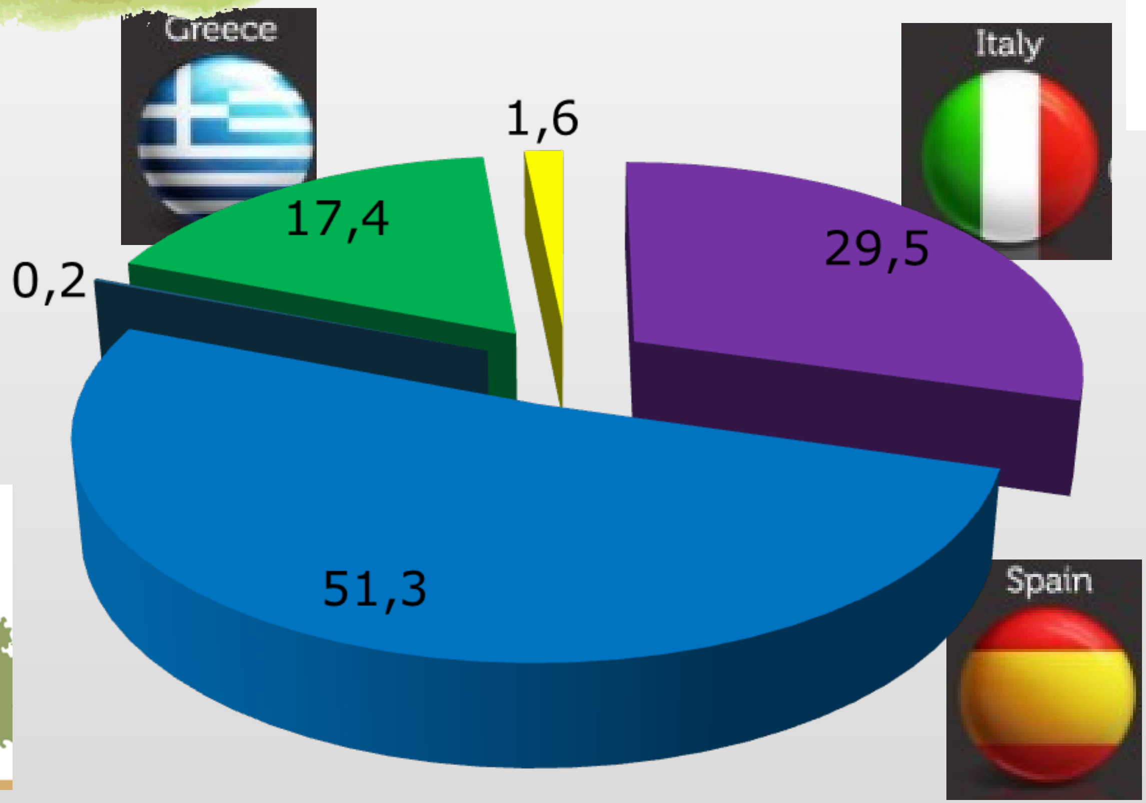
D. Thanos, A. Maragkaki, M. Fountoulakis, T. Manios

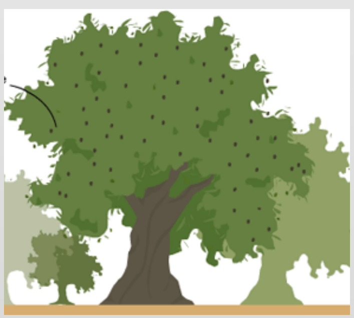
Laboratory of Natural Resources, Management & Agricultural Engineering
Hellenic Mediterranean University, Greece

Heraklion, June 2019


FRANCE
MILAN
SPAIN
ITALY
GREECE
MOROCCO
MEDITERRANEAN
SEA

78.2
world’s


Greece
Italy
Spain
1,6
17,4
0,2
29,5
51,3



Three – phase process

Environmental problem

- High degree organic load
- High content of polyphenols
- High content of solid matter

Anaerobic digestion

Aim

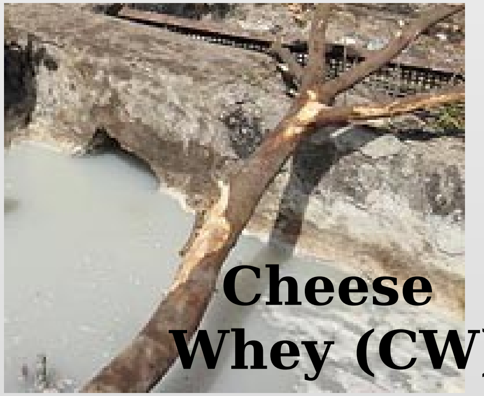
Examine on a pilot scale, the effect of different waste mixtures available in Crete on methane production for bioenergy generation and to find environmental friendly and economically feasible solutions to re-use and valorize the majority of agricultural waste and by-products in Crete, Greece

Specific aim:
Investigate biogas production for raw OMW mixed with varying amounts of Poultry Manure and different liquid feedstocks

The approach and results could facilitate the development of biogas production in other Mediterranean regions with similar sources of

Raw Materials

Afte
r



Raw Materials

Composition of Liquid Pig Manure (LPM), Olive Mill Waste Water (OMW), Cheese Whey (CW) and Poultry Manure (PM)						
Parameters	LPM	OMW_A	OMW_B	CW	PM_A	PM_B
pH	7.7 ± 0.1	4.9 ± 0.0	5.7 ± 1.6	4.5 ± 0.1	8.9. ± 0.0	8.8 ± 0.1
TS (g/l)	9.5 ± 9.6	94.9 ± 2.5	38.9 ± 21.4	73.9 ± 1.1	268.2 ± 3.2	283.9 ± 52.5
VS (g/l)	5.9 ± 6.9	83.2 ± 2.4	32.6 ± 17.4	59.9 ± 1.9	180.2 ± 1.6	186.9 ± 19.8
t-COD (g/l)	12.9 ± 9.2	195.6 ±15.3	71.4 ± 22.3	80.7 ± 3.2	7.7 ± 3.3	7.7 ± 3.3

Experimental procedure

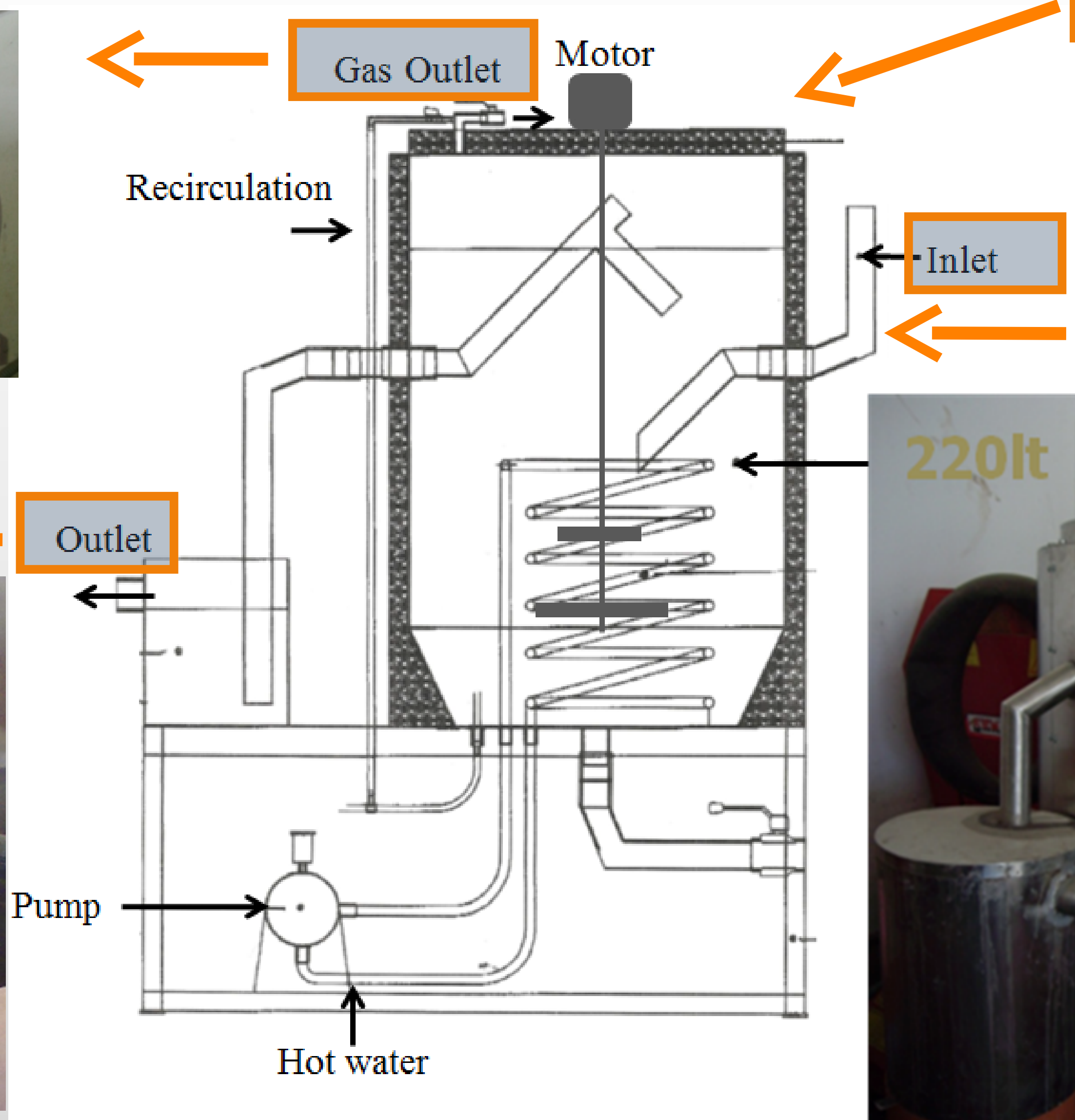
- ✓ **2 type of feedstock:**
- ❖ **Sub A: 30 % v/v OMW & 70 % PM & LPM - TS ratio ~ 10%**
- ❖ **Sub B: 40 % v/v OMW & 60 % PM & CW - TS ratio ~ 10%**
- ❖ **Mesophilic AD,** 35° C, HRT = 30 days
- ✓ Influent & effluent samples analyzed TS, VS, pH, TCOD, d-COD and methane

2 HRTs

Operational parameters – Reactor characteristics					
Reactor no	**Digester working volume (L)**	**HRT (days)**	**Time (days)**	**Feedstock**	**OLR ($kgVSm^{-3}d^{-1}$)**
1 – Sub A	180	30	1 – 66	30 % OMW & 70 % PM & LPM	2.2
2 – Sub	180	30		40 % OMW	

Pilot Scale digester

Drum-type gas meter



Digester

Feedstock Results

Characteristics of experimental materials as feedstock

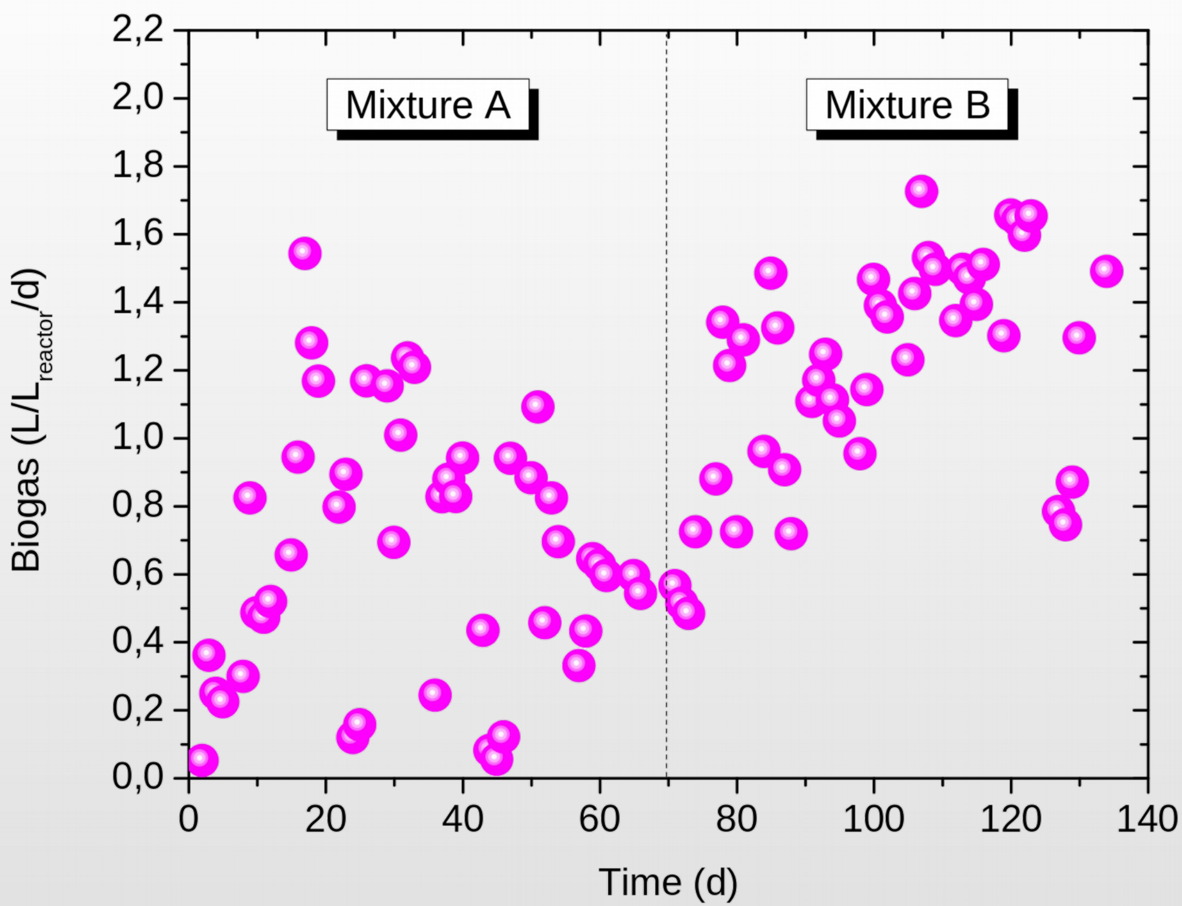
Parameters	Co-substrate A	Co-substrate B
pH	6.9 ± 0.1	6.1 ± 0.4
TS (g/l)	84.6 ± 9.1	85.9 ± 10.9
VS (g/l)	59.8 ± 5.9	62.1 ± 8.4
t-COD (g/l)	90.1 ± 7.5	90.3 ± 13.0
d-COD (g/l)	42.3 ± 2.7	50.9 ± 15.9
N (g/l)	6.5 ± 0.5	4.4 ± 0.6
P (mg/l)	471 ± 92	437 ± 86
$L_{biogas}/L_{reactor}$/day	0.7 ± 0.4	1.2 ± 0.3
$\%CH_4$	60 ± 4.7	61 ± 3.4

Organic load of OMW_A was reduced because of OMW 'dilution' with LPM

OMW & PM & LPM

OMW & PM & CW

Results



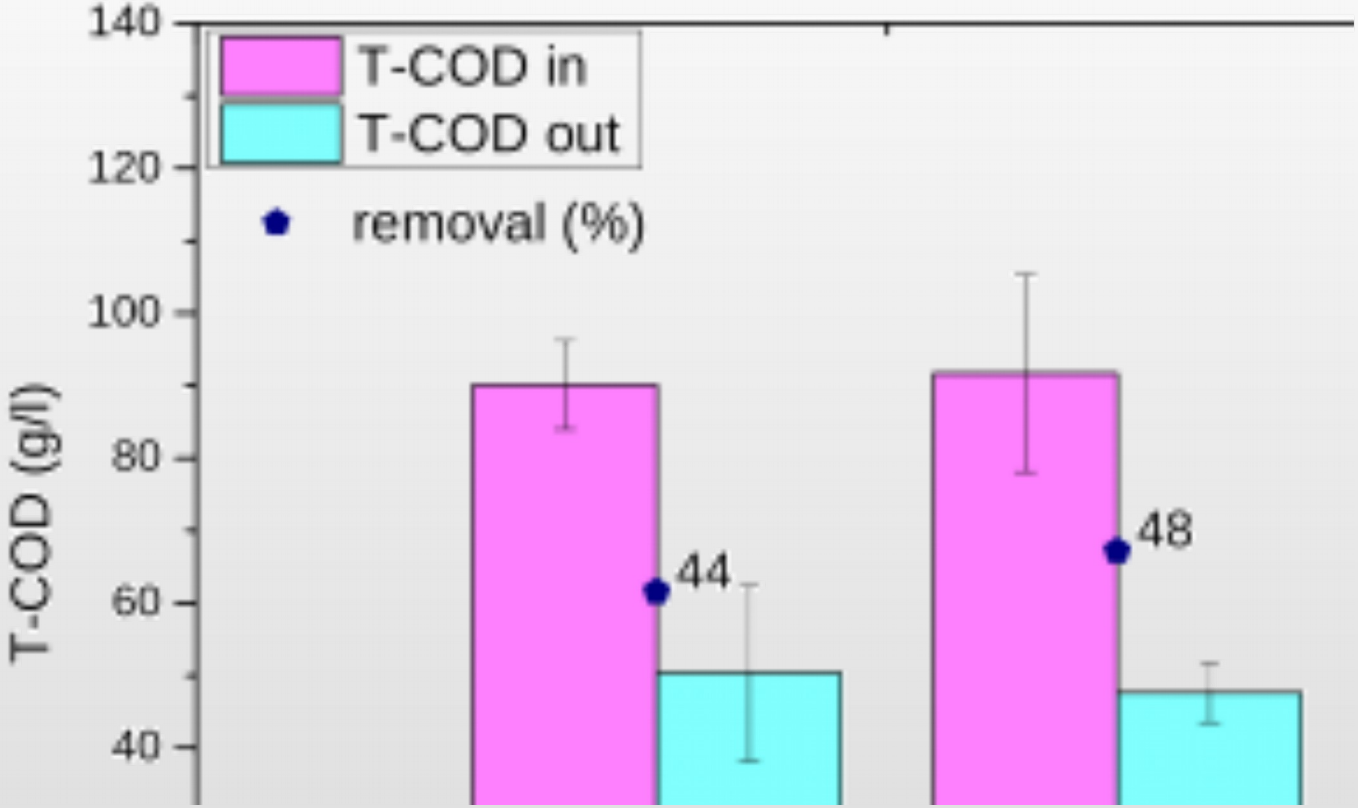
Increase of OMW and CW co-digestion improved biogas production

1.7 times

A: 30 % OMW & 70 % PM & LPM → 0.7 ± 0.4 L/L$_{reactor}$/d

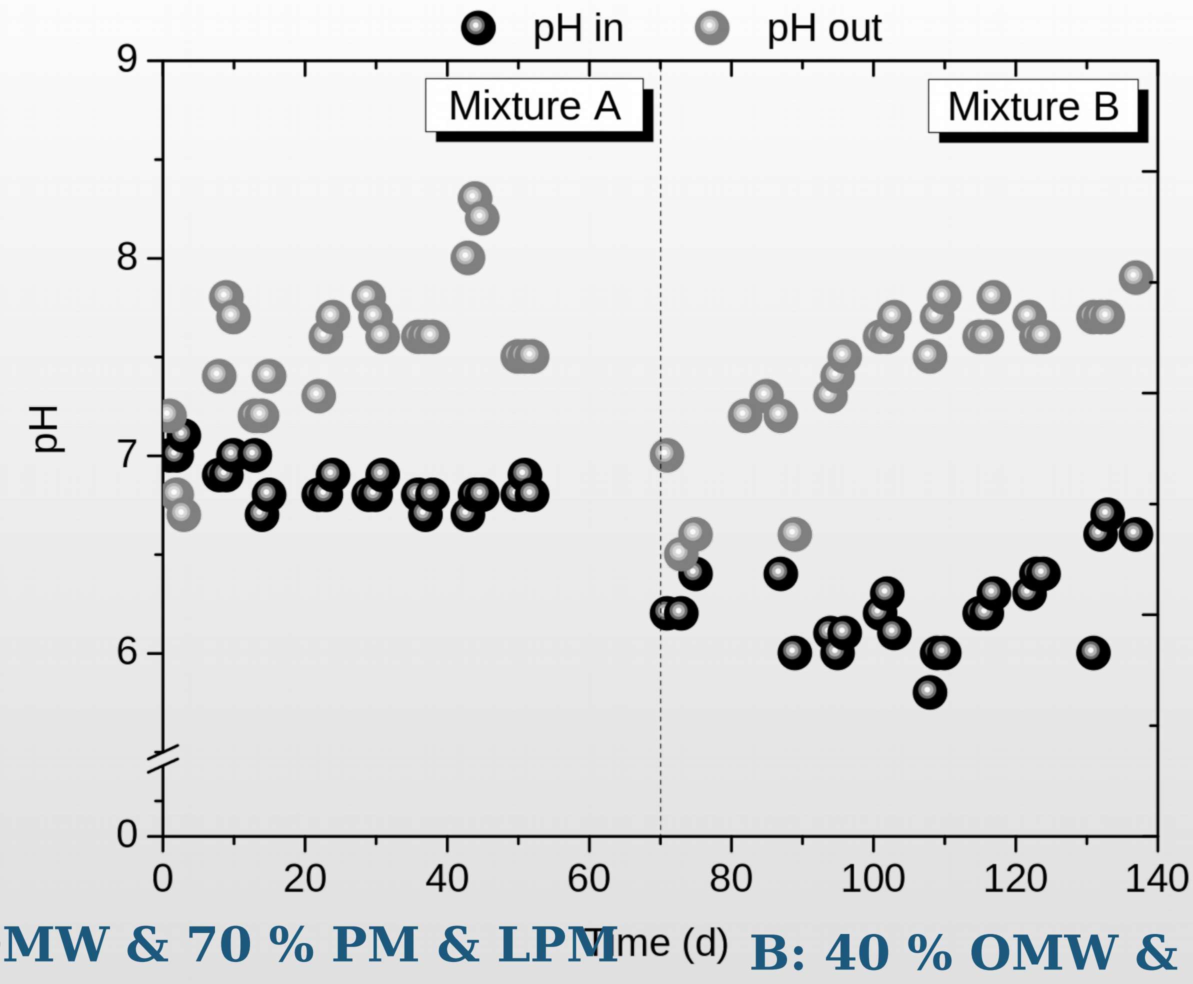
B: 40 % OMW & 60 % PM & CW → 1.2 ± 0.3 L/L$_{reactor}$/d

Results – T - COD



A: 30 % OMW & 70 % PM & LPM → 44%
B: 40 % OMW & 60 % PM & CW → 48%

Results – pH



A: 30 % OMW & 70 % PM & LPM

B: 40 % OMW & 60 % PM & CW

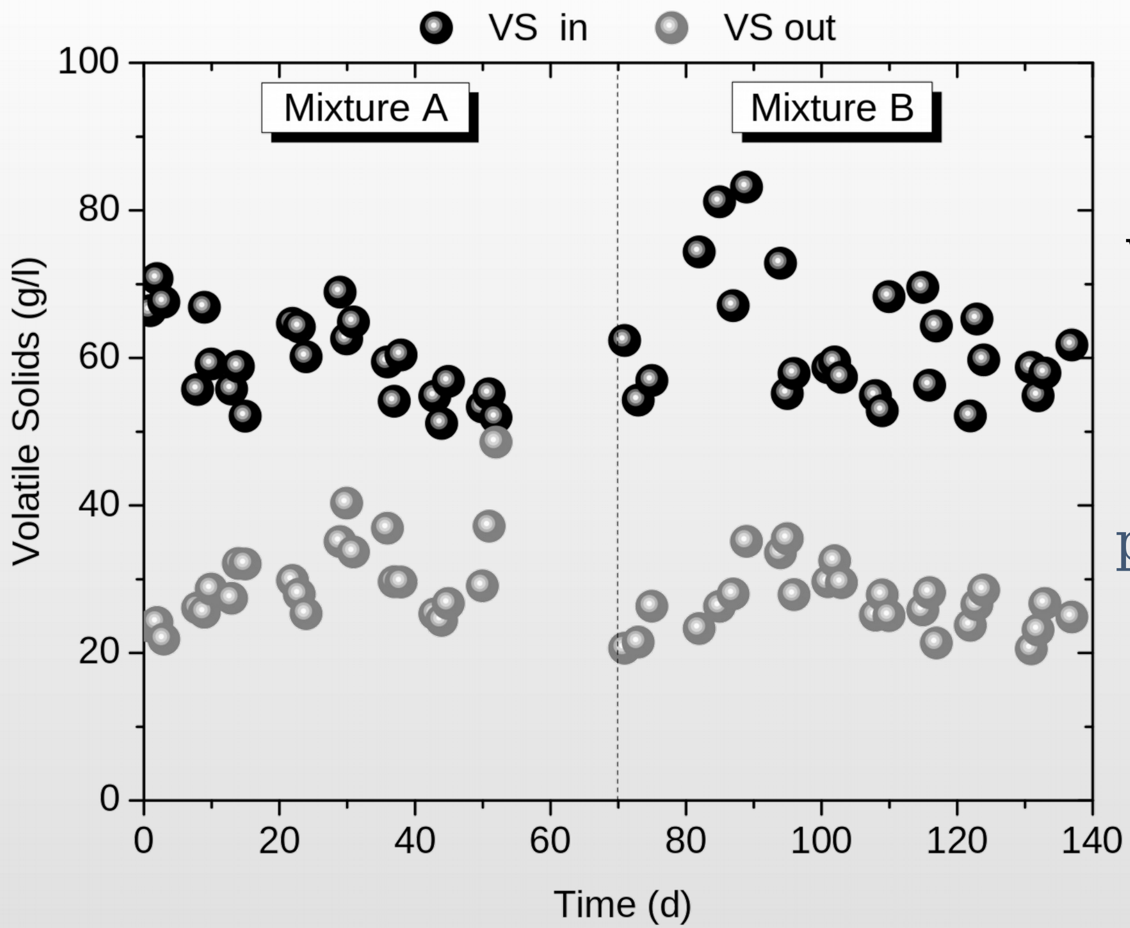
pH out 6.7 - 8.3

pH in 6.7 - 7.1

pH out 6.5 - 7.9

pH in 4.8 - 6.7

Results -VS



VS concentration was almost the same.

Mixture B presented a higher VS removal

A: 30 % OMW & 70 % PM & LPM → 50%
B: 40 % OMW & 60 % PM & CW → 57%

Conclusions

✓ Co-digestion of OMW, PM and CW is an attractive treatment option for these wastes, because manure improves the buffer capacity of the mixture and a high methane yield can be achieved

✓ Co-digestion of 40 % v/v OMW and 60 % PM and CW increased biogas production from 0.7 ± 0.4 $L/L_{reactor}/d$ to 1.2 ± 0.3 $L/L_{reactor}/d$

→ meaning that the increase of OMW and CW co-digestion improved biogas production by 1.7 times

Laboratory of Natural Resources, Management & Agricultural Engineering
Hellenic Mediterranean University, Greece