



ΔΗΜΟΚΡΙΤΕΙΟ
ΠΑΝΕΠΙΣΤΗΜΙΟ
ΘΡΑΚΗΣ

DEMOCRITUS
UNIVERSITY
OF THRACE

Comparison of a CSTR and a cascade of CSTR-PFR for anaerobic digestion of diluted poultry manure

A. Eftaxias, V. Diamantis and A. Aivasidis

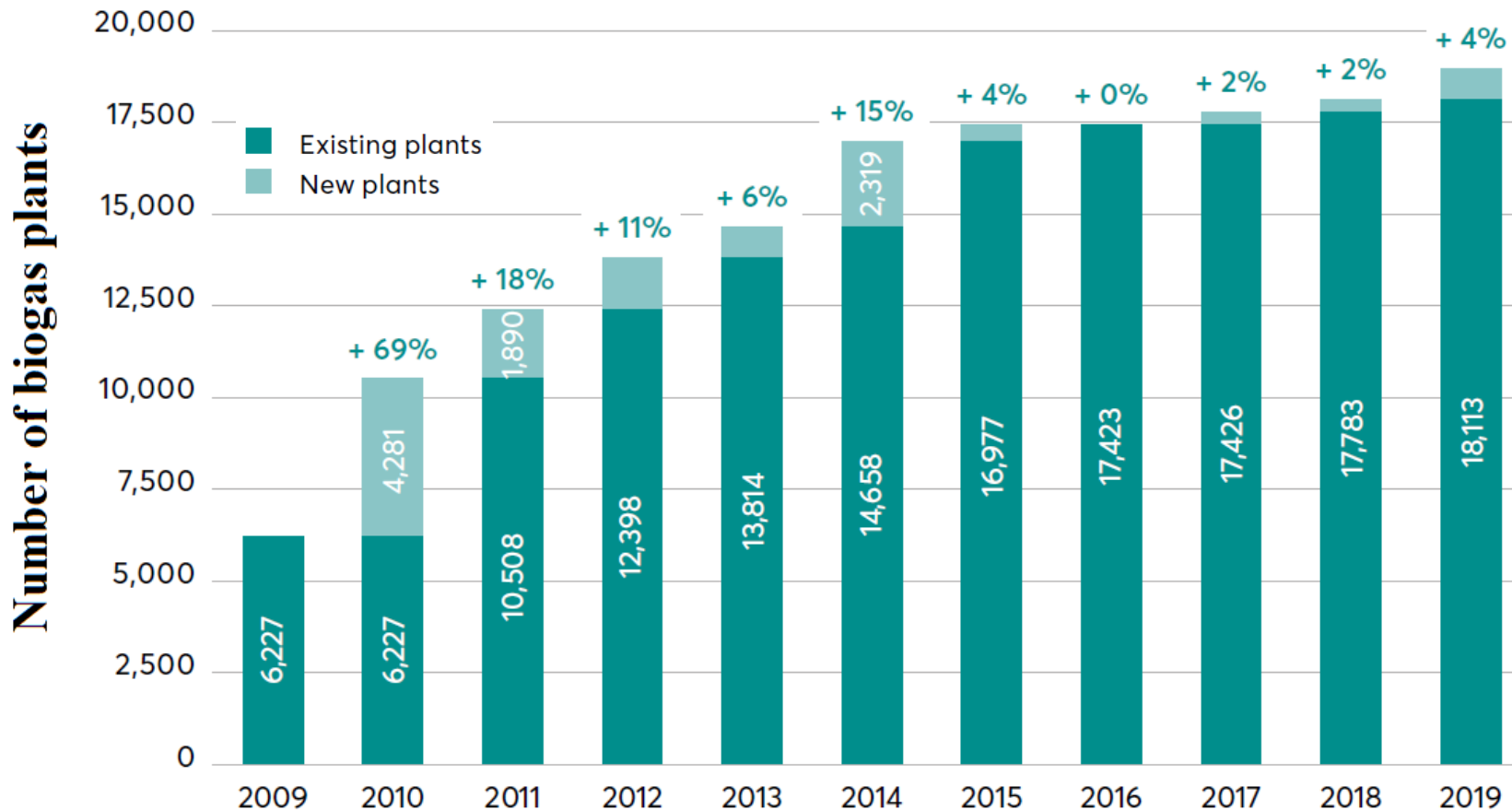


Ευρωπαϊκή Ένωση
Ευρωπαϊκό Ταμείο
Περιφερειακής Ανάπτυξης

Με τη συγχρηματοδότηση της Ελλάδας και της Ευρωπαϊκής Ένωσης



Biogas plants in European Union



- Annual biogas production
- Currently:
- 18 bil m³ CH₄ (~ **18 Mtoe**)
- EU Methane strategy:
- **54 – 72 Mtoe** in 2050

Πηγή: EBA Statistical Report 2020 (<https://www.europeanbiogas.eu/>)

Project objectives

Research and development:

- High-rate anaerobic reactor for agro-industrial wastewater treatment and biogas production.
- Digestate upgrade by lime clarification followed by ammonia stripping and recovery.
- Biogas upgrade by neutralization with caustic stripper effluent.
- Low-cost technology for small and medium agro-industrial and agricultural enterprises.



Ευρωπαϊκή Ένωση
Ευρωπαϊκό Ταμείο
Περιφερειακής Ανάπτυξης

ΕΠΑνεΚ 2014-2020
ΕΠΙΧΕΙΡΗΣΙΑΚΟ ΠΡΟΓΡΑΜΜΑ
ΑΝΤΑΓΩΝΙΣΤΙΚΟΤΗΤΑ
ΕΠΙΧΕΙΡΗΜΑΤΙΚΟΤΗΤΑ
ΚΑΙΝΟΤΟΜΙΑ



ανάπτυξη - εργασία - αλληλεγγύη

Με τη συγχρηματοδότηση της Ελλάδας και της Ευρωπαϊκής Ένωσης

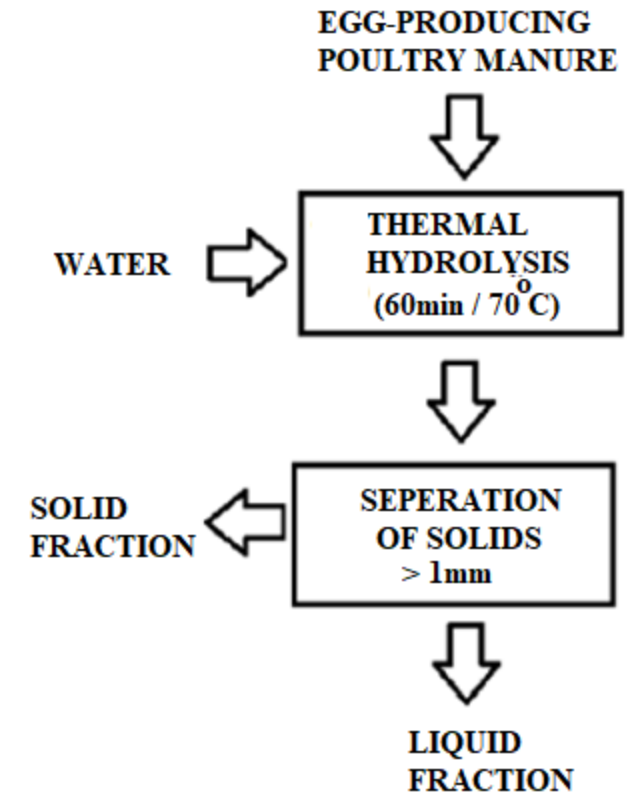
Anaerobic digestion of poultry manure

- Large number of poultry breeding enterprises
- Limited penetration of AD technologies
- High CAPEX for small and medium SMEs
- Social awareness, legislation, incentives

	Poultry breeding (Greece)
Number of enterprises	1866
Number of workers	3840
Annual turnover (mil €)	528

Anaerobic digestion of poultry manure

- High organic matter content
- Ligno-cellulosic bedding material having low degradability
- High protein content leading to ammonia formation
- High salinity
- Pathogen content (salmonella and other)



Aim of this study

- Compare process performance of a CSTR and a CSTR-PFR cascade treating diluted poultry manure at similar organic loading rate
- Treatment of poultry manure alone and in co-digestion with other substrates (cheese whey, glycerol, lipids)
- Evaluate the effect of salinity and ammonia build-up on process performance

Materials and methods

Wastewater composition

- Mixture was performed twice per week

Period	Mixture (% v/v)
Period I (days 1-90)	Diluted poultry manure (100%)
Period II (days 90-140)	Diluted poultry manure (79.5%) Cheese whey (20%) Glycerol (0.5%)
Period III (days 140-190)	Diluted poultry manure (99%) Used cooking oil (1%)

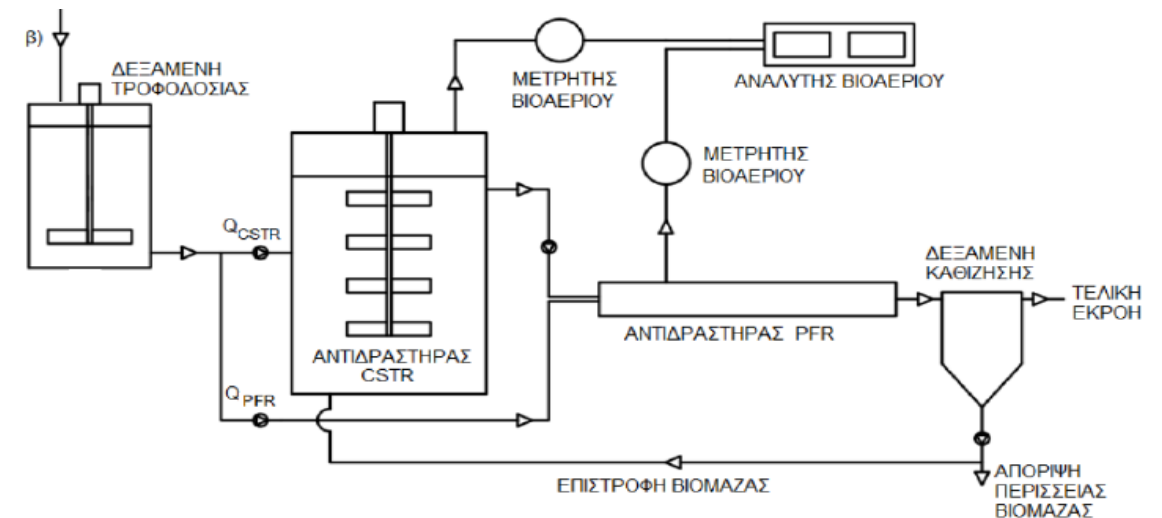
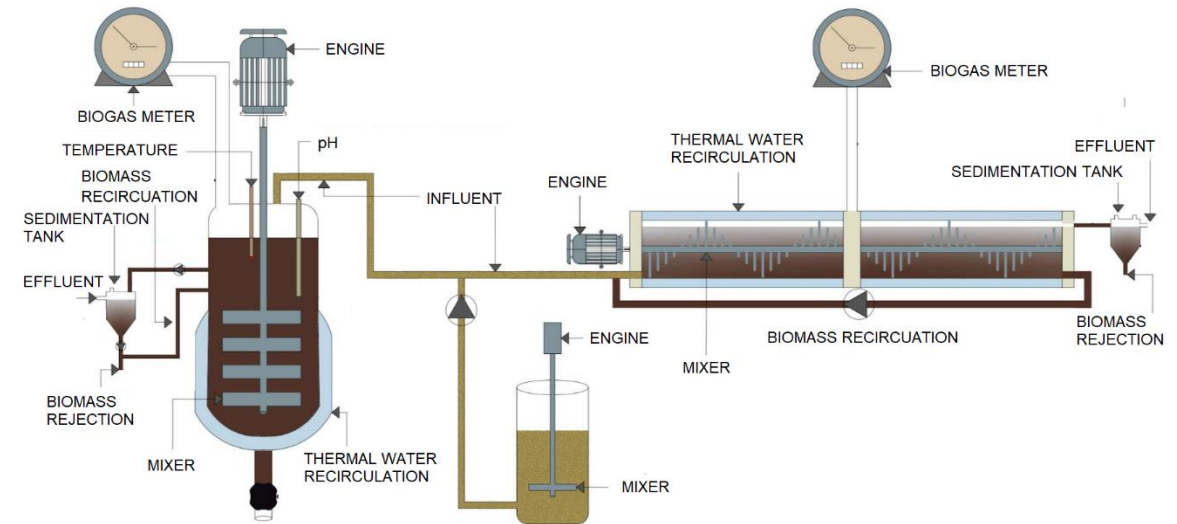
Materials and methods

- **Wastewater physicochemical properties**

Parameter	Period I (DPM)	Period II (DPM+CW+GL)	Period II (DPM+FOG)
pH	6.82 (0.43)	6.69 (0.37)	6.78 (0.52)
EC (mS/cm)	20.6 (1.7)	20.5 (1.9)	18.0 (1.0)
TCOD (g/L)	65.6 (12.6)	71.3 (2.8)	66.9 (11.9)
SCOD (g/L)	25.2 (9.3)	41.2 (12.1)	32.8 (2.7)
TSS (g/L)	27.6 (11.1)	28.1 (4.4)	20.9 (7.1)
VSS (g/L)	23.5 (12.1)	18.3	18.3 (4.9)
NH ₄ -N (g/L)	2.56 (0.64)	Nd	2.18
TKN (g/L)	4.74 (0.72)	Nd	4.06
FOG (g/L)	3.9 (0.1)	nd	10 (3)

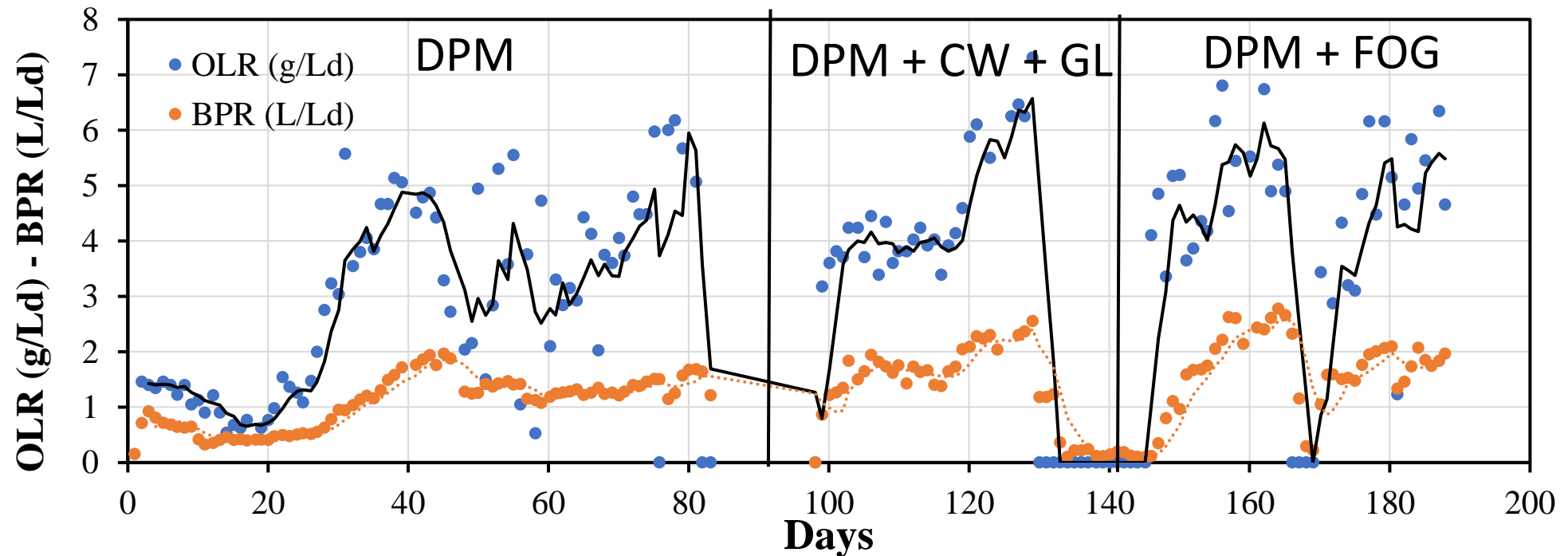
Materials and methods

- **Anaerobic digester design**
- Working volume = 40 L + 20 L
- Temperature = 36 ± 1 °C
- Sludge recycle = $20\% * Q_{in}$
- Process monitoring:
 - COD removal efficiency
 - Biogas production rate
 - Methane yield
 - VFA accumulation



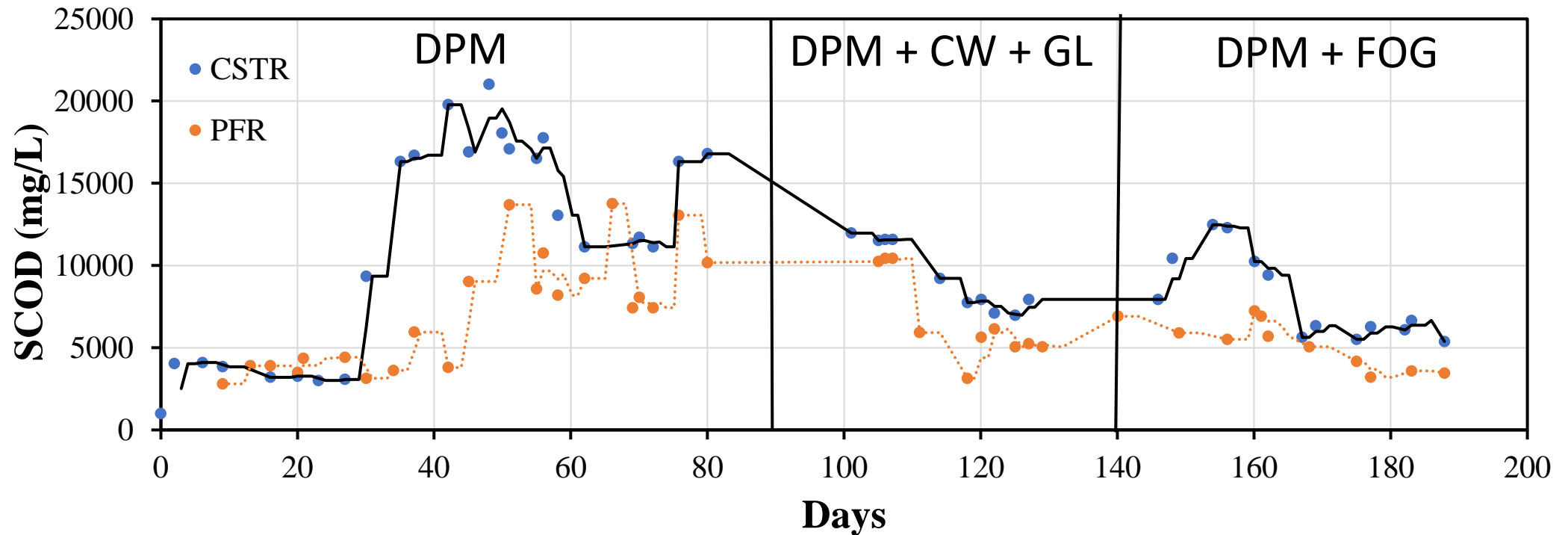
Results – Organic loading and biogas production rate

- Variation of the organic loading rate (OLR) and biogas production rate (BPR) during the study period



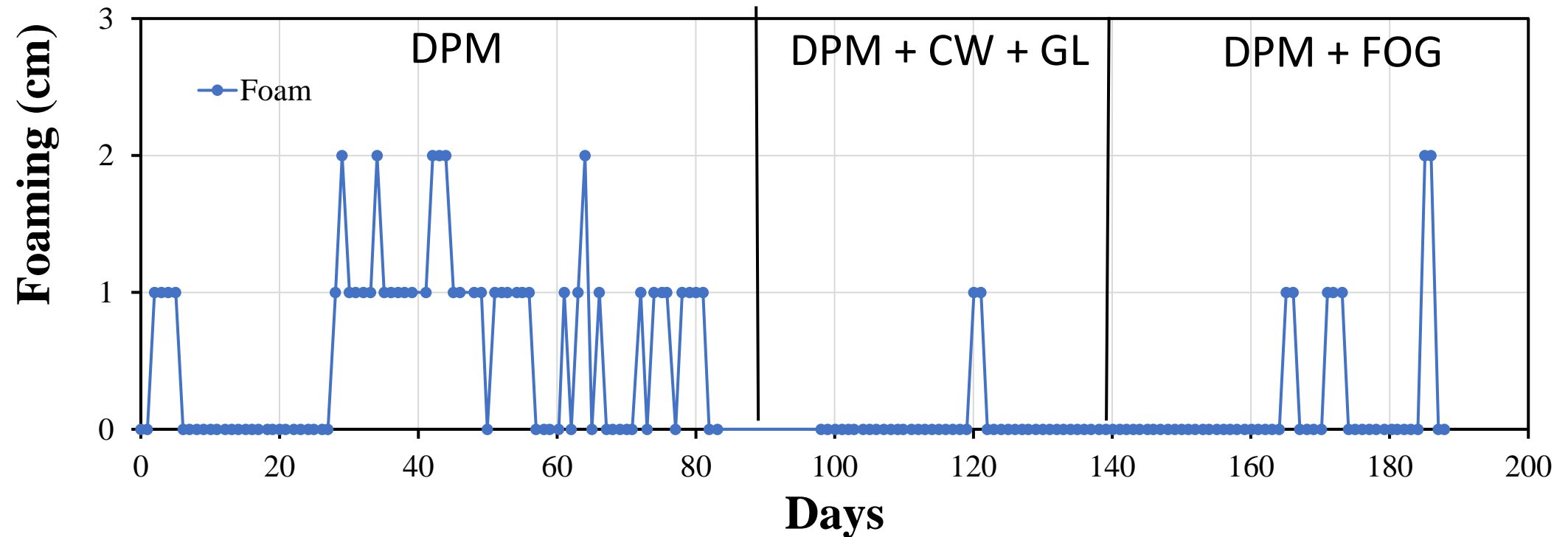
Results – supernatant COD

- Supernatant COD remained around 5 g/L at the reactor effluent



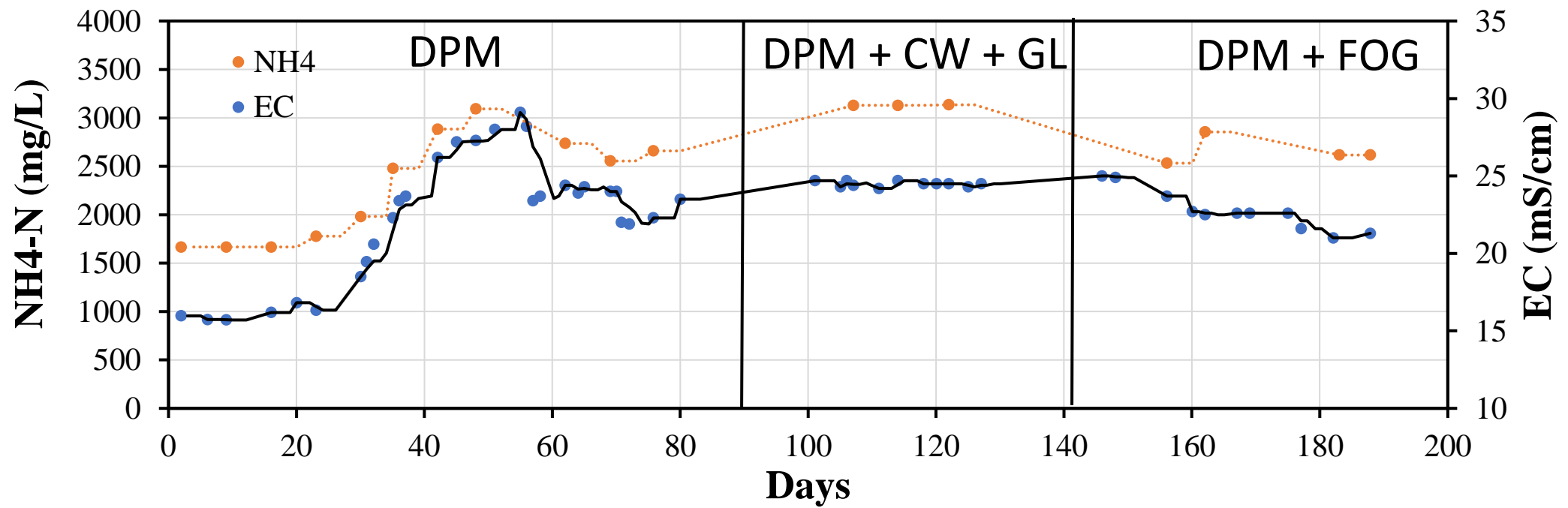
Results - Foaming

- Foaming was recorded during reactor operation with poultry manure alone



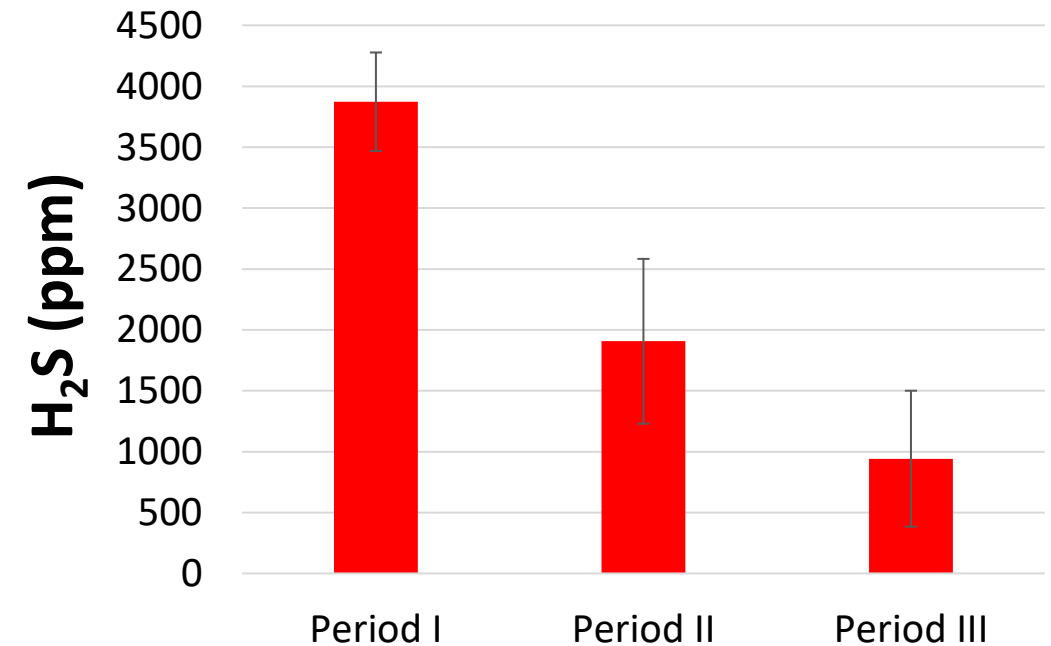
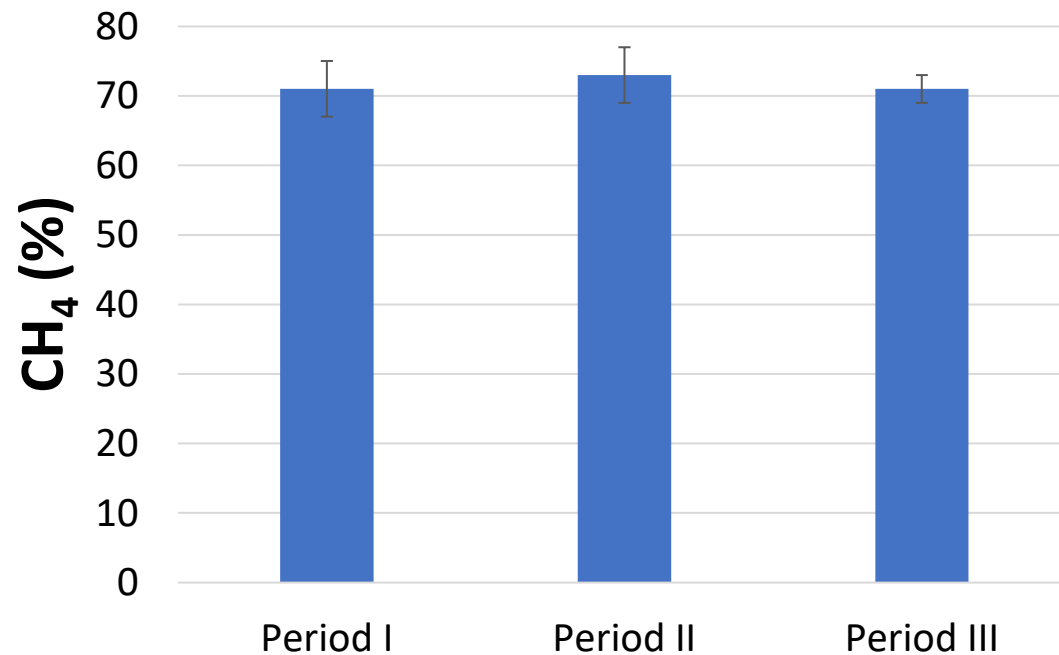
Results – Ammonia and salinity

- Ammonia remained between 2.5-3.1 g/L during the study
- Salinity remained between 20-30 mS/cm during the study



Results - Biogas composition

- Biogas methane content remained constant during the study
- Hydrogen sulfide decreased with co-digestion



Conclusions

- Anaerobic digestion of poultry manure can result in salinity and ammonia buildup which significantly deteriorates process performance.
- Anaerobic co-digestion of poultry manure with cheese whey and used cooking oil is of interest to alleviate problems associated with salinity buildup.
- Penetration of anaerobic digestion technologies to small and medium agro-food enterprises is more than necessary.
- We need new technologies and business models, combined with financial incentives, legislation and social awareness measures.

Acknowledgements



Alexandros Aivasidis Vasileios Diamantis Alexandros Eftaxias Alexandra Koumara Christos Michailidis Maria Dolores Koskinari



ΕΠΑνεΚ 2014-2020
ΕΠΙΧΕΙΡΗΣΙΑΚΟ ΠΡΟΓΡΑΜΜΑ
ΑΝΤΑΓΩΝΙΣΤΙΚΟΤΗΤΑ
ΕΠΙΧΕΙΡΗΜΑΤΙΚΟΤΗΤΑ
ΚΑΙΝΟΤΟΜΙΑ



Με τη συγχρηματοδότηση της Ελλάδας και της Ευρωπαϊκής Ένωσης