

10<sup>th</sup> International Conference on Sustainable Solid Waste Management Chania, Greece,  
21 - 24 JUNE 2023

# Investigation of the effect of different packing materials on biogas upgrading

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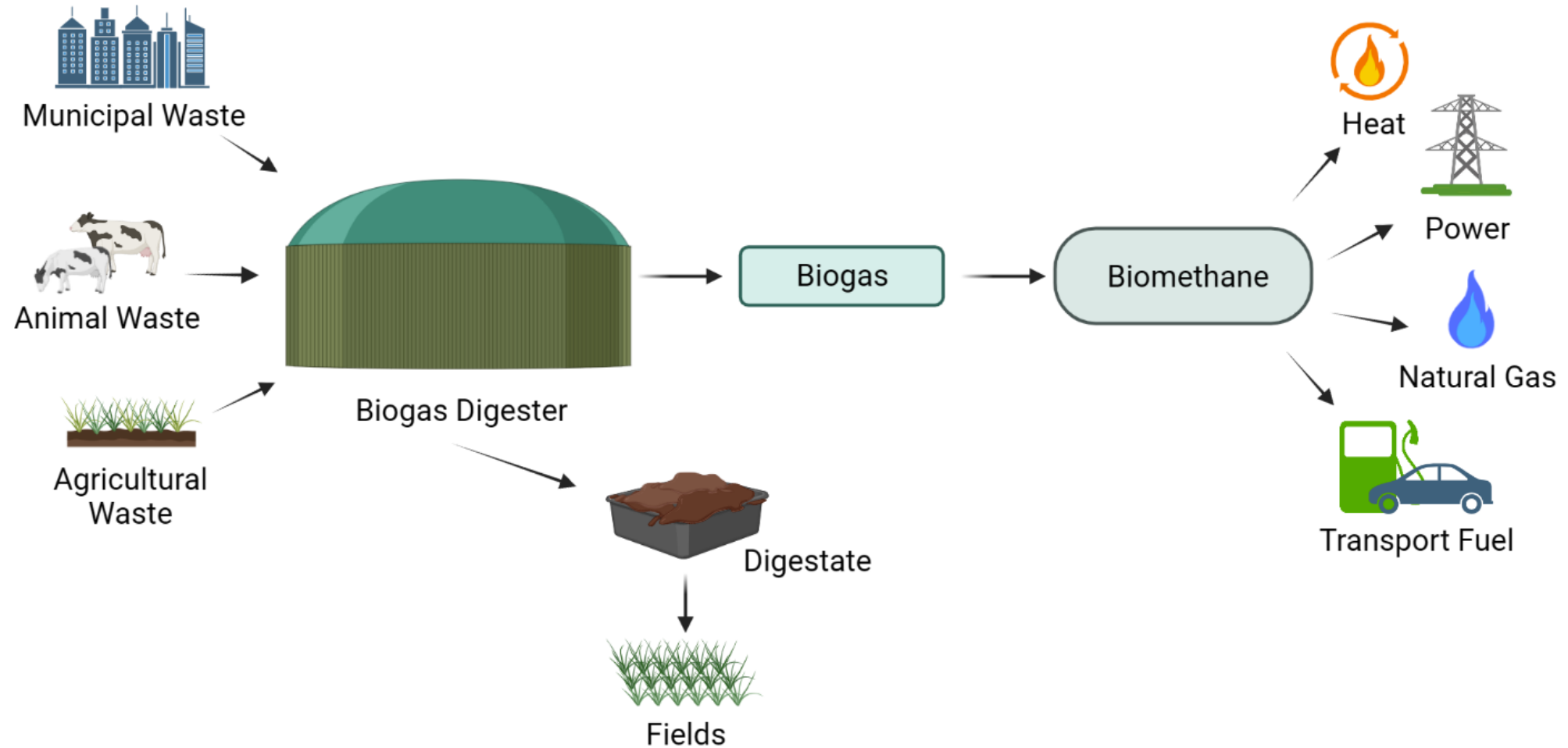


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Thermi-Thessaloniki, GR

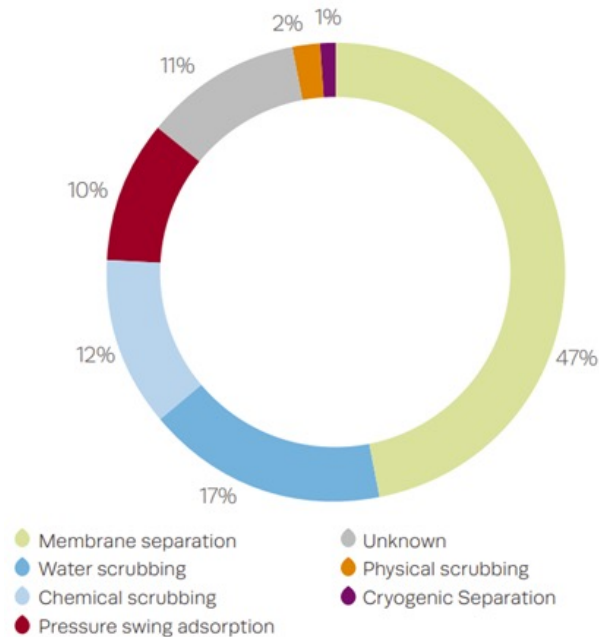
# Biogas Upgrading



**Figure 1.** Schematic overview of the biogas upgrading process

# Upgrading technologies for biomethane production

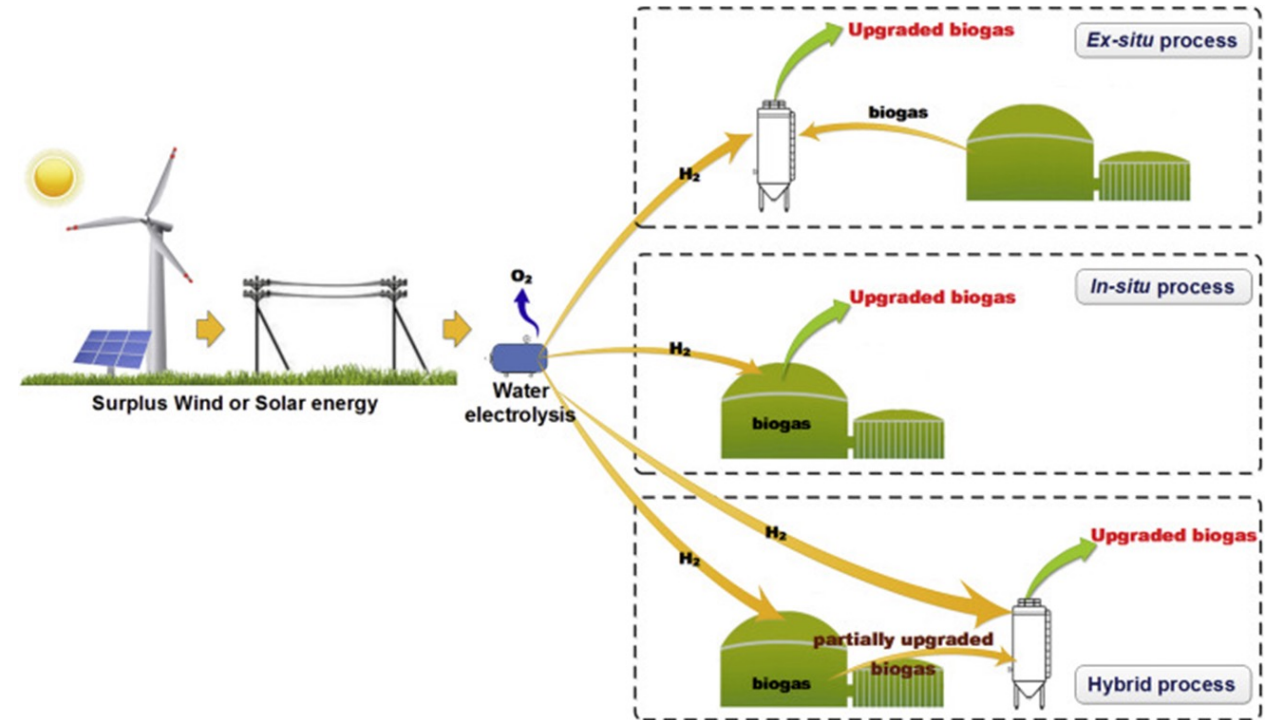
## Physical and Chemical Technologies



EBA-Statistical Report 2022

**Figure 2.** Relative use of different upgrading technologies in Europe in 2021

## Biological Technologies

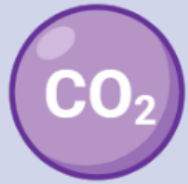


Aggelidaki et al., 2018

**Figure 3.** In-situ, ex-situ and hybrid biological biogas upgrading technologies based on hydrogen methanation.

# Biological Methanation

## CCUS Technology



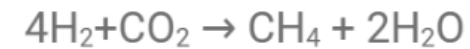
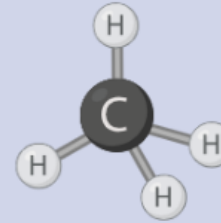
Carbon Capture, Utilization, and Storage

## Renewable Energy Sources



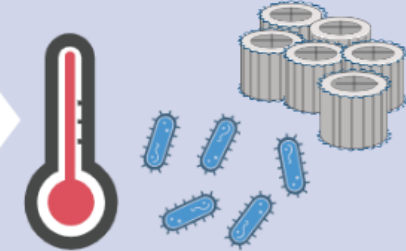
Synergy with renewable energy sources (green hydrogen)

## Biomethanation Reaction



$$\Delta G^\circ = -130.7 \text{ KJ/mol}$$

## Method



Biological process (30-50°C, hydrogenotrophic microorganisms, packing materials)

# Biofilm and Packing Materials

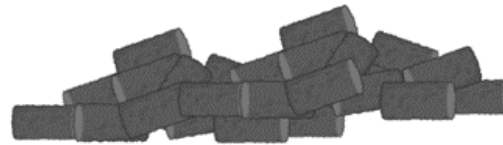
## Biofilm

- microbial communities
- attached to a surface
- extracellular polymeric substance

✓ immobilisation of hydrogenotrophic methanogenesis on the surface of packaging materials



Raschig rings



Carbon pellets

## Packing Materials

### Categories :

- Organic
- Inorganic
- Mixed materials

### Characteristics :

- Adequate surface area
- Optimal particle size
- Non-toxic
- Reusable, economical

# Scope

This research focuses on finding the suitable packing material that contributes to the efficient biofilm formation and therefore leads to maximum metabolism of carbon dioxide.



Raschig Rings



Biochar



Carbon Pellets



Carbon Foam

# Materials and Method

1<sup>st</sup> step



Raschig Rings



Biochar



Carbon Pellets



Carbon Foam

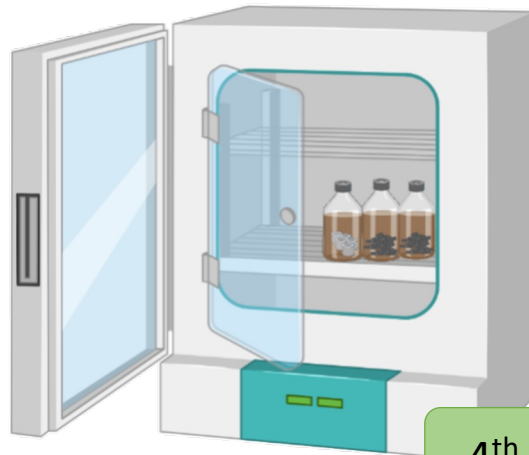
week 1  
week 2  
week 3  
week 4  
week 5

2<sup>nd</sup> step



H<sub>2</sub> : CO<sub>2</sub>  
4:1

3<sup>rd</sup> step

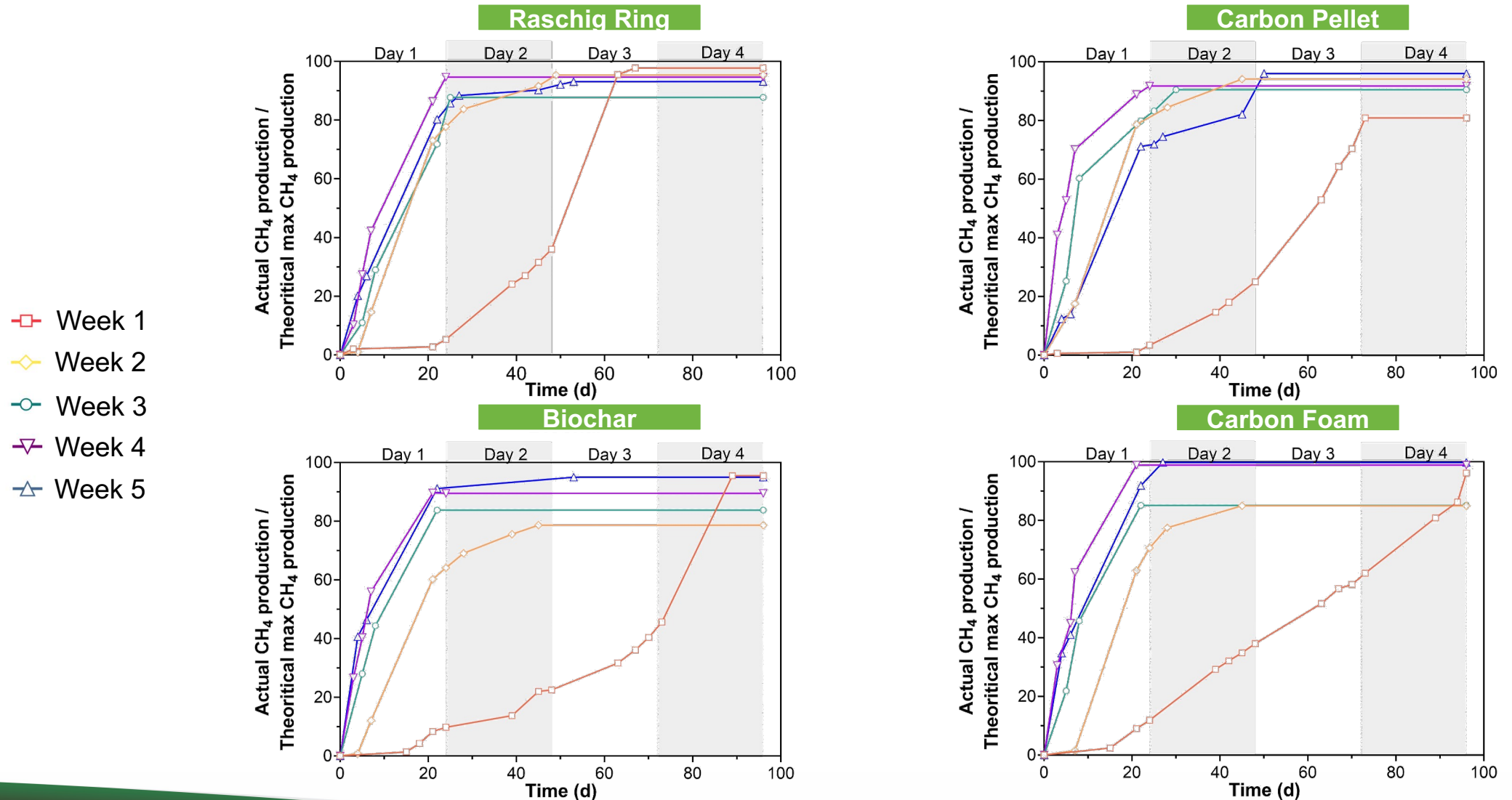


4<sup>th</sup> step

## Monitoring:

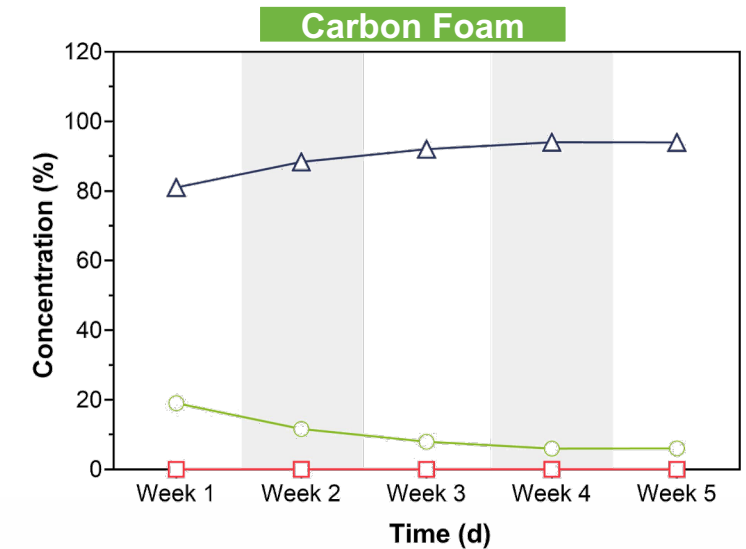
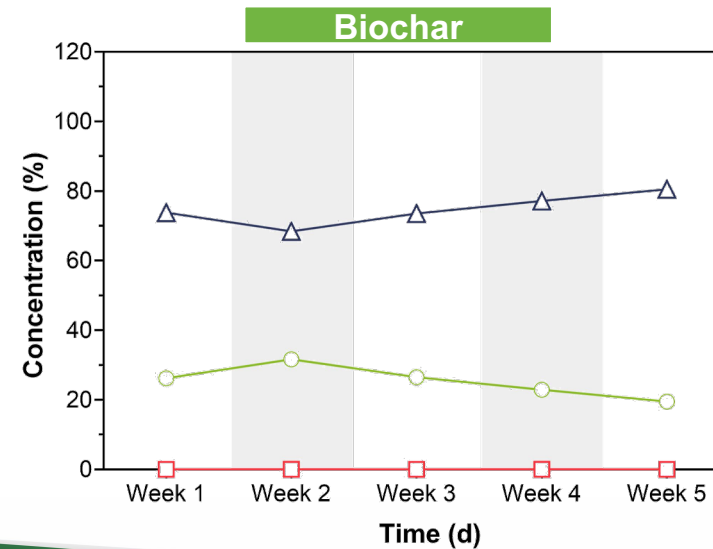
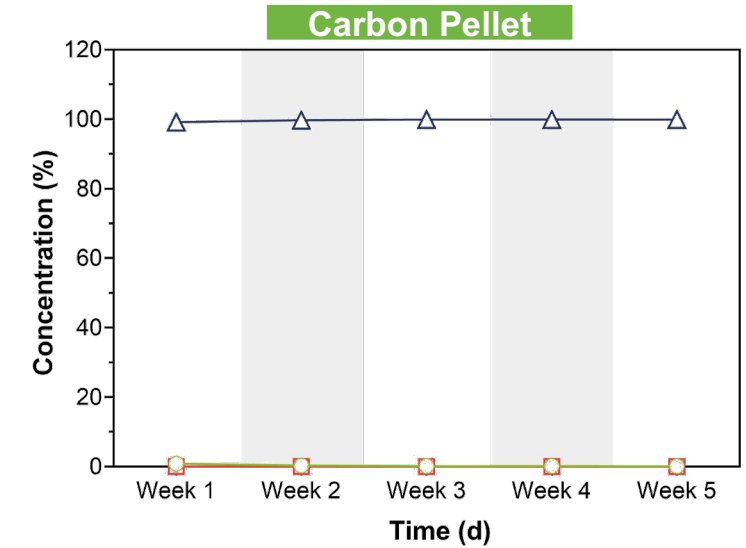
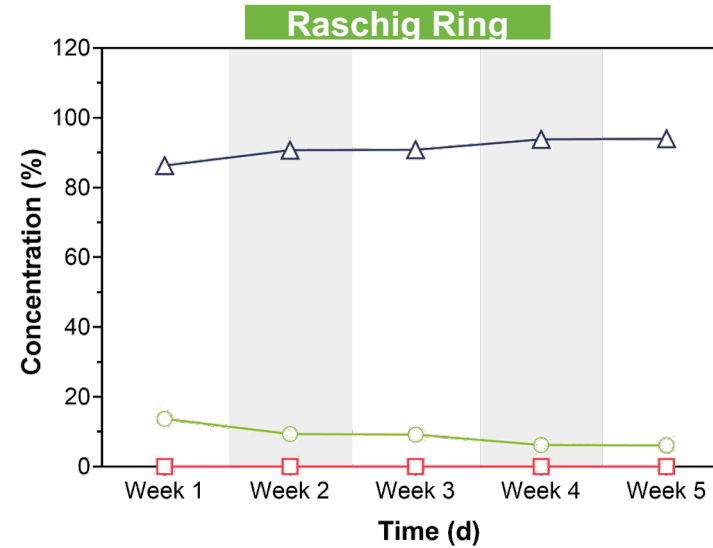
1. Pressure → Electronic manometer
2. Output gases → GC - TCD
3. Volatile Fatty Acids → GC - FID
4. Crystal Violet → Spectrophotometer

# Results and Discussion – CH<sub>4</sub> Production



# Results and Discussion – Output gases

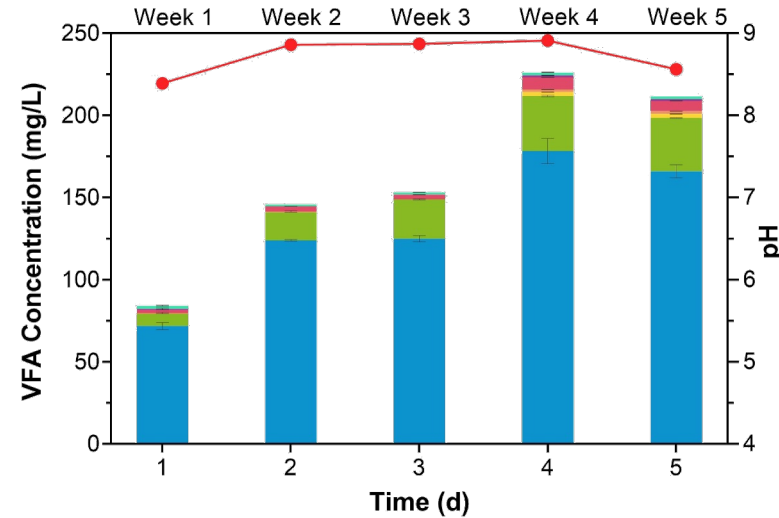
○  $\text{CO}_2$   
□  $\text{H}_2$   
△  $\text{CH}_4$



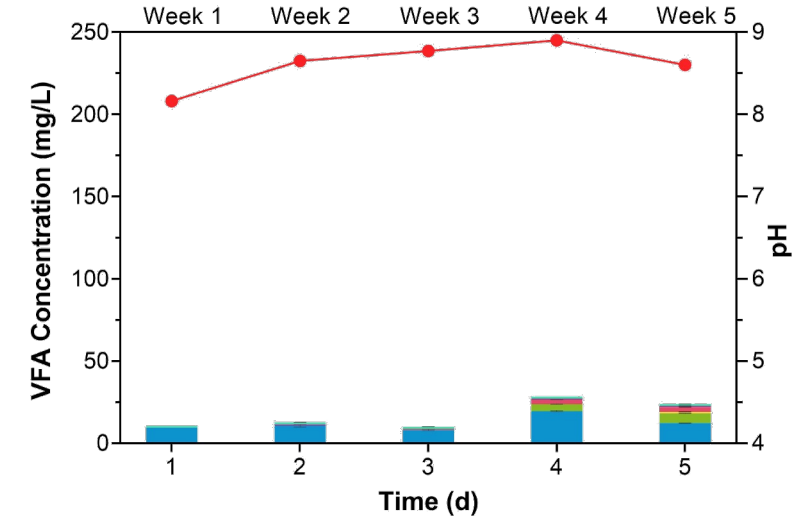
# Results and Discussion – Volatile Fatty Acids

- Acetic acid
- Isovaleric acid
- Propionic acid
- Valeric Acid
- Isobutyric acid
- Hexanoic acid
- Butyric acid
- pH

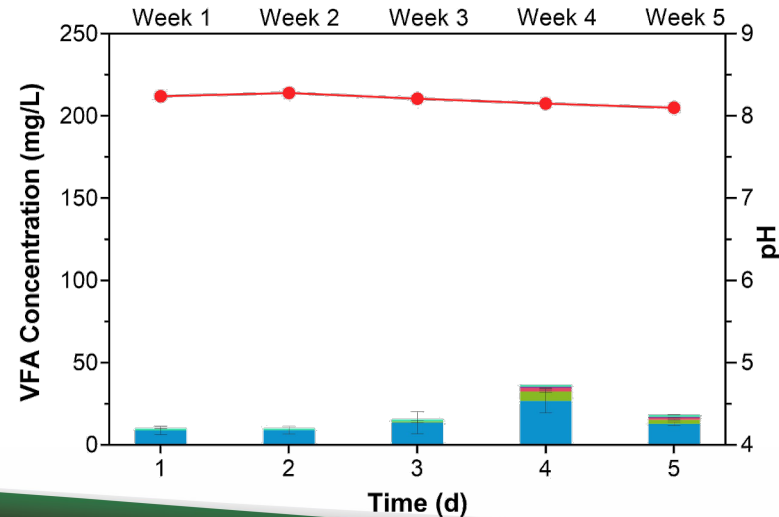
**Raschig Ring**



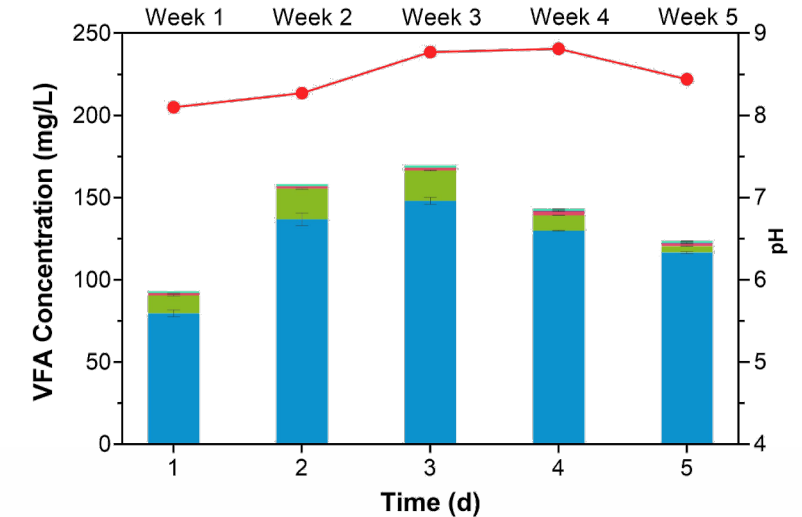
**Carbon Pellet**



**Biochar**



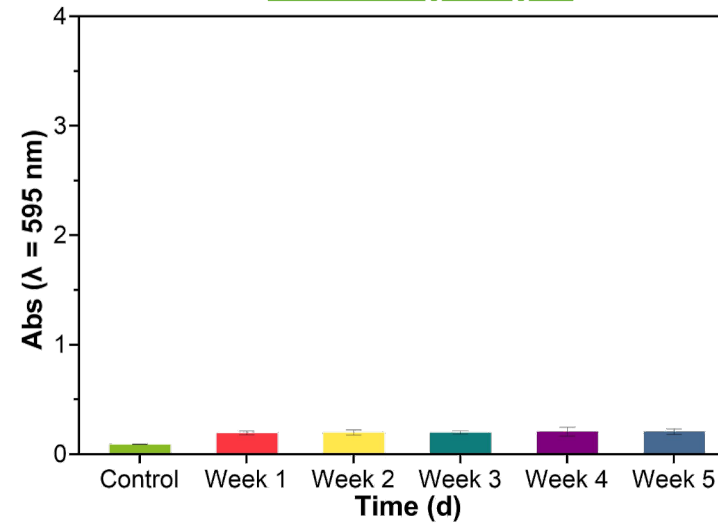
**Carbon Foam**



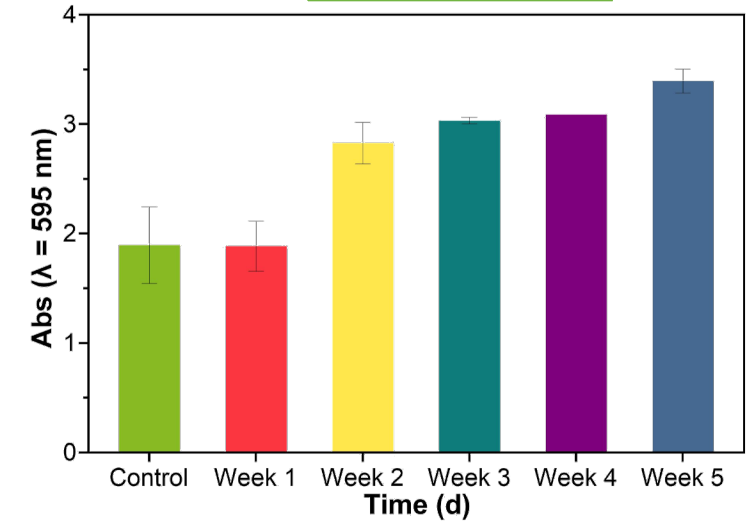
# Results and Discussion – Crystal Violet

- Control
- Week 1
- Week 2
- Week 3
- Week 4
- Week 5

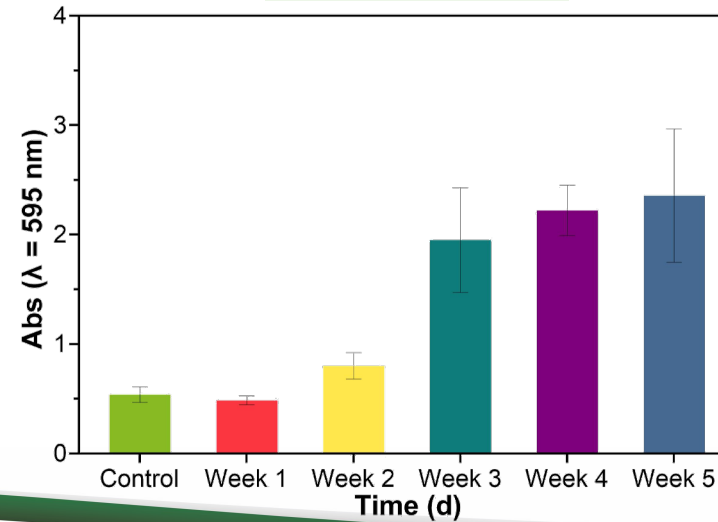
Raschiq Ring



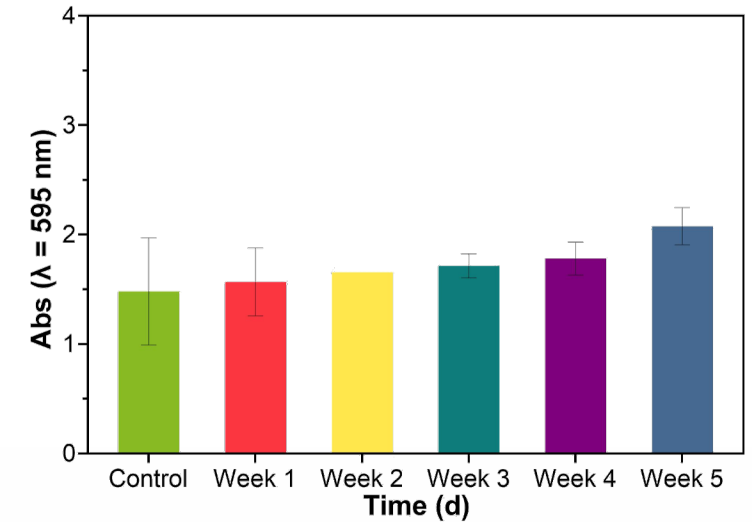
Carbon Pellet



Biochar



Carbon Foam



# Conclusions

## Rasching Ring :

- optimal CH<sub>4</sub> production in the 4<sup>th</sup> week
- low concentration of VFA
- rapid biofilm and stable formation

## Biochar :

- optimal CH<sub>4</sub> production in the 4<sup>th</sup> week
- low concentration of VFA
- **increasing trend in biofilm formation after the 3<sup>rd</sup> week**

## Carbon Pellet :

- optimal CH<sub>4</sub> production in the 4<sup>th</sup> week
- low concentration of VFA
- **stable increase on CH<sub>4</sub> composition 99%**
- CH<sub>4</sub> composition stable increase

## Carbon Foam :

- optimal CH<sub>4</sub> production in the 4<sup>th</sup> week
- low concentration of VFA
- gradual biofilm formation

# Acknowledgment

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The "Demonstration of a mobile unit for hybrid energy storage based on CO<sub>2</sub> capture and renewable energy sources (LIFE CO<sub>2</sub>toCH<sub>4</sub> - LIFE 20/CCM/GR/001642)" project has received funding from the LIFE Programme of the European Union.



**Thank you for your  
attention !!**

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