Using A New Anaerobic Digestion Configuration To Treat Hydrothermal Liquefaction Aqueous By-product

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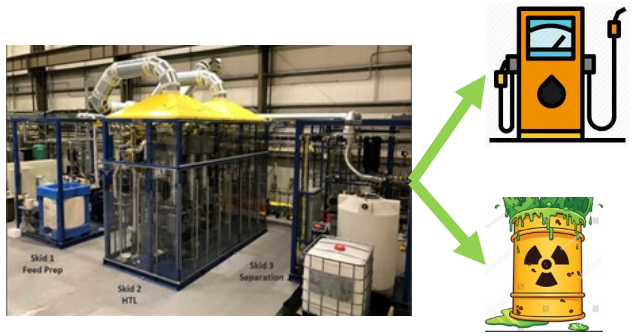
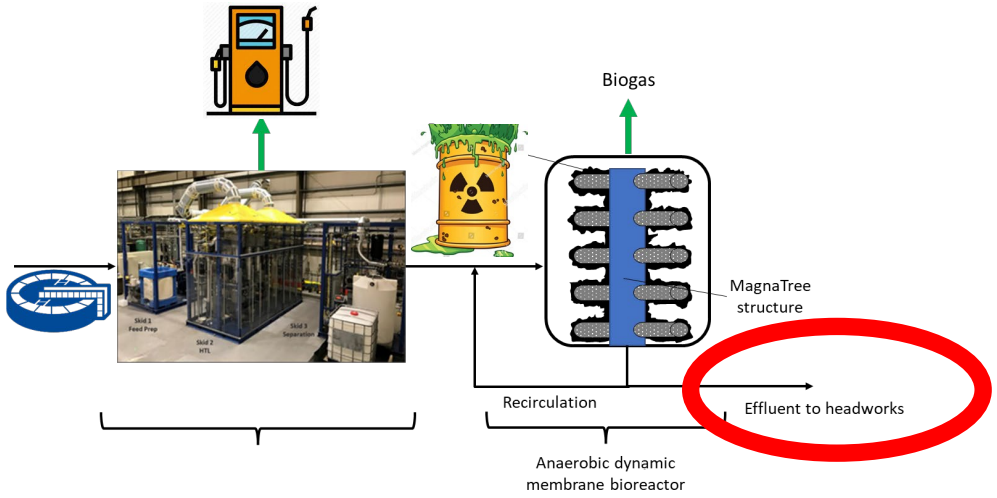
Anaerobic digestion can remove contaminants from HTL wastewater but we still need to know the risks



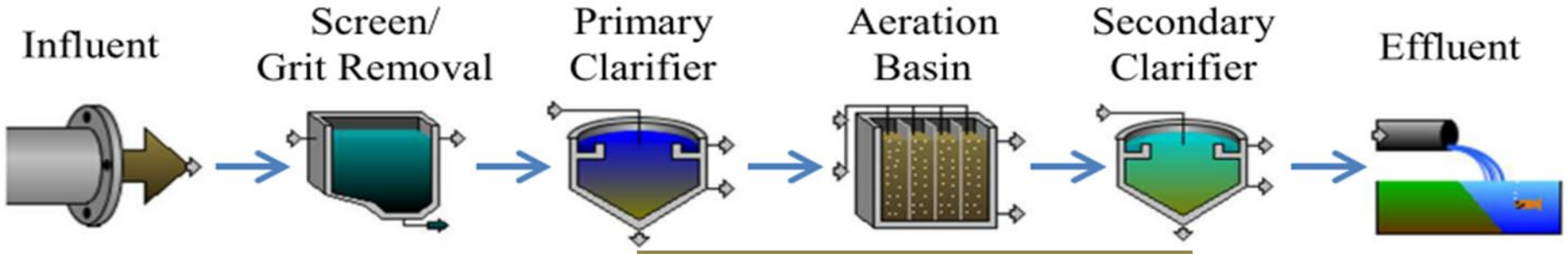
- **US utilities are looking at HTL, but challenges like the aqueous stream toxicity are hampering implementation**

- **Anaerobic biofilms can degrade some wastewater contaminants but co-digestion is needed**

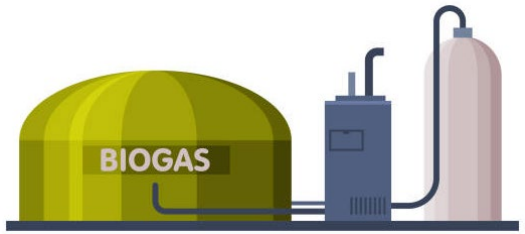


- **Future research: We want to the know the risks of the remaining contaminants**

Sludge management in the US present challenges



Sewage sludge



Anaerobic digestion
(40%)

Land application (52%)

Incineration (16%)

Landfill (22%)

Sludge management in the US present challenges

- Waste of resources
- Fugitive CH_4 emissions
- Increasing costs

Landfill (22%)

Anaerobic digestion
(40%, only 10% of the plants)

- Recovers biogas
- Only 50% volume reduction
- Big footprint
- Low density energy

- Reduces volume of sludge and remove PFAS (Winchell et al., 2024, Water Environment Research)
- High capital and operation costs
- Air emissions regulations

Incineration (16%)

- Changes in legislation due to emerging contamiants (Maine, US)
- Increasing costs

Land application (52%)

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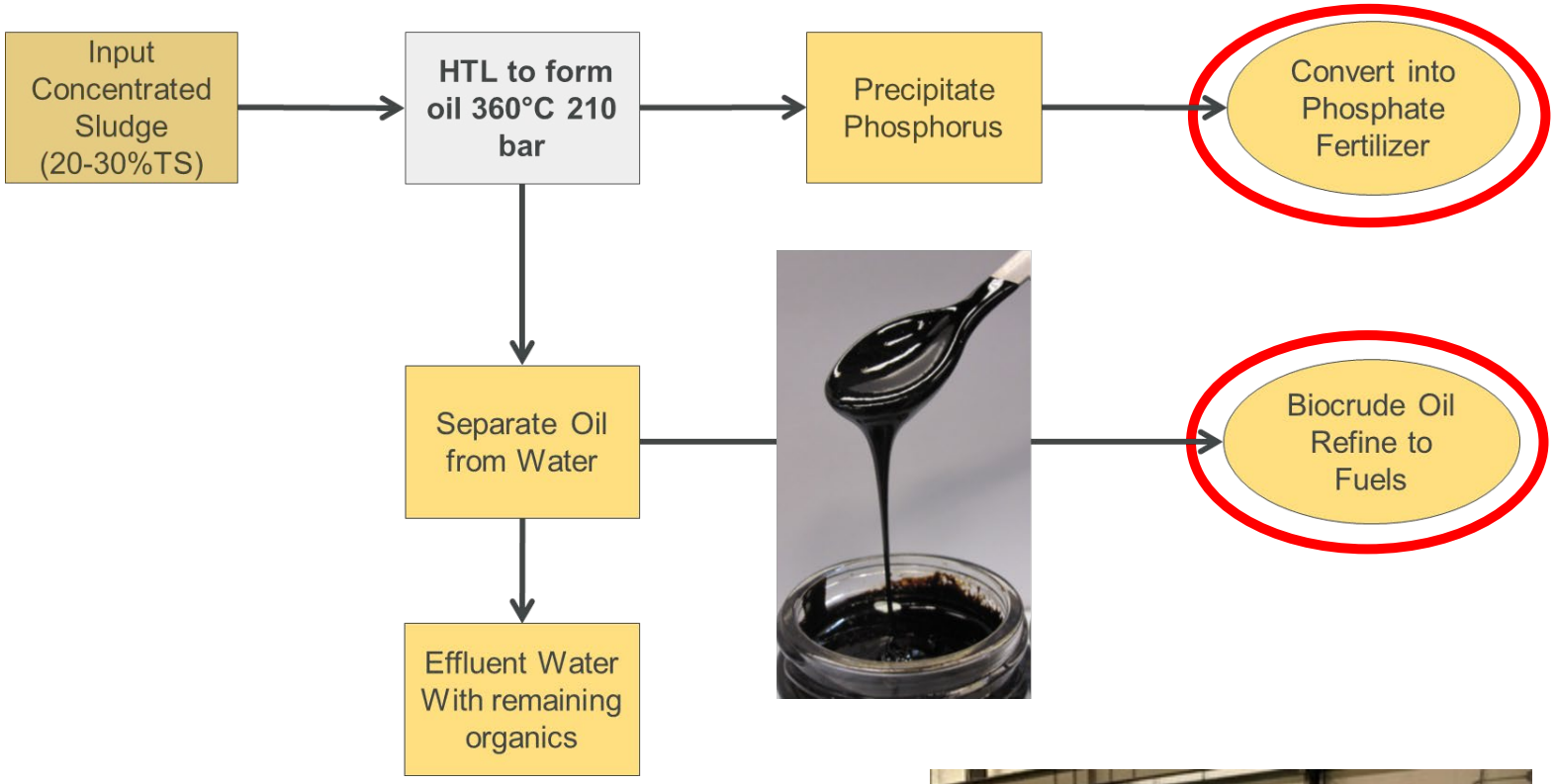
Research article

Municipal wastewater sludge as a sustainable bioresource in the United States

Timothy E. Seiple*, André M. Coleman, Richard L. Skaggs

Pacific Northwest National Laboratory, P.O. Box 999, Richland, WA, 99352, USA

Hydrothermal liquefaction has the potential to advance resource recovery in the US



- Sludge is converted into biocrude, a petroleum-like liquid and P is captured separately
- Retention time of 30-60 min (low footprint, good for small utilities)
- Potential to destroy emerging contaminants

Minimum fuel selling price: **2.85 $/GGE**

Snowden-Swan,…, **Fonoll** et al., 2022.

Feasibility study to implement HTL in Detroit WWTP: Fundamental and applied research

Transportation fuel

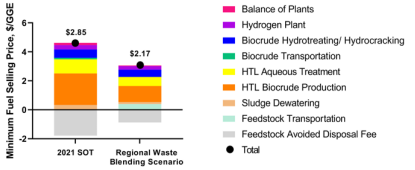
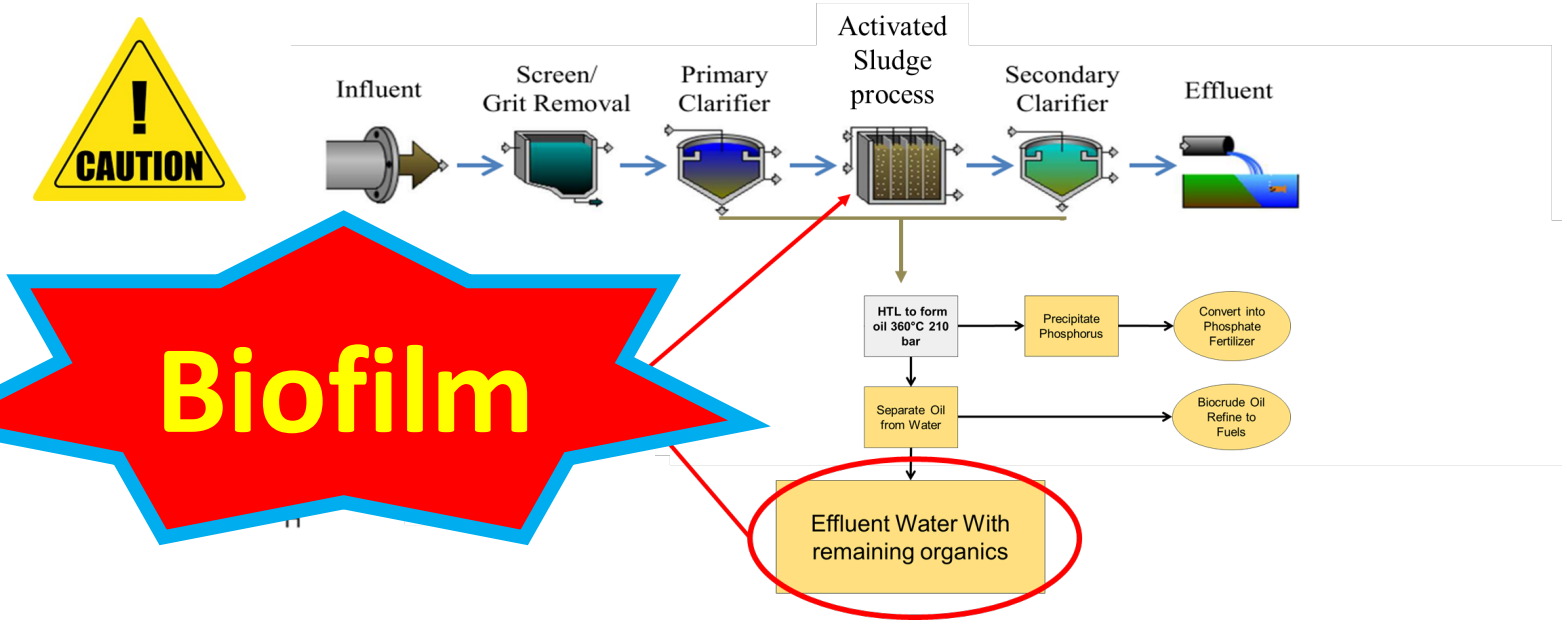


Figure 17. MFSP and cost allocation of regional waste blending case compared to the 2021 SOT.

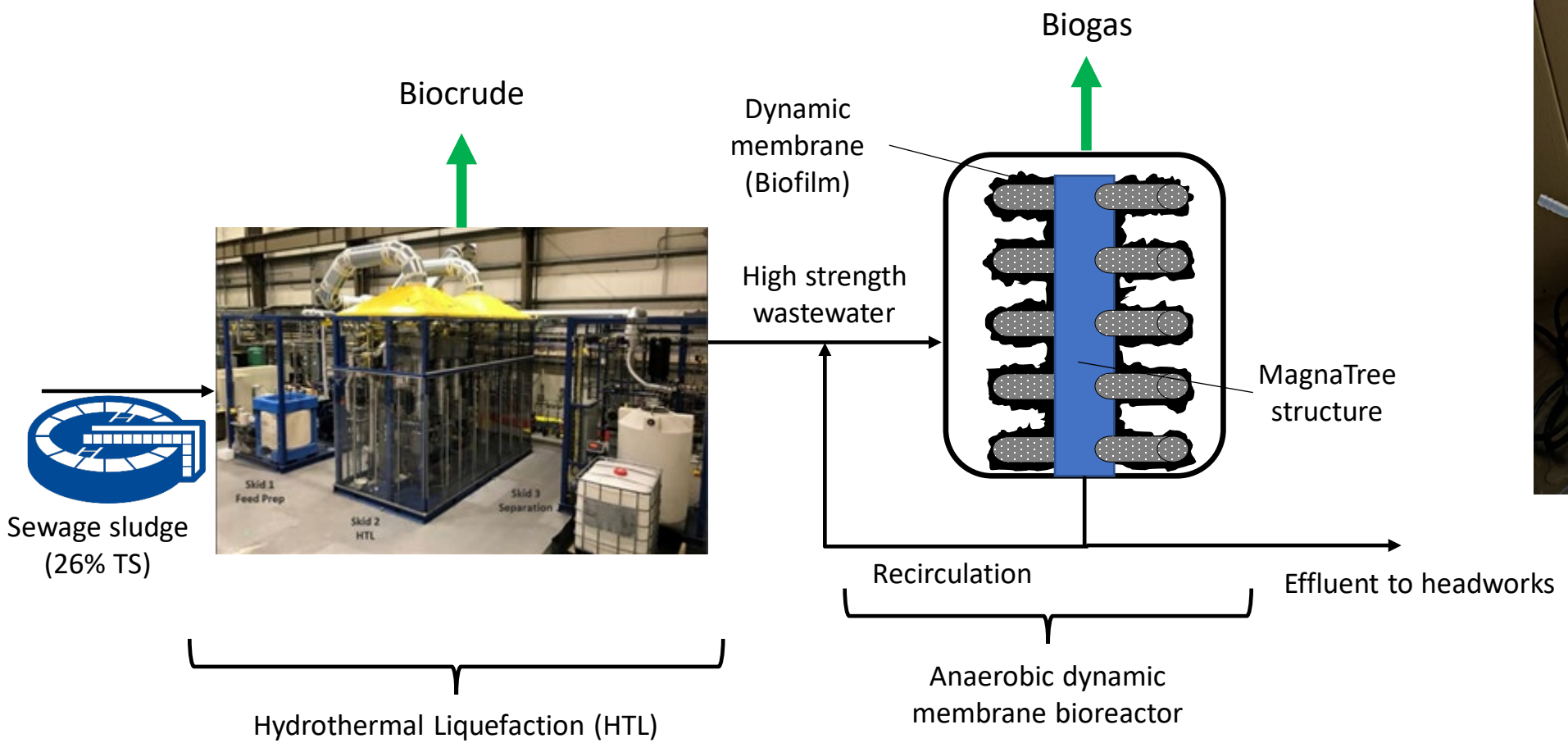
- Operational Challenges
- Aqueous by-product

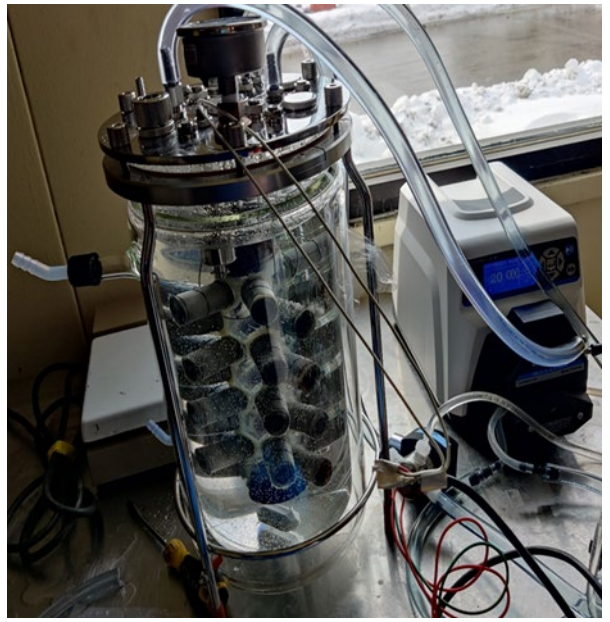
HTL generates an aqueous by-product that could be inhibitory for WWTP processes



- Zhu et al. 2023, Chemical Engineering Journal
- Usman et al. 2019, Environment International

We used a new anaerobic membrane bioreactor to promote biofilm formation



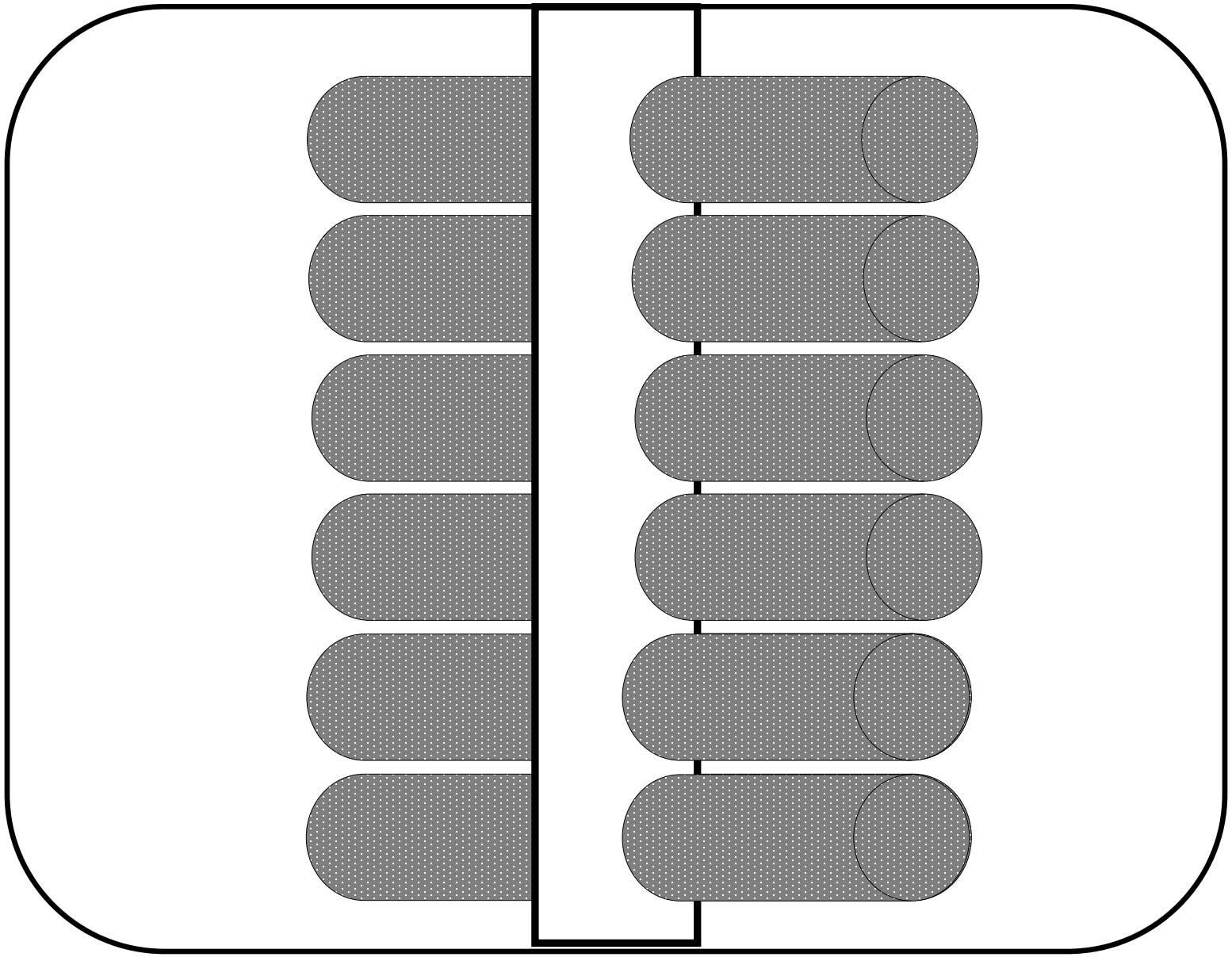


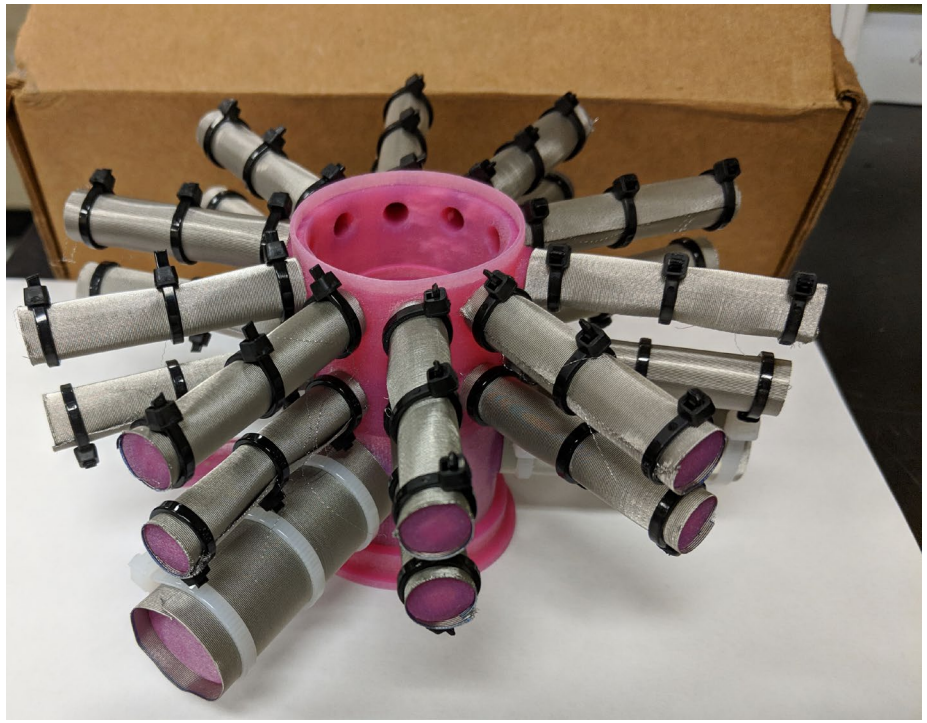
Recirculating Anaerobic Dynamic Membrane Bioreactor Treatment of Municipal Wastewater

Timothy Fairley-Wax, Lutgarde Raskin, and Steven J. Skerlos*

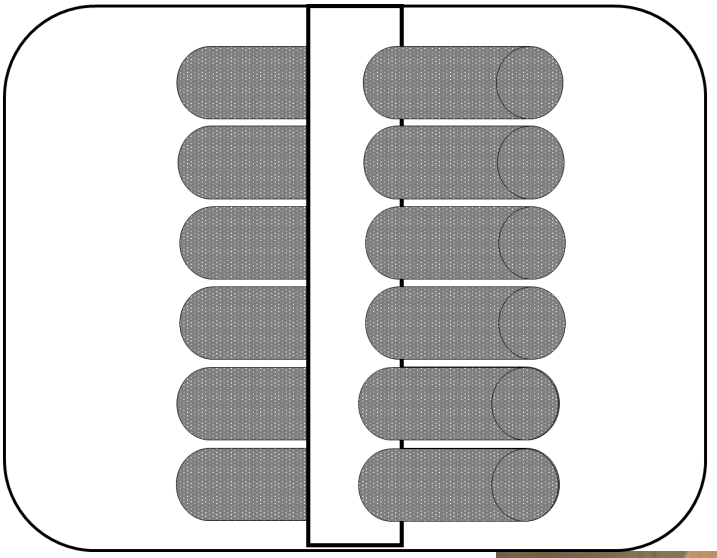
Goal: Reduce COD load at a hydraulic retention time (HRT) < 7 days (low footprint).

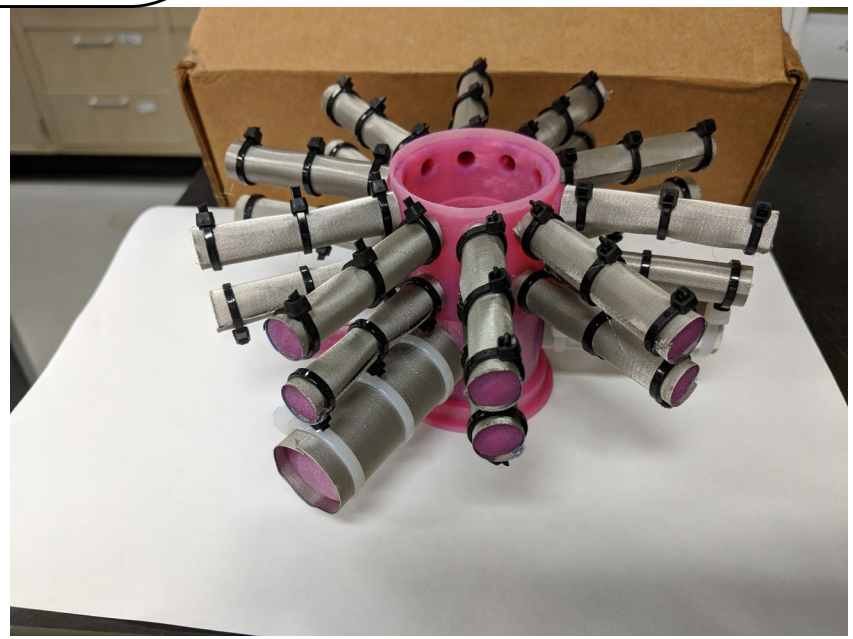
THE TREE STRUCTURE INSIDE OF THE BIOREACTOR IS HOLLOW



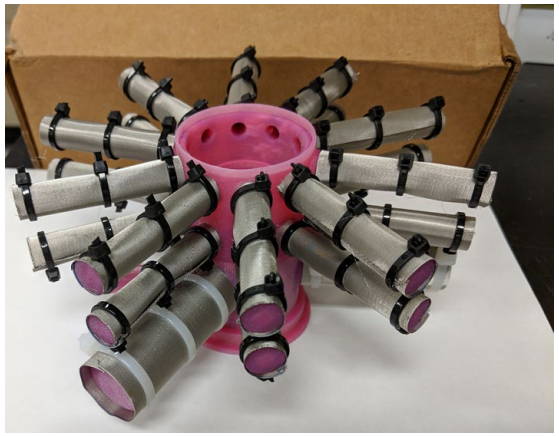


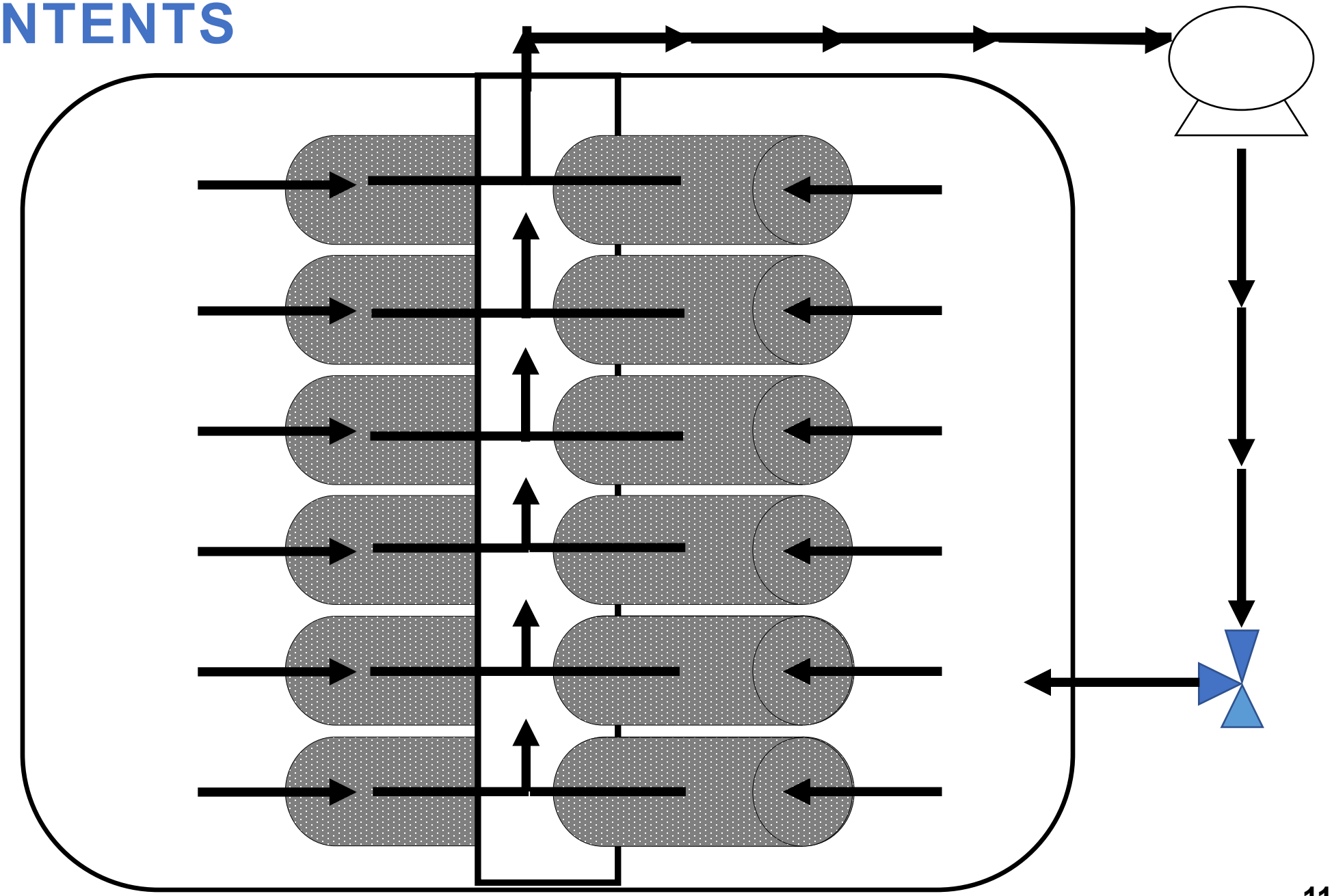
THE BRANCHES OF THE TREE ARE SURROUNDED BY A 25 MM PORE SIZE MESH WHERE BIOFILM WILL GROW



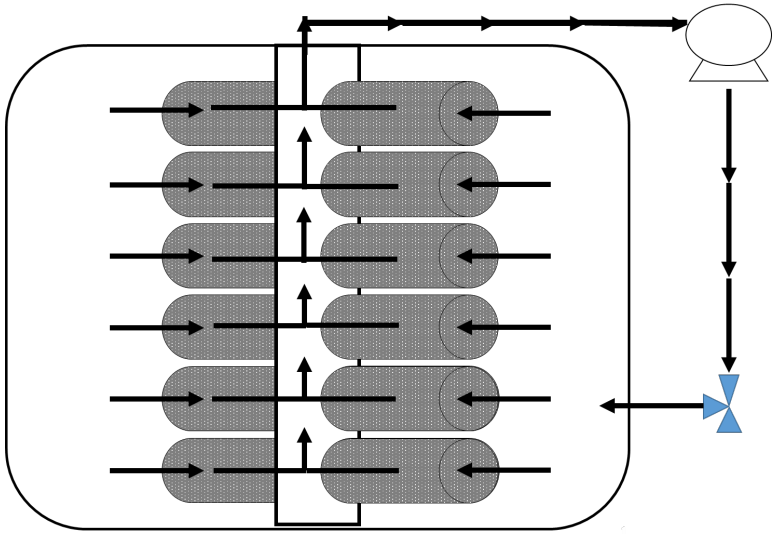


BIOFILM GROWTH IS ENHANCED BY RECIRCULATING THE REACTOR CONTENTS

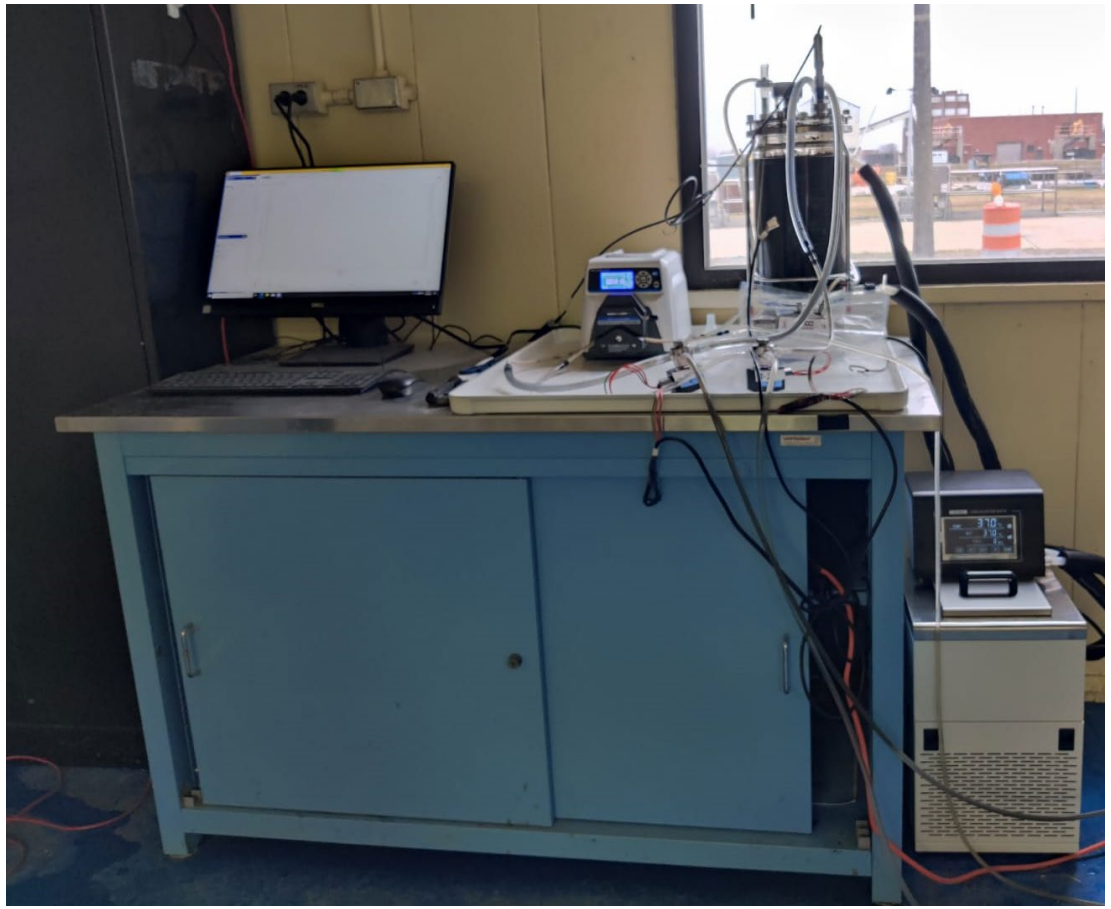




DYNAMIC MEMBRANE: THE MEMBRANE IS THE ACTUAL BIOFILM CREATED ON A 25 MIICRO PORE SIZE MESH

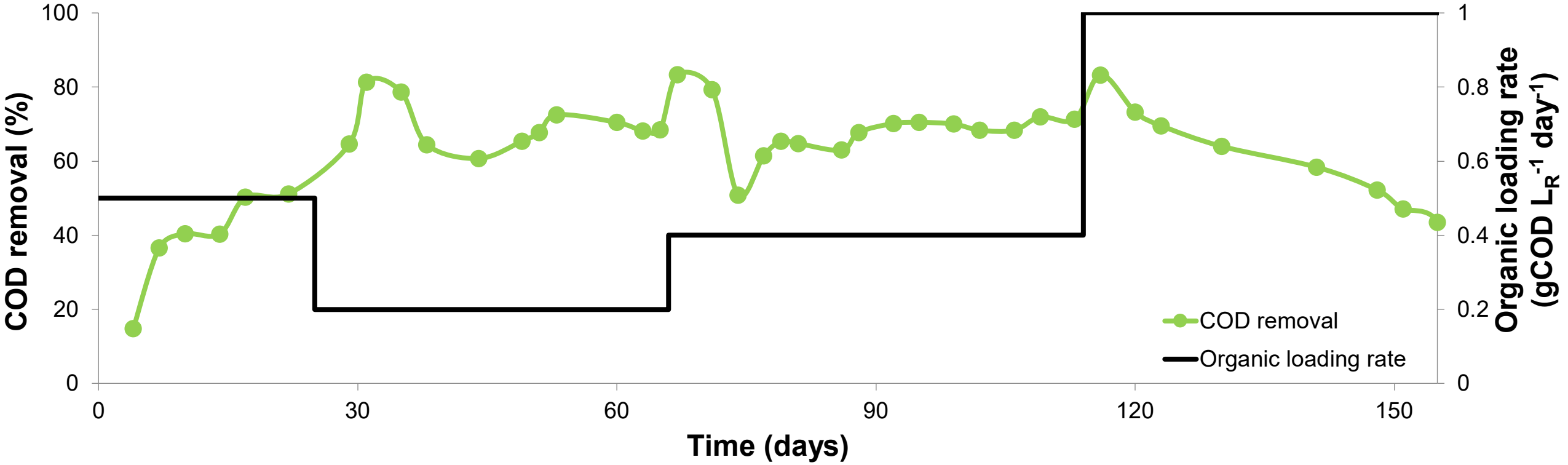


HTL wastewater was treated after applying different dilutions



- Working volume: 5 L
- Mesh pore size: 25 µm
- Raw COD concentration: 75 gCOD L^{-1}
- Feedstock concentration: 2.0 to 10.0 gCOD L^{-1}
- Organic loading rate: 0.2-1.0 gCOD L_R^{-1} day^{-1}
- HRT: 5-10 days
- Inoculum: Food waste and sludge co-digestion

70% of the COD is removed but at low OLR



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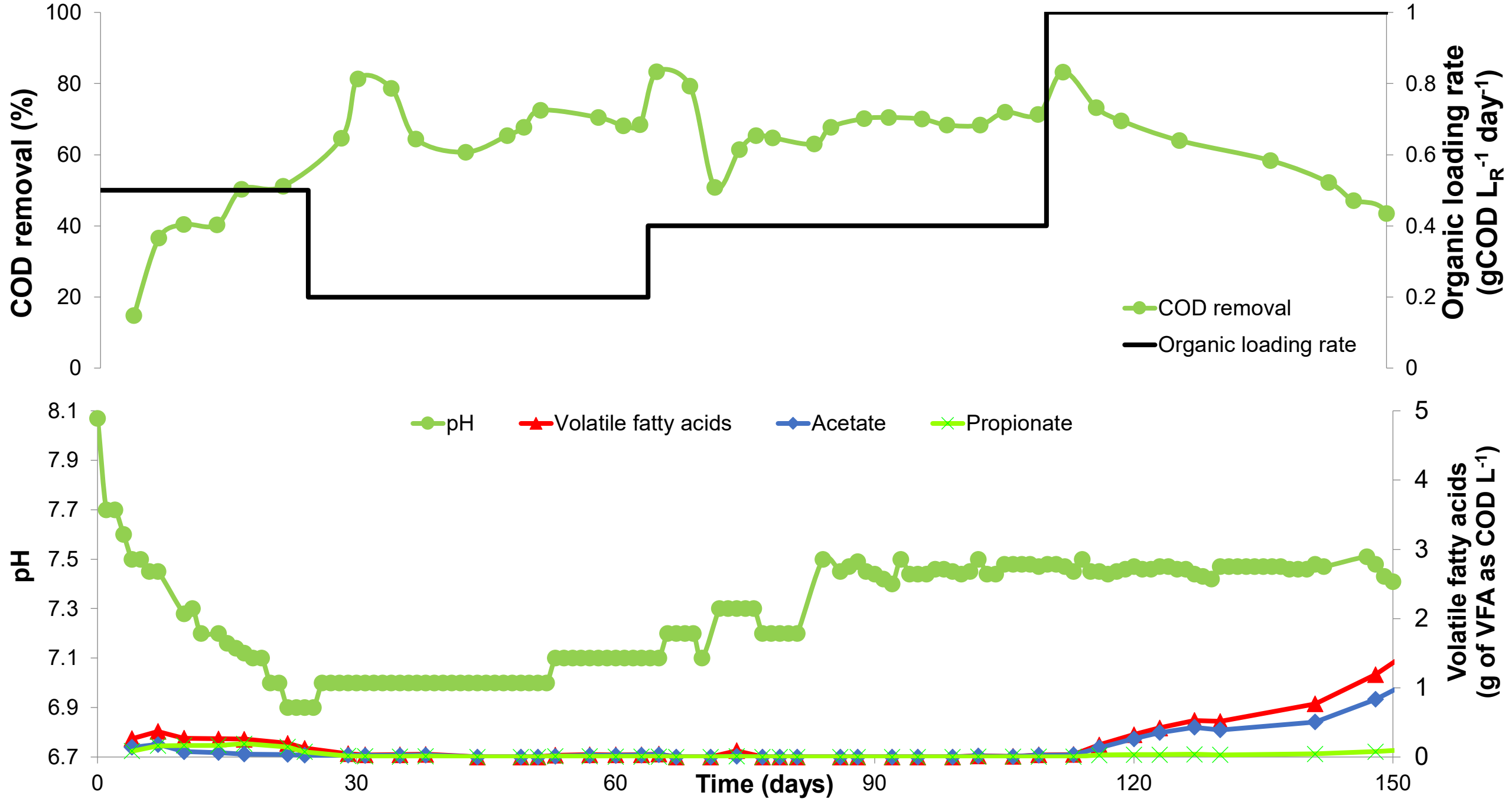
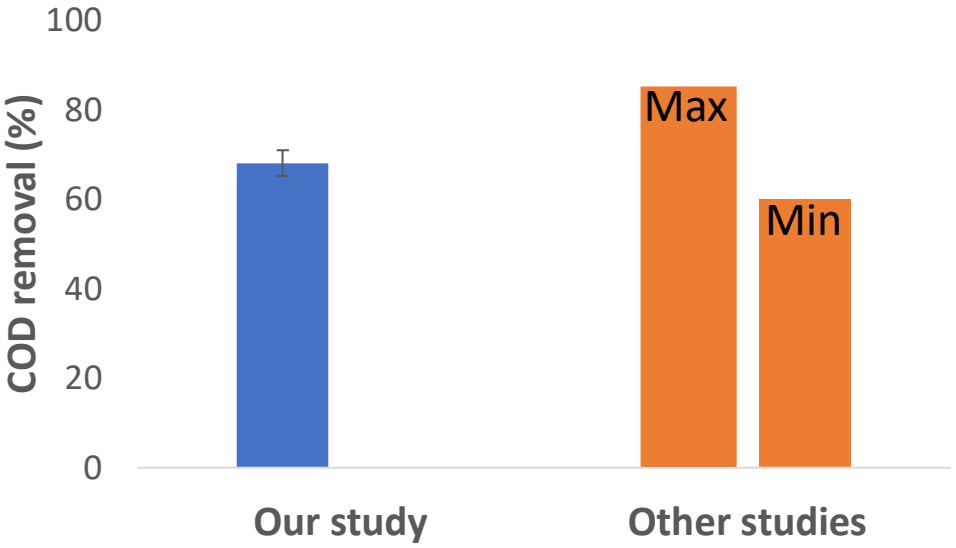
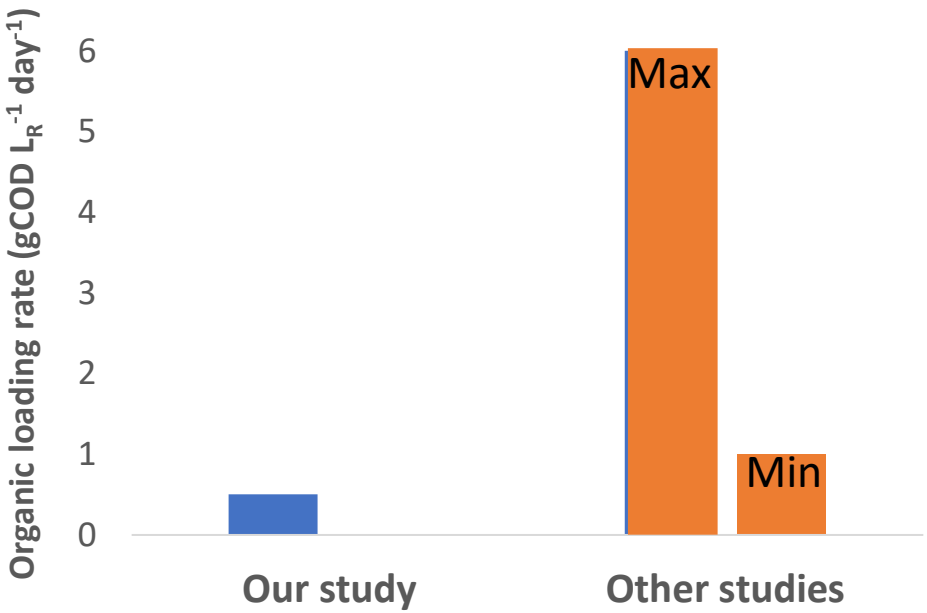
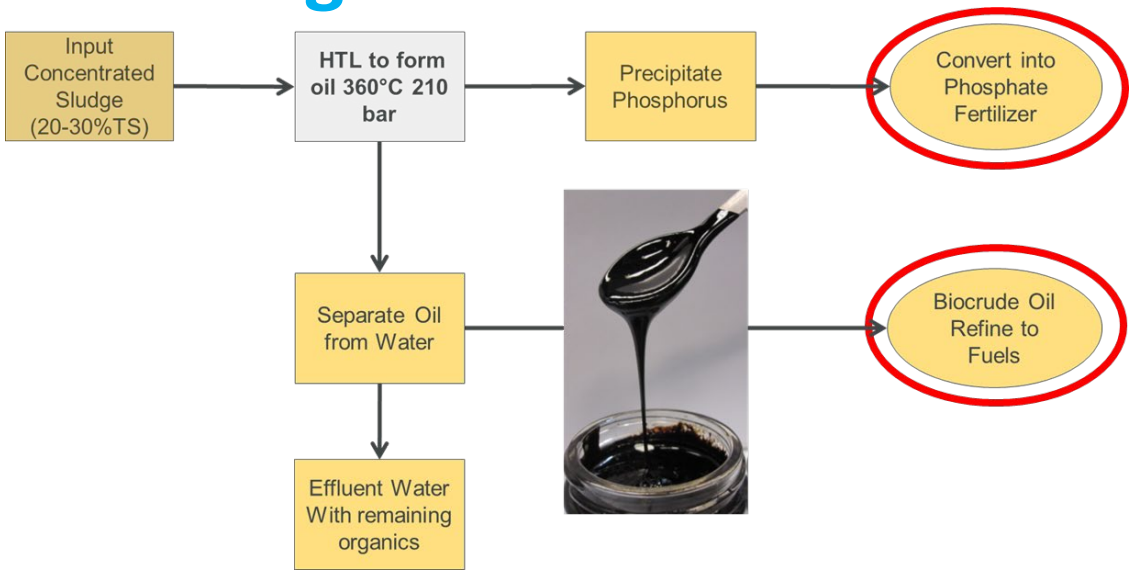


Other studies achieve similar performance at a higher OLR



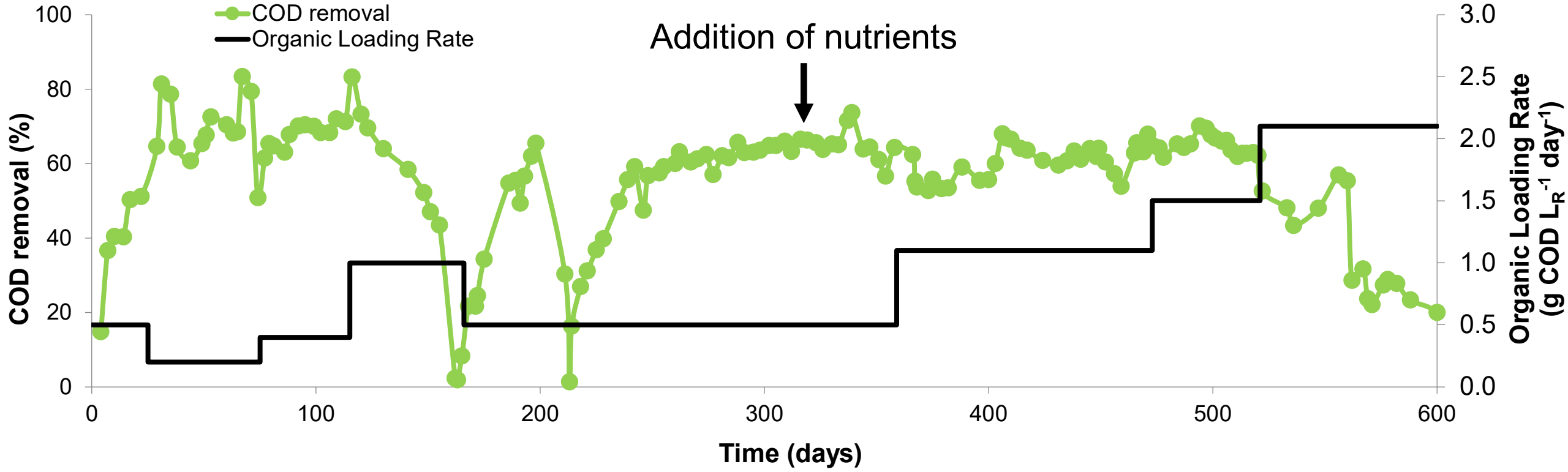


HTL wastewater lacks important nutrients for anaerobic microorganisms



	Concentration (ppm)		
Compound	HTL Aqueous phase	Reactor day 248	Reactor day 260
N	630 ± 15	642 ± 49	
P	1.2 ± 0.4	5.6 ± 0.1	
S	11	9	6
Na	8	6	8
Ca	62.2	9.4	10.9
K	22	24	24
Mg	3	3	3
Fe	1.8	5.8	3.6
Ni	< 1.6	< 1.6	< 1.6
Co	< 0.2	< 0.2	< 0.2
Zn	< 0.6	< 0.6	< 0.6
Mo	< 0.3	< 0.3	< 0.3
W	< 1	< 1	< 1
Cu	0.15	0.3	0.3
Mn	< 0.3	< 0.3	< 0.3

70% of the COD was removed at low dilution rates, but co-digestion is necessary



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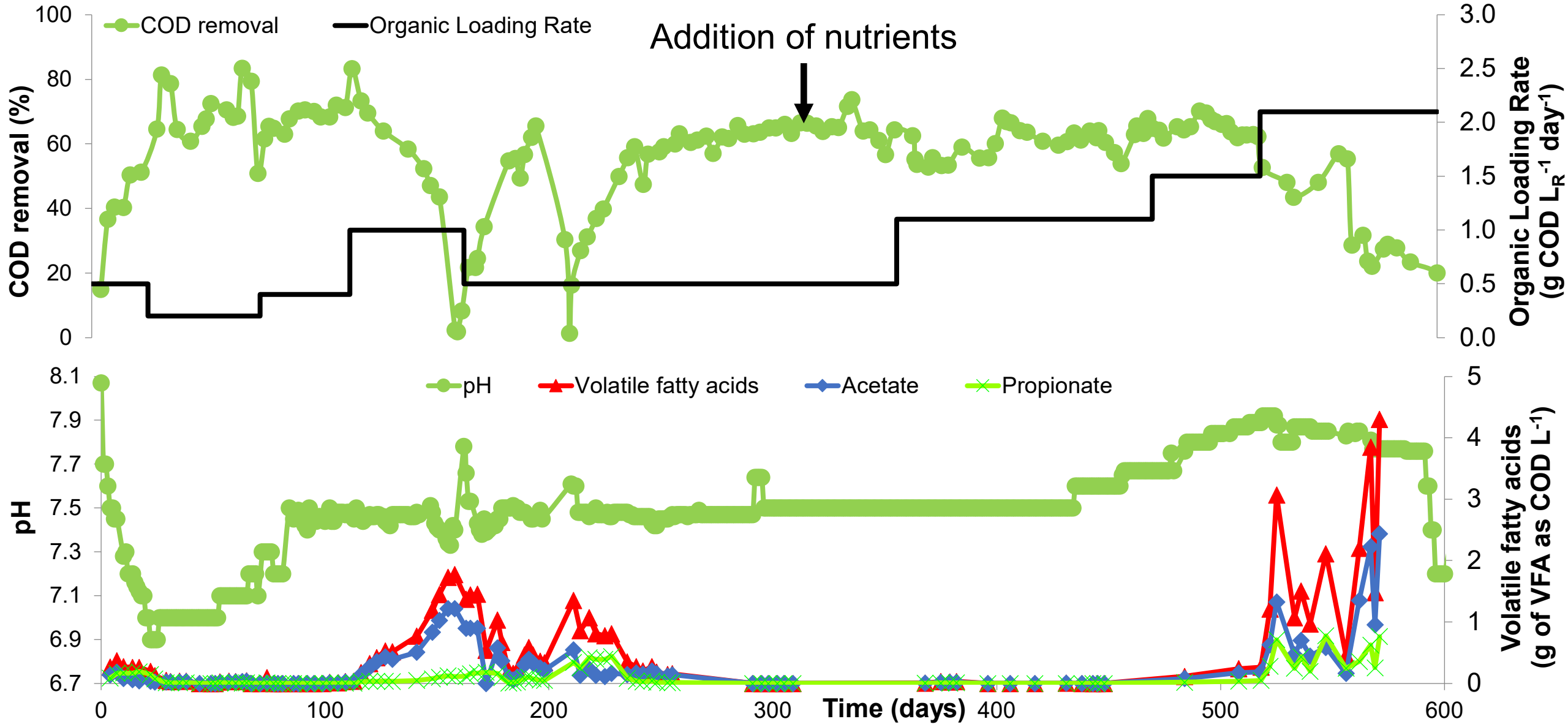
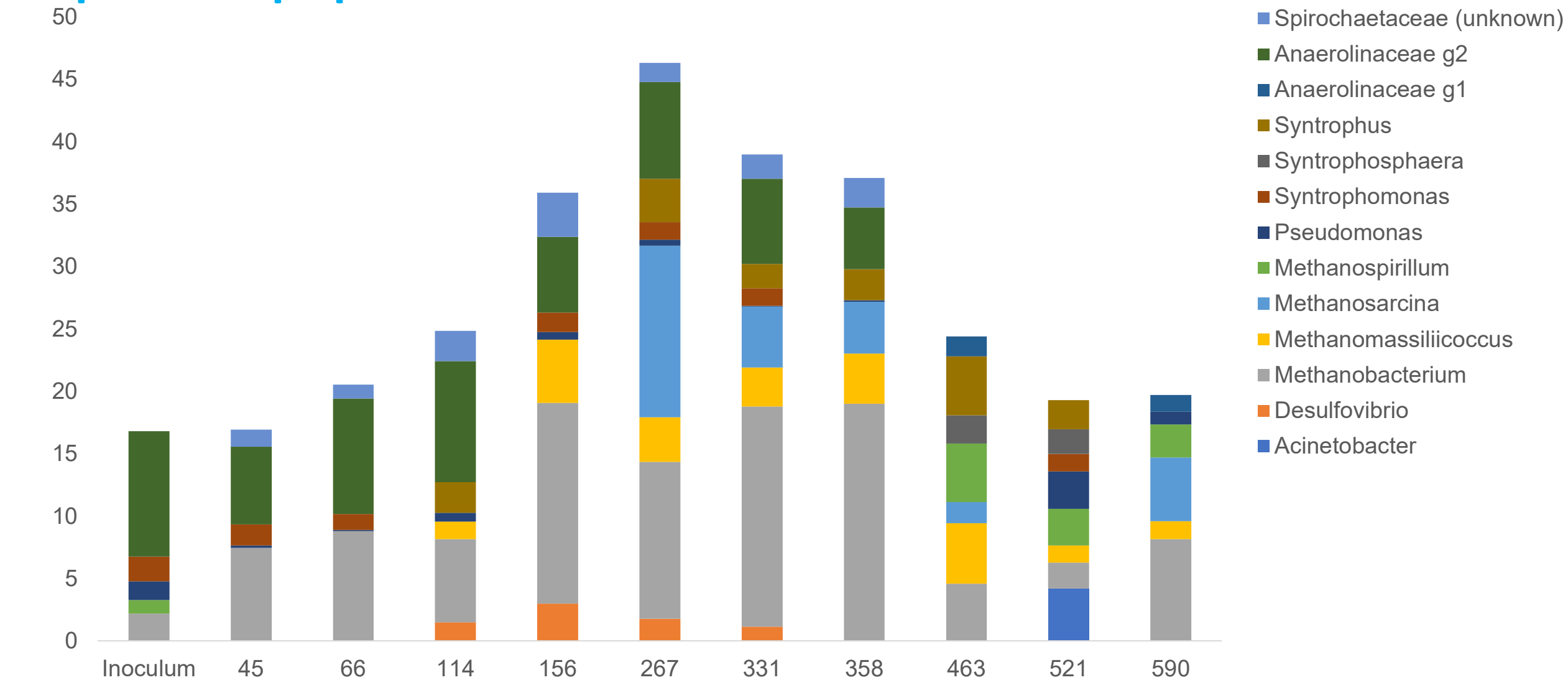
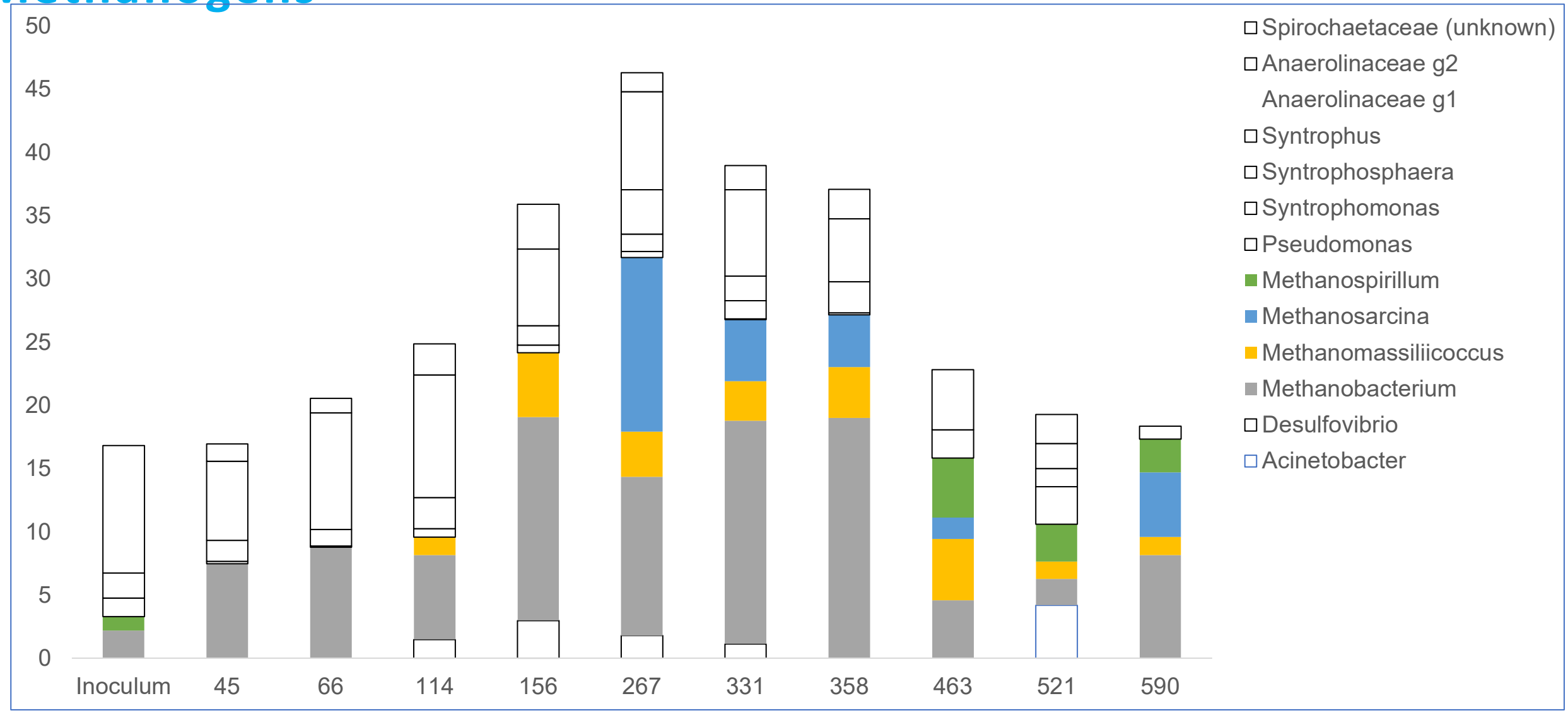


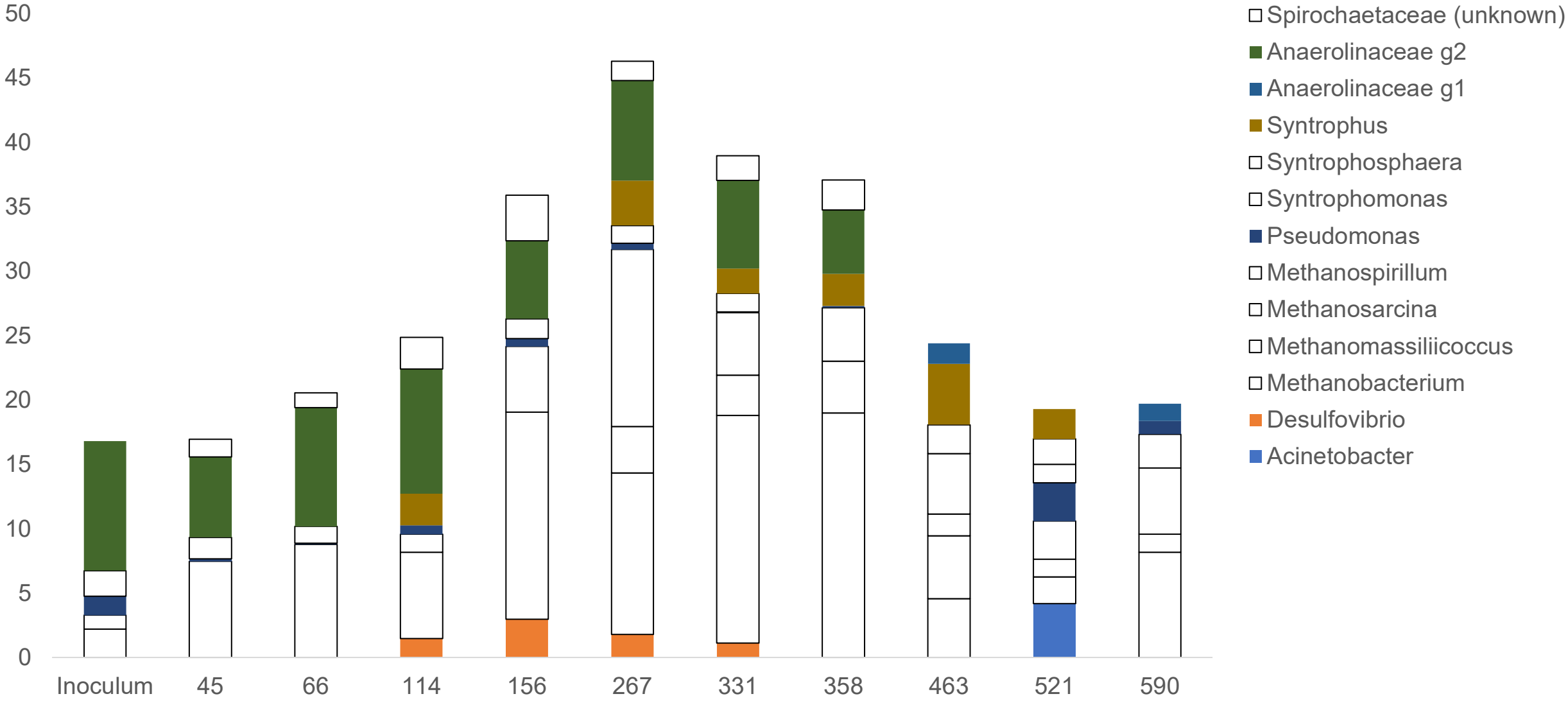
The biofilm presented a diverse microbial community with important populations



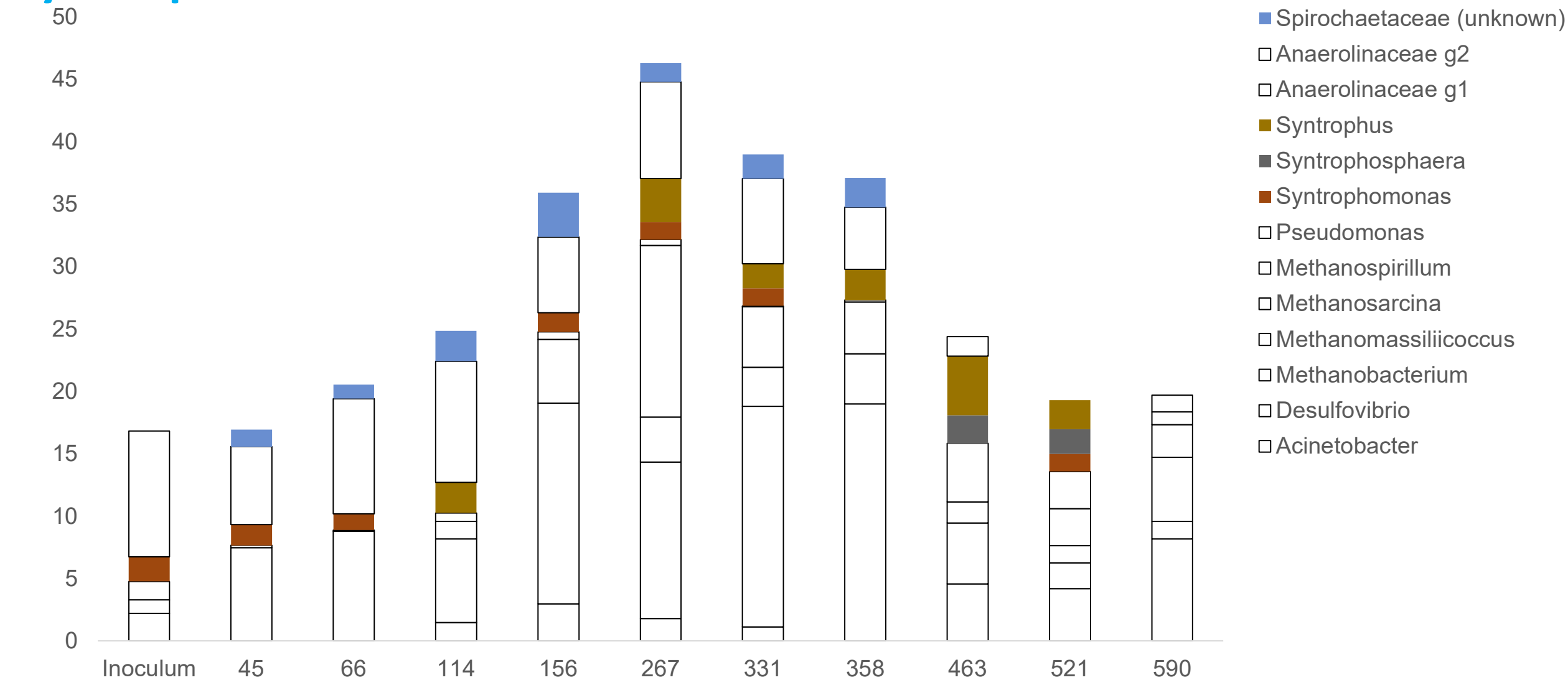
The biofilm presented a diverse microbial community with Methanogens



The biofilm presented a diverse microbial community with aromatic and phenol compounds degraders

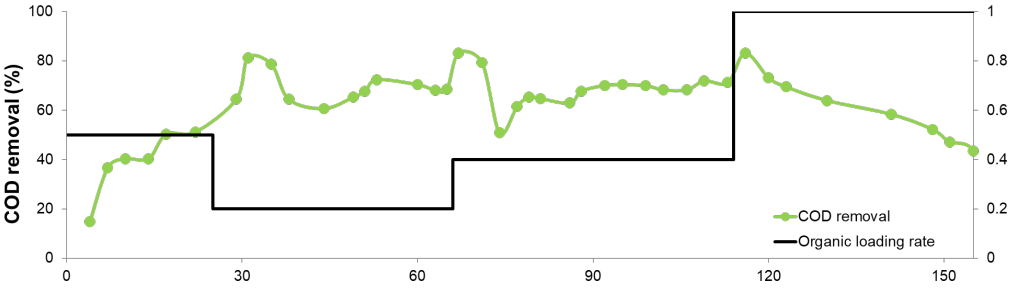


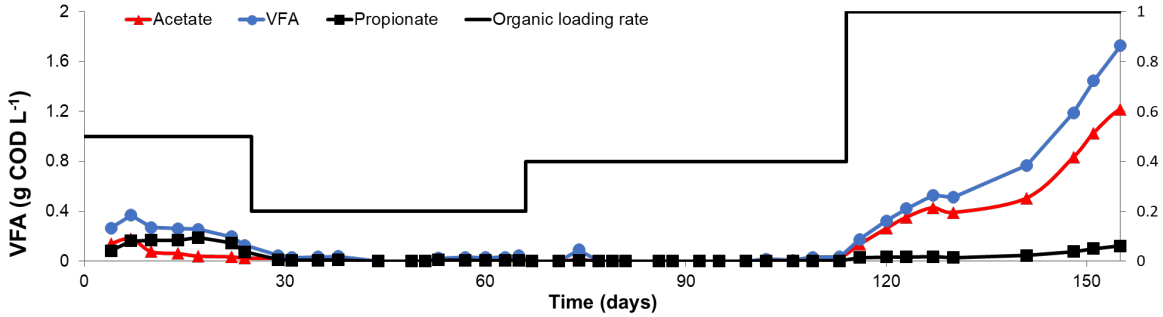
The biofilm presented a diverse microbial community with syntrophic bacteria



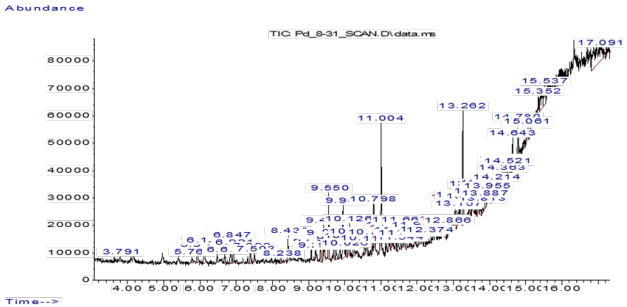
Conclusions and ongoing work

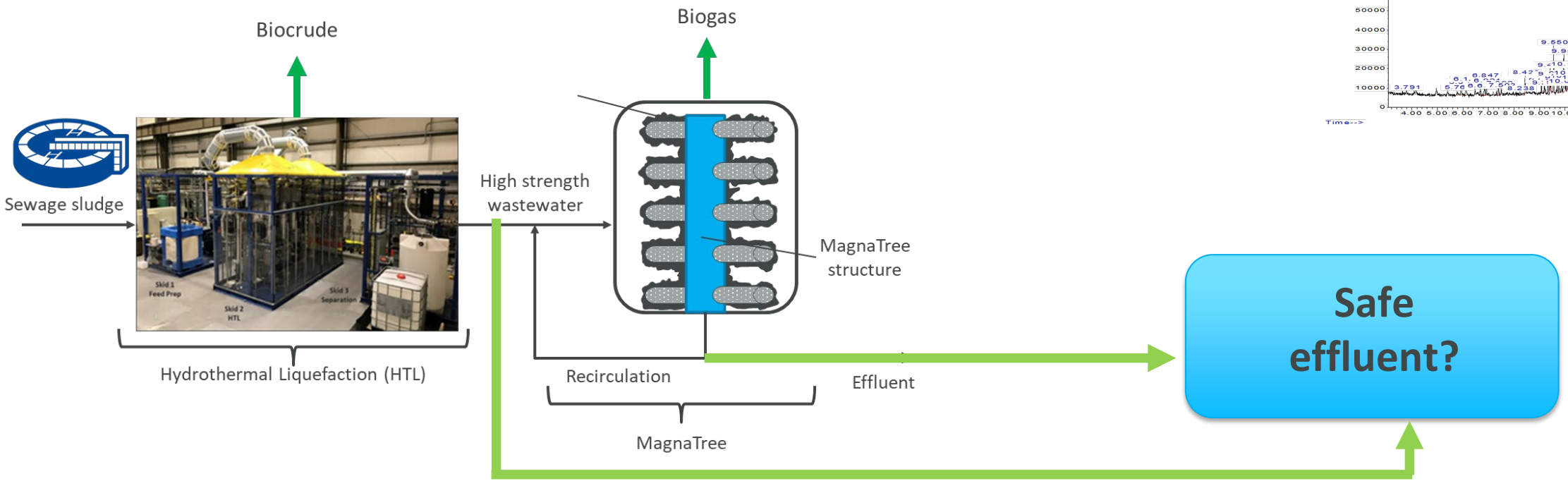
Co-digestion is crucial to bring nutrients to the system



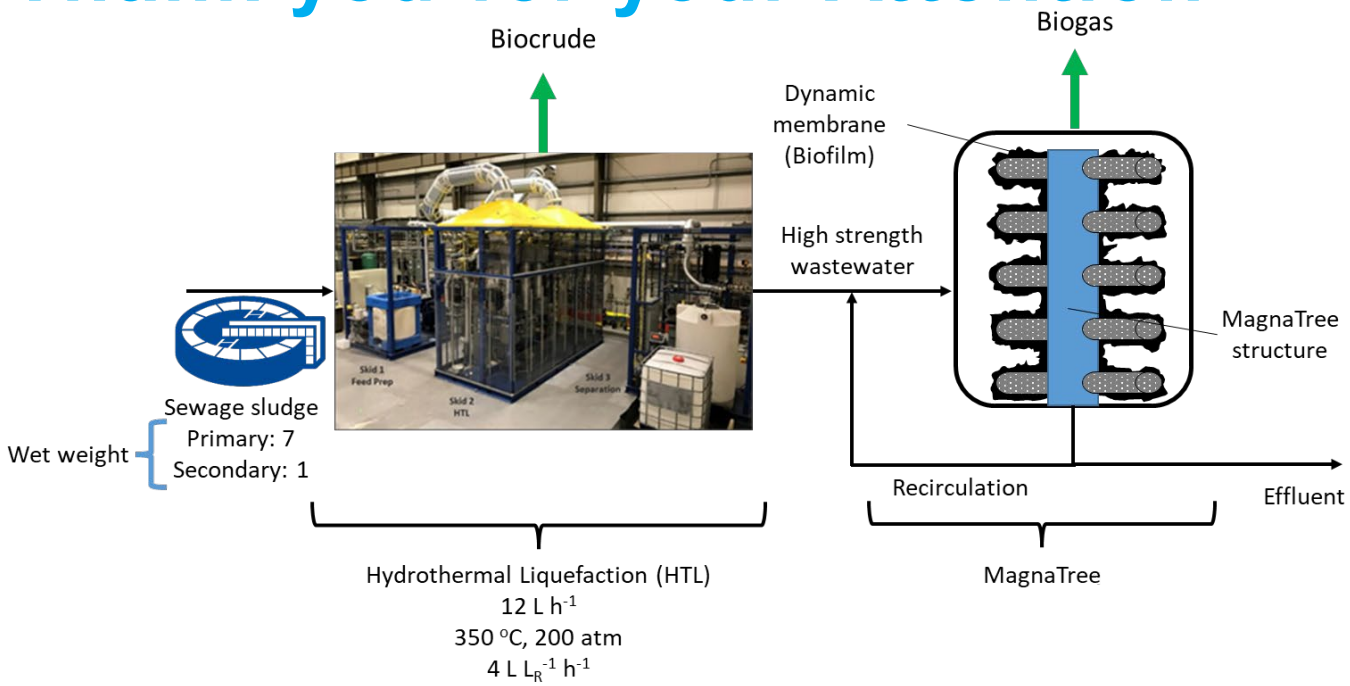


Is it safe to recirculate the effluent?





Thank you for your Attention



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- Pacific Northwest National Laboratory
- Wayne State University (Judy Westrick, Nicholas Peraino)

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