Three years of MABR operation at Ejby Mølle

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Innovationsfonden

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DIT VAND · VORES ELEMENT

Content

- What is MABR?
- Potential benefits
- State of the technology
- Ejby Mølle case study
- Future

What is MABR

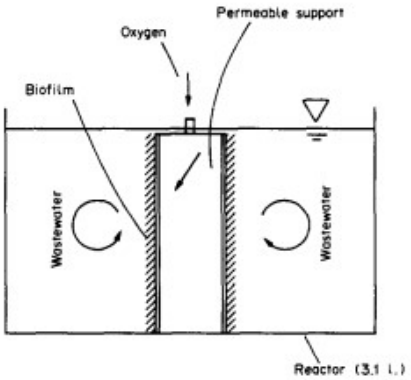


Fig. 2. Schematic of laboratory PSB reactor.

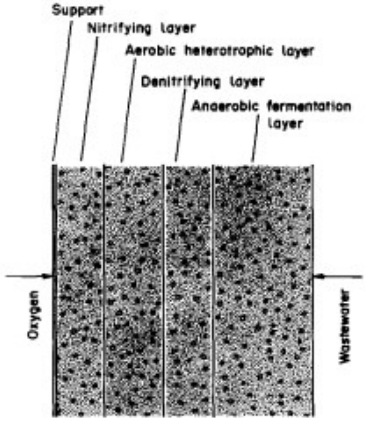
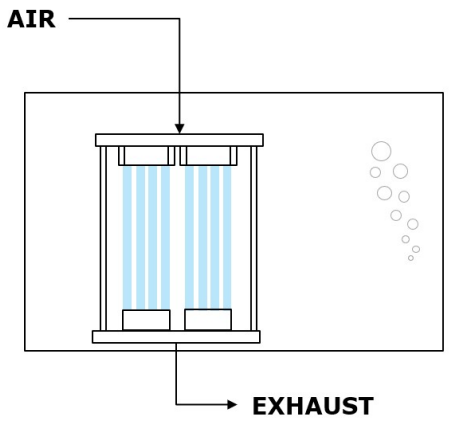
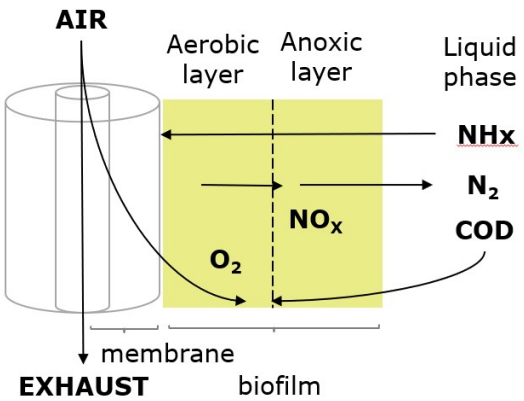


Fig. 1. Structure of support-aerated biofilm.

Timberlake, D. L., Strand, S. E., & Williamson, K. J. (1988). Combined aerobic heterotrophic oxidation, nitrification and denitrification in a permeable-support biofilm. *Water Research*, *22*(12), 1513–1517. https://doi.org/https://doi.org/10.1016/0043-1354(88)90163-7

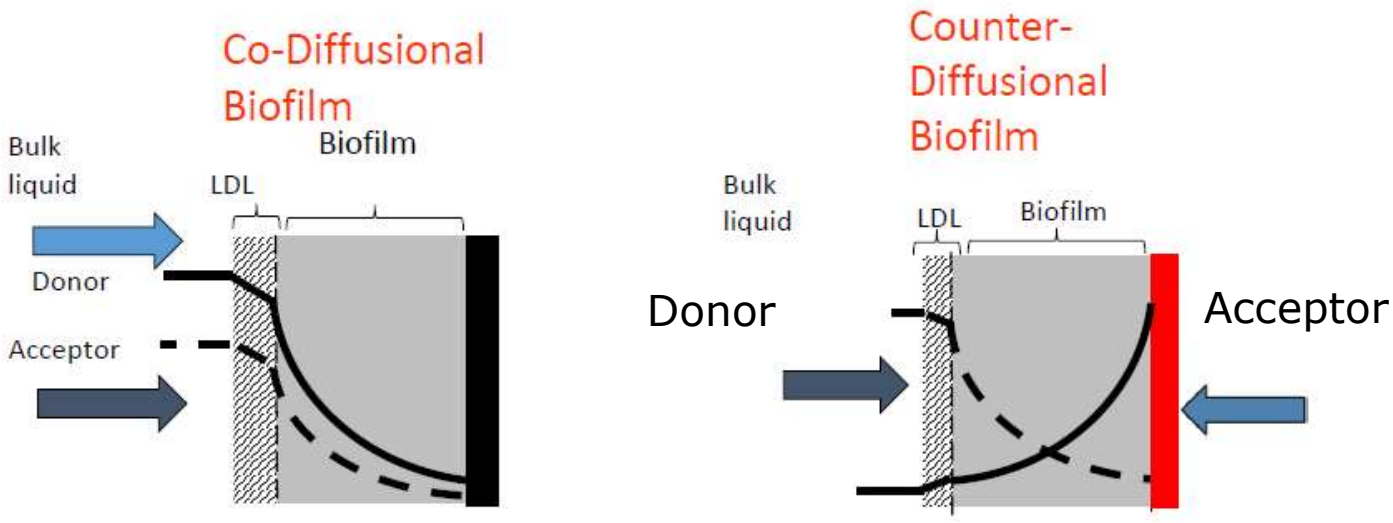
What is MABR





- Energy savings
- Biofilm-based benefits: intensification, peak loads handling, micropollutants, etc…
- Counter-diffusional biofilm: simultaneous nitrification-denitrification, reduced N_2O emissions, etc…

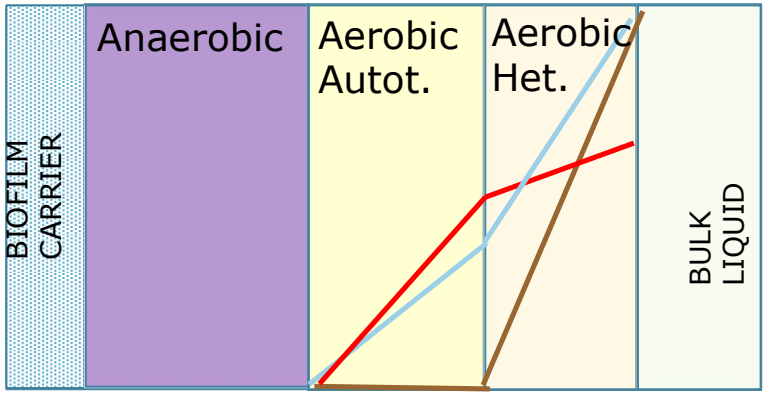
Difference between co and counter diffusion



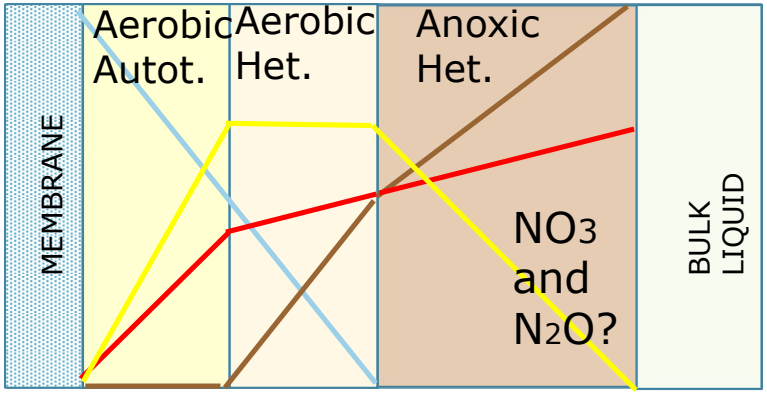
(Rob Nerenberg, 2018)

Counter-diffusional biofilm

Co-diffusion Biofilm



Counter-diffusion Biofilm

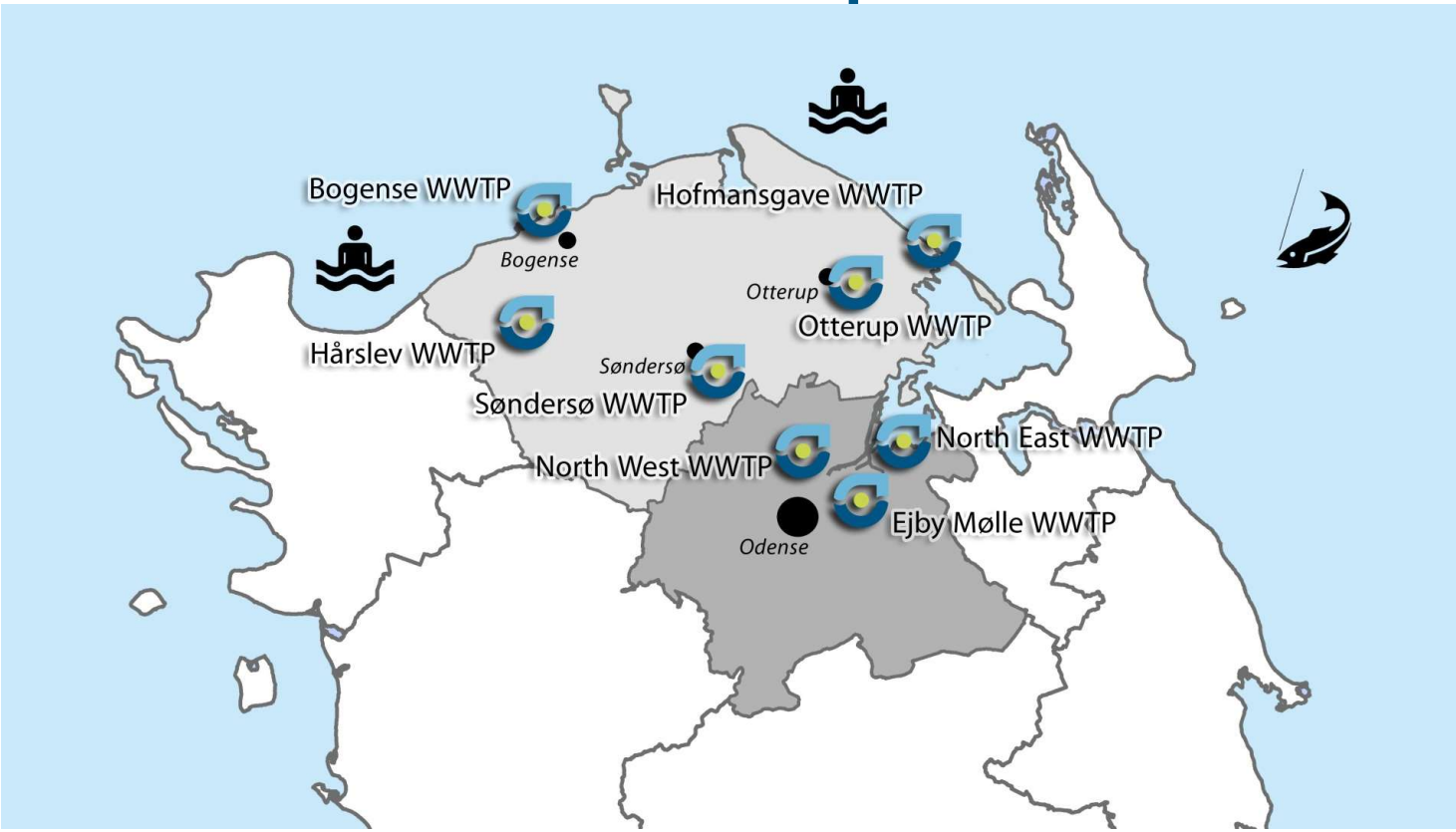


DO AMMONIA COD

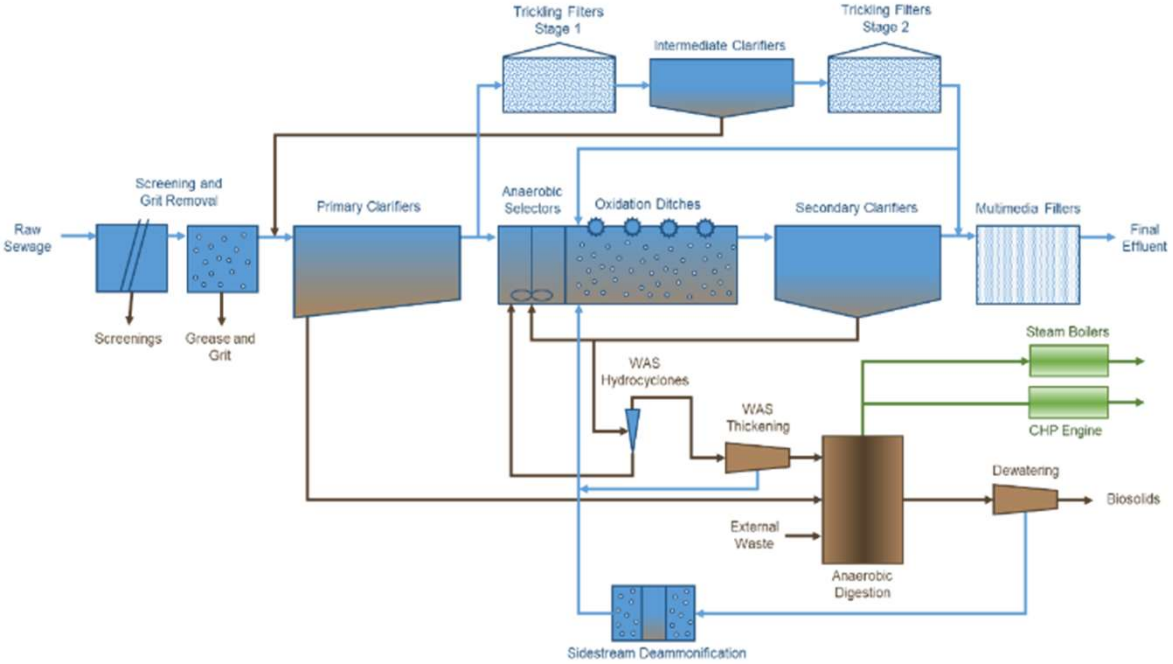
Applications – state of the art

- Gas: air
  - Hybrid applications (IFAS):mainstream and sidestream
  - Pure biofilm
- Gas: pure oxygen
- Gas: hydrogen, methane, sulfide, etc…

VCS Denmark-Wastewater treatment plants

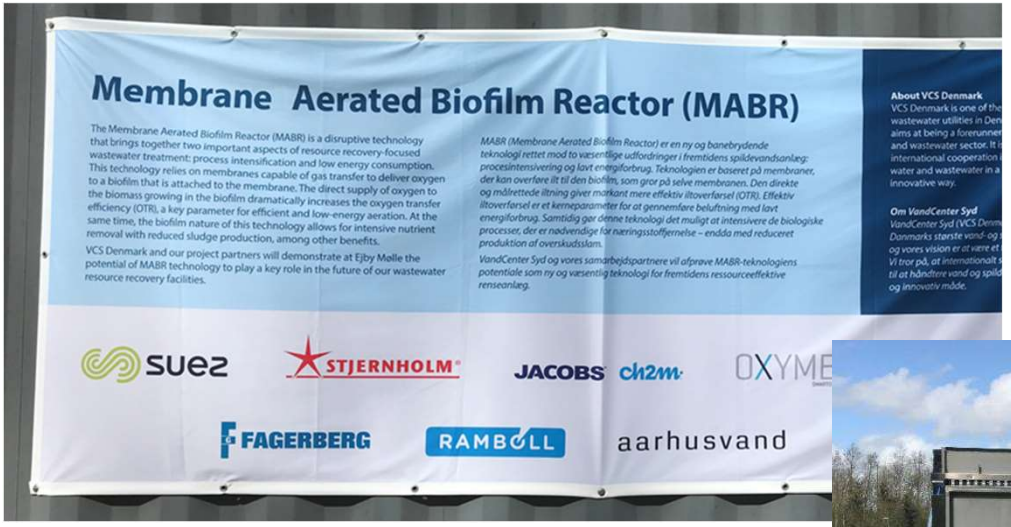


Ejby Mølle WRRF



- Very stringent effluent limits (tax on effluent)
- Energy neutral since 2014

Demonstration Study Initiated in Summer of 2018



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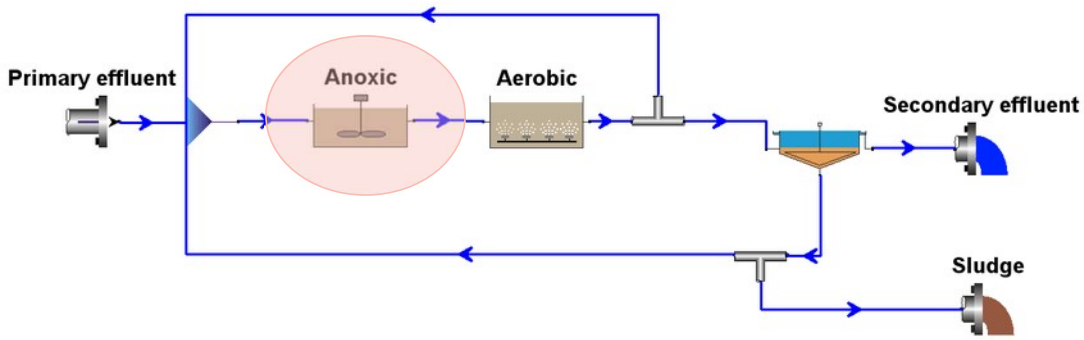
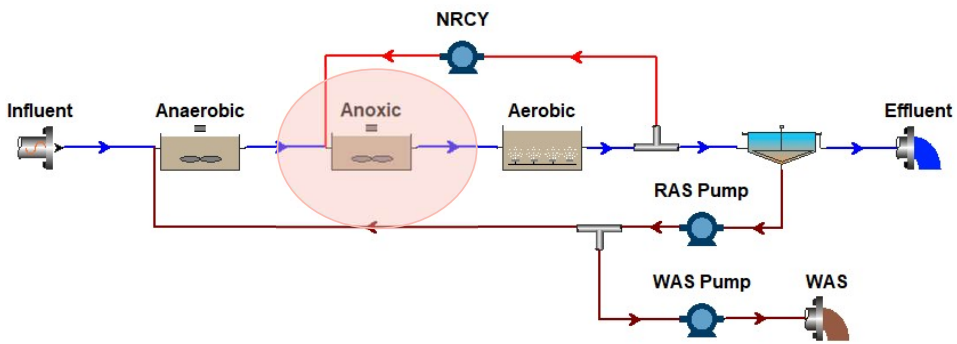
Retrofitting MABR into activated sludge

Rules of

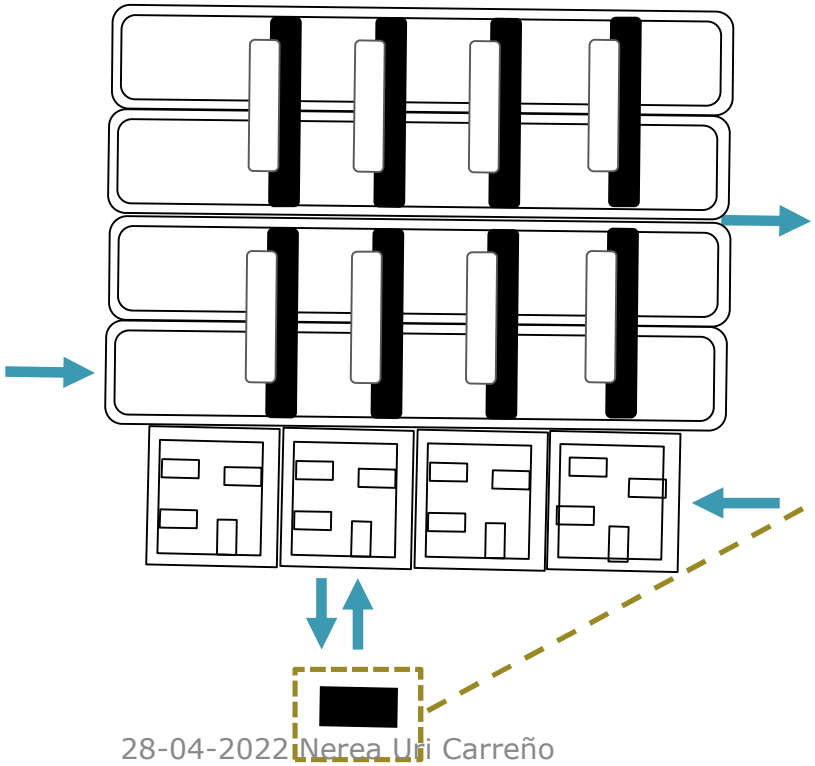
- Highest ammmonia conc.
- Lowest COD conc.
- Lowest DO conc.



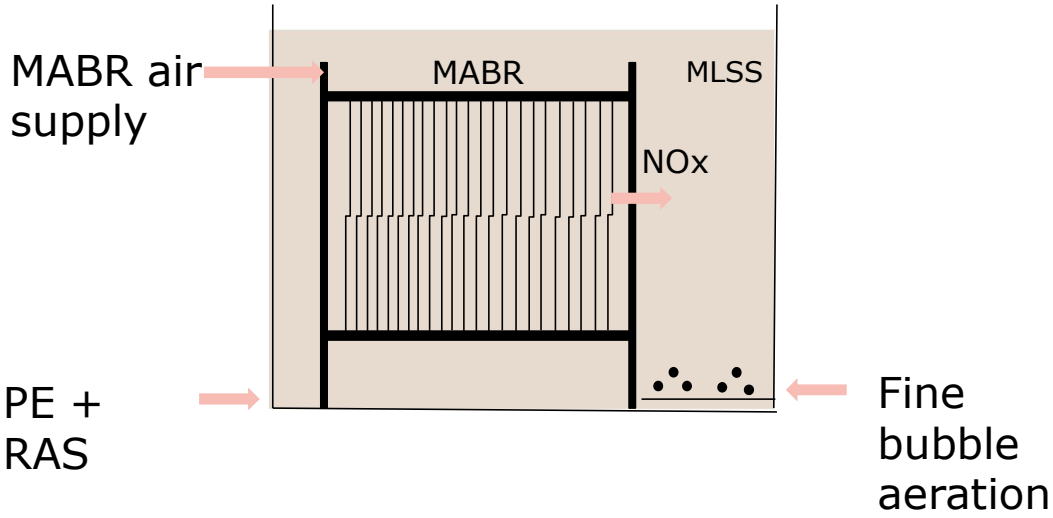


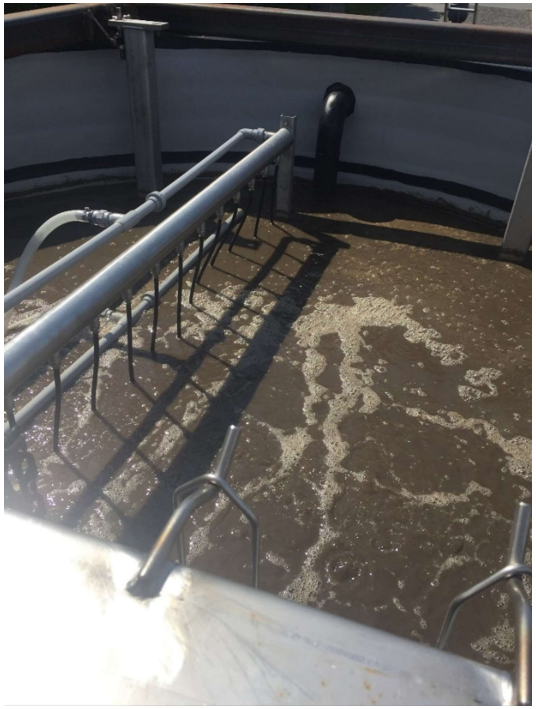
Demonstration at Ejby Mølle

Pilot Configuration

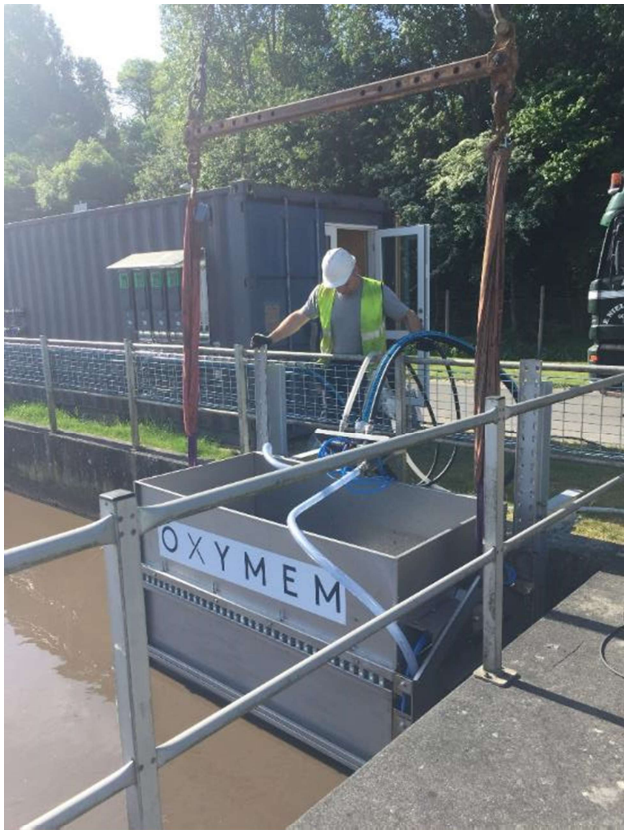


MABR reactors

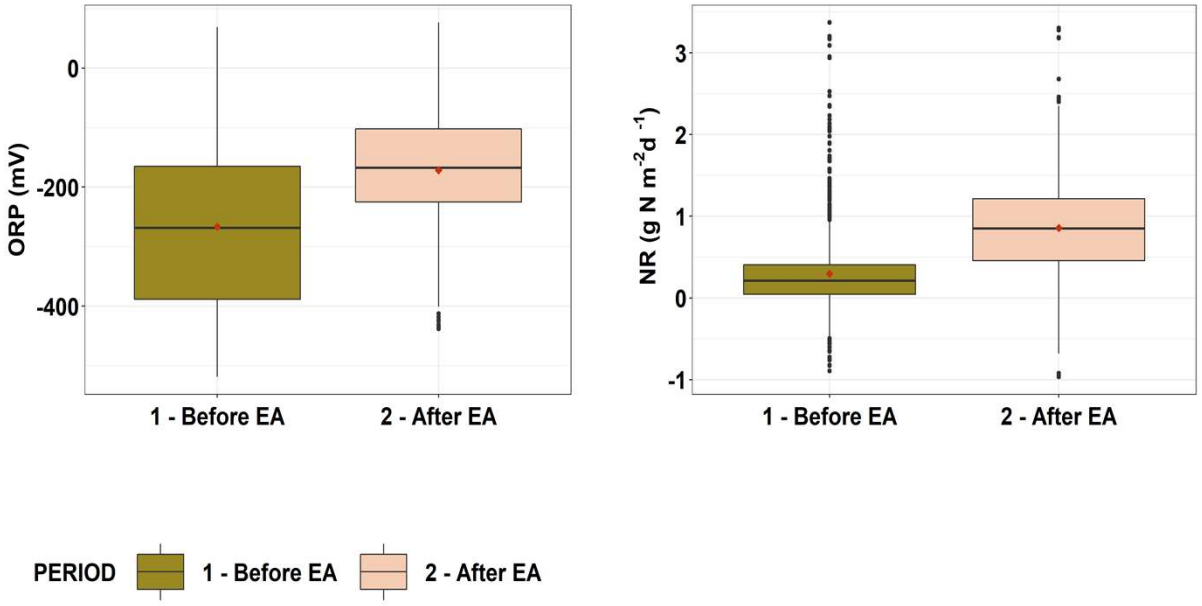




Installation of Full-Scale units (2018)



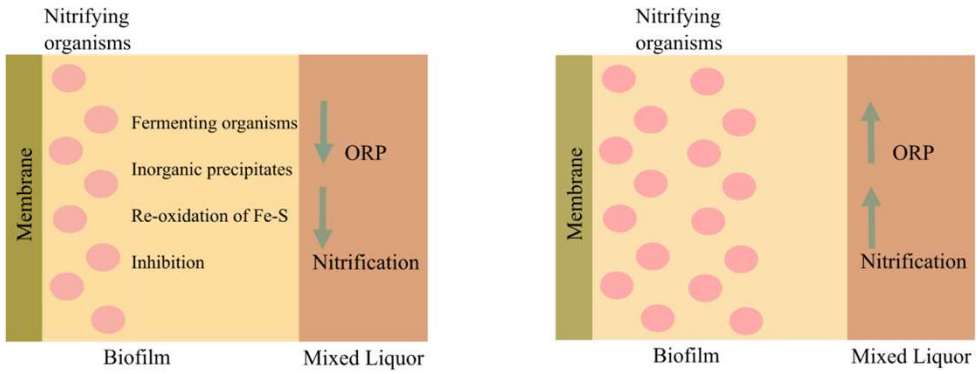
Two distinct periods of operation



16s analysis - AAU

Uri Carreño, N., Nielsen, P.H., Gernaey, K. V., Wang, Q., Gro Nielsen, U., Nierychlo, M., Hansen, S.H., Thomsen, L., Flores-Alsina, X., 2021. The effects of low oxidation-reduction potential in the performance of full-scale hybrid membrane aerated biofilm reactors. Submitted.

Understanding the effect of low ORP

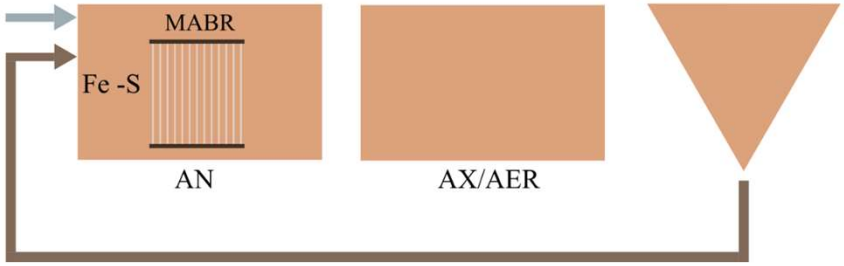


Iron-Sulfur and anaerobic conditions:

a) Competition for space

b) Competition for oxygen

c) Nitrification inhibition



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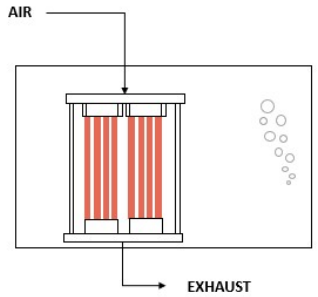
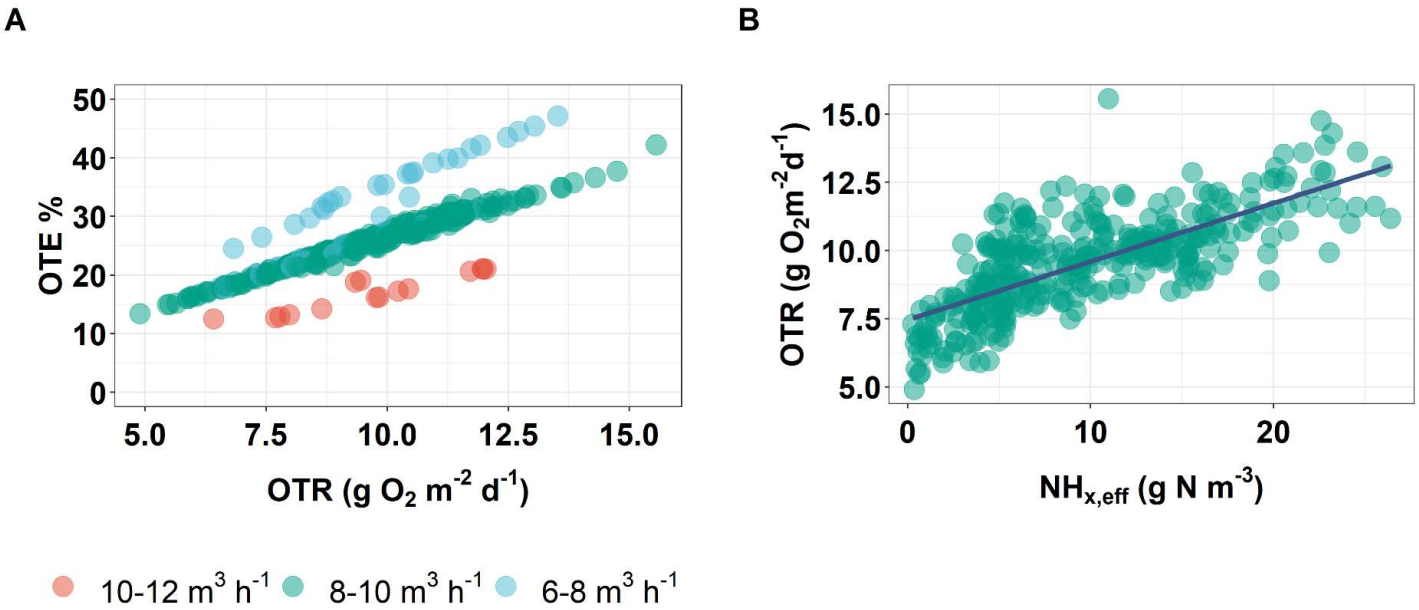
Oxygen transfer



55% more efficient than fine bubble and 75% more efficient than surface aerators at Ejby Mølle



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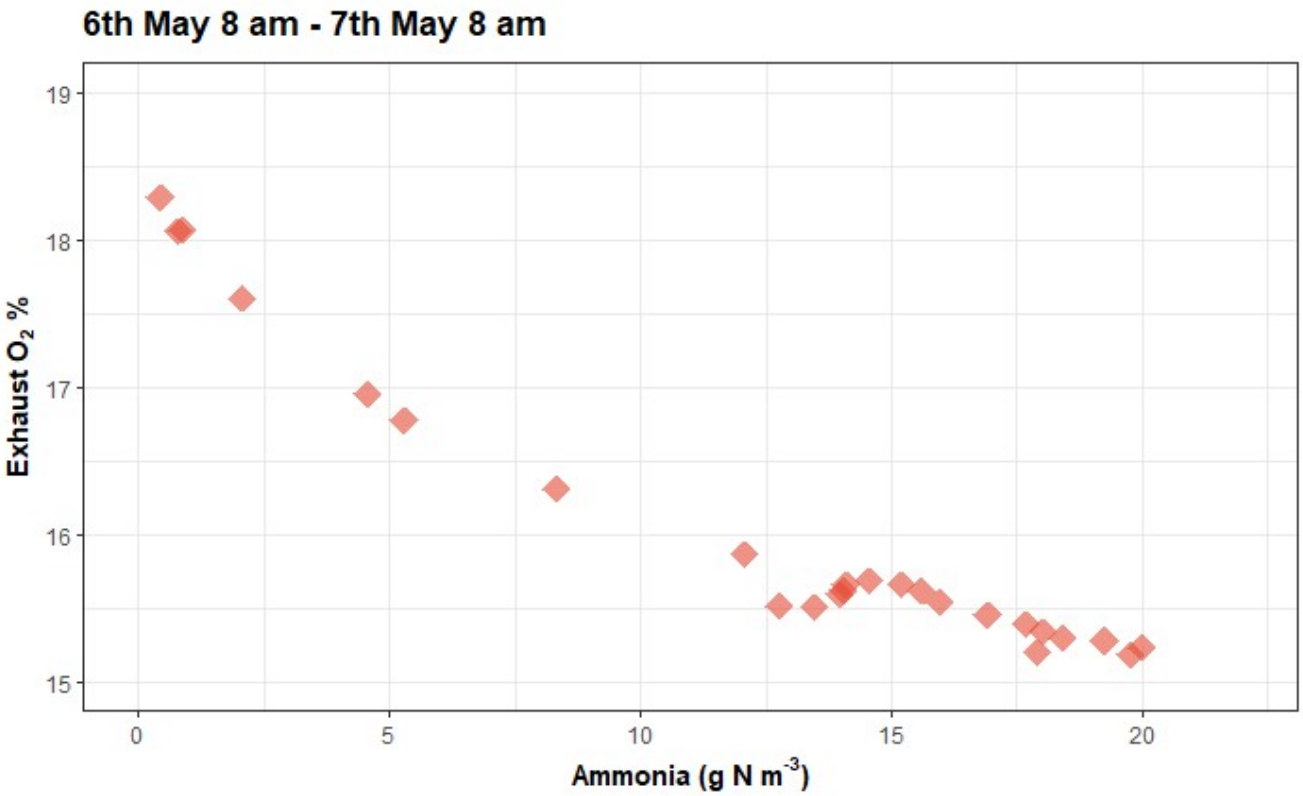
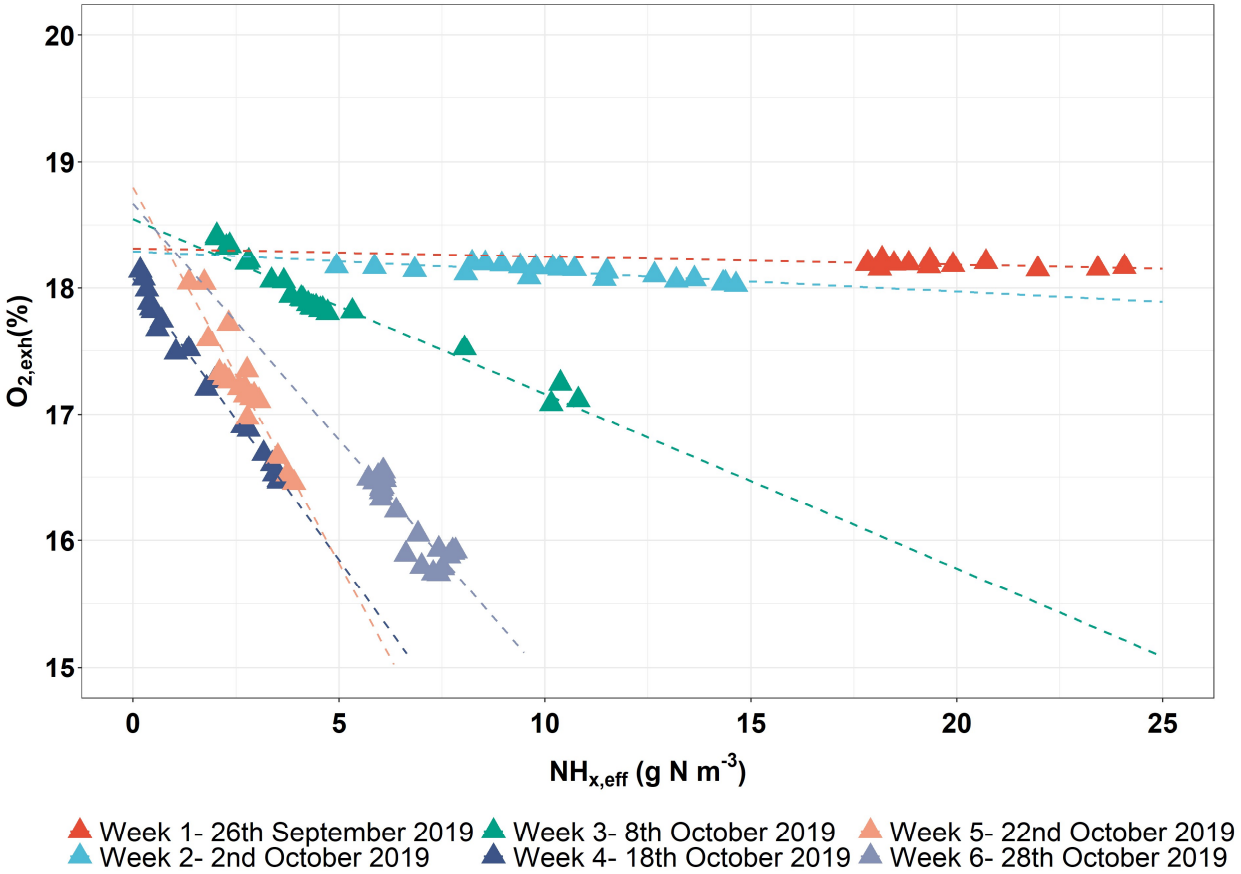
Oxygen transfer - Ammonia conc.



Startup time



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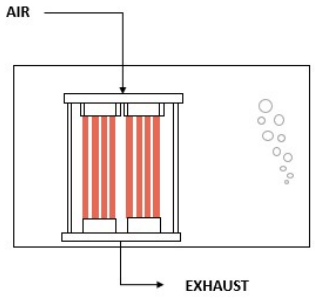
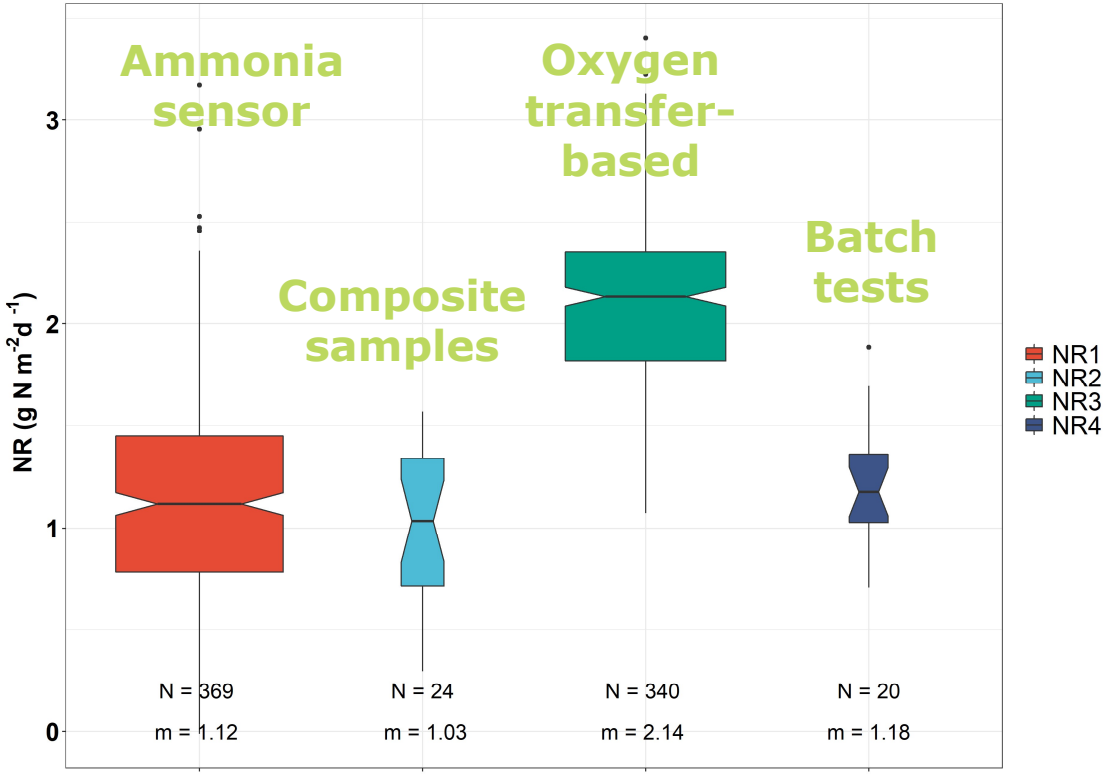
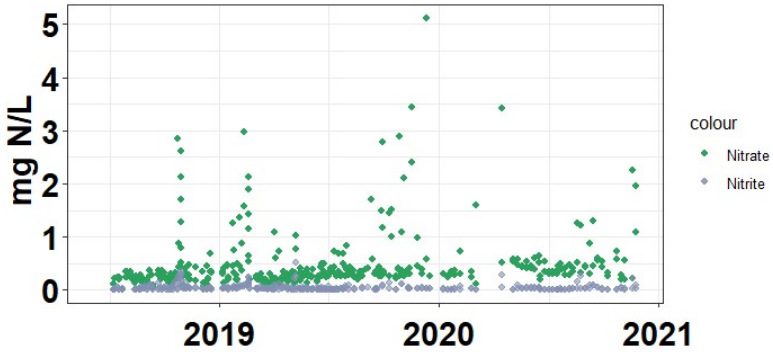
Nitrogen removal



Average volumetric nitrification rates (175-364) g N/m³/d





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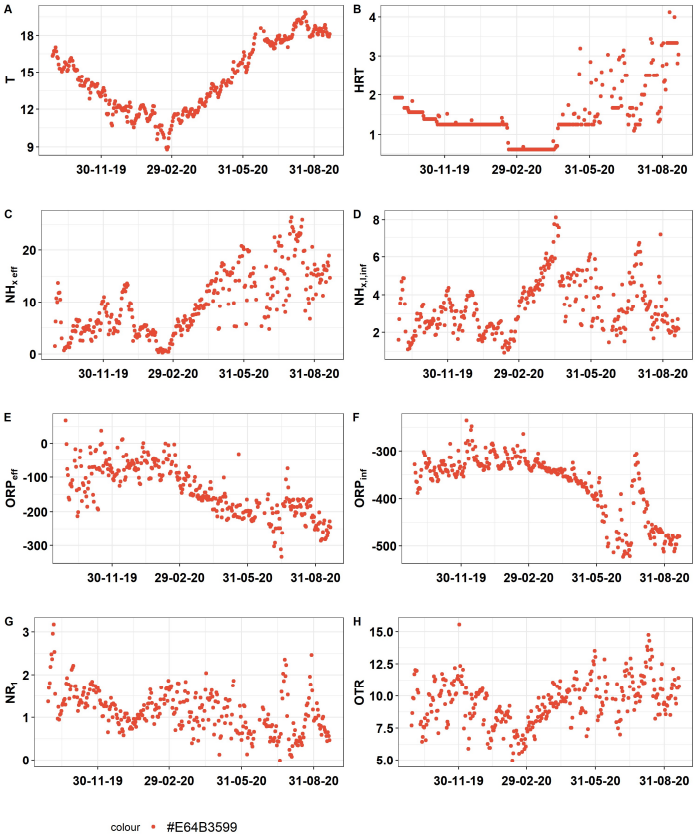
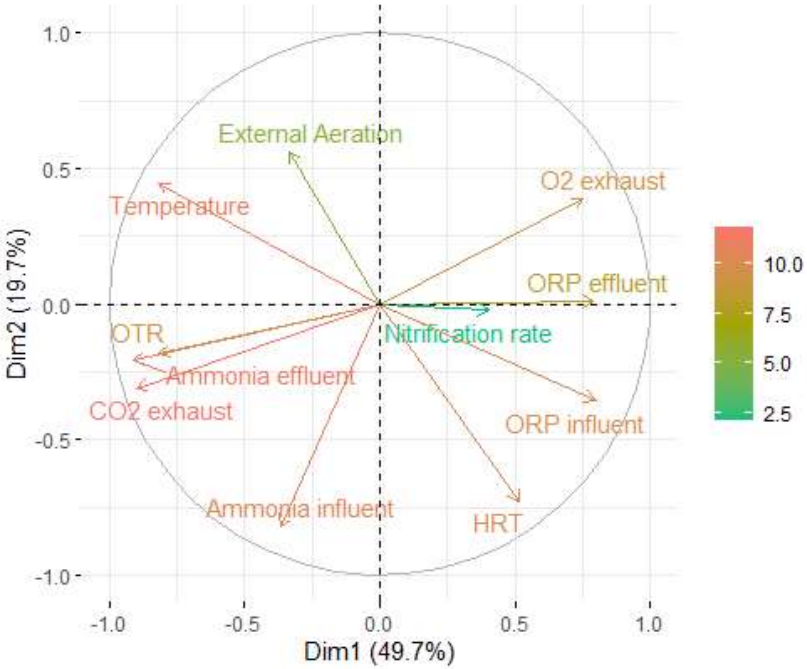
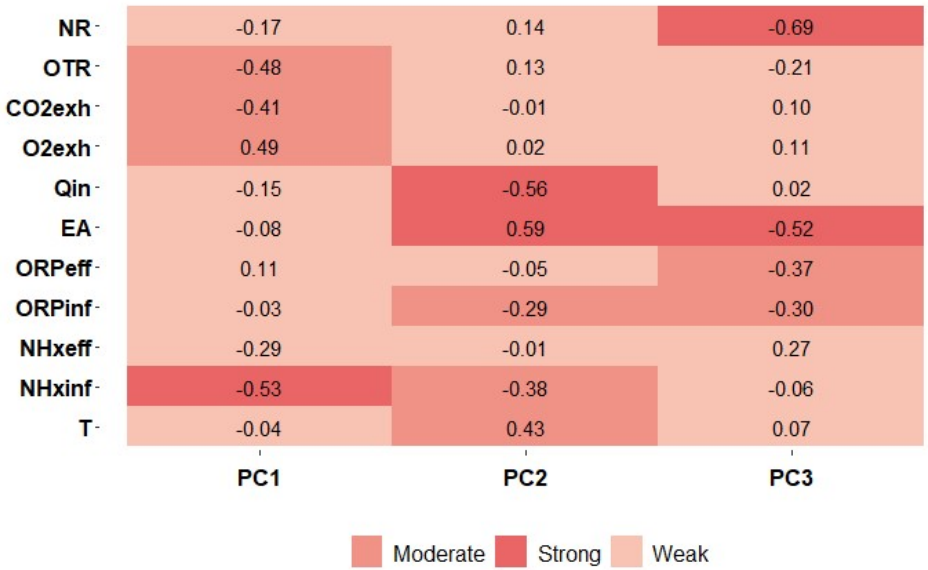
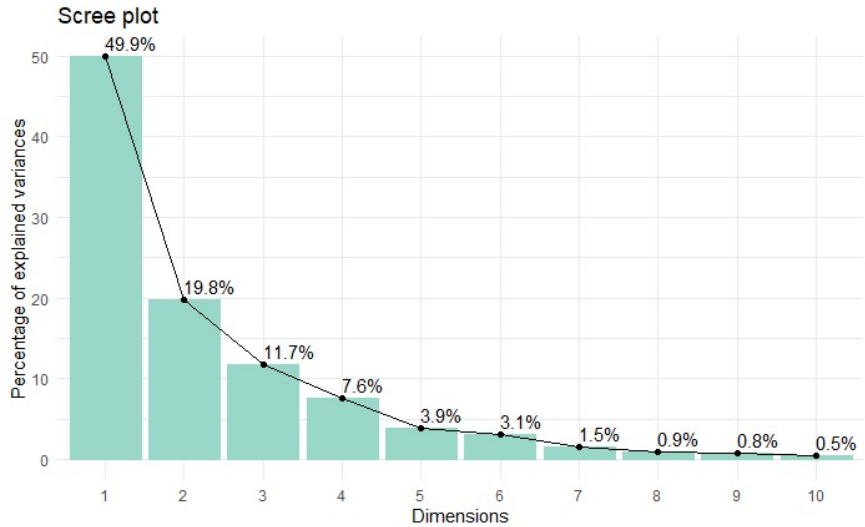
Principal Component Analysis for Dimensionality Reduction



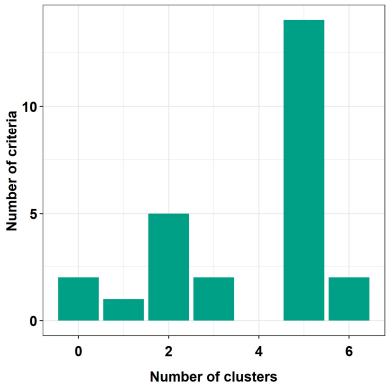


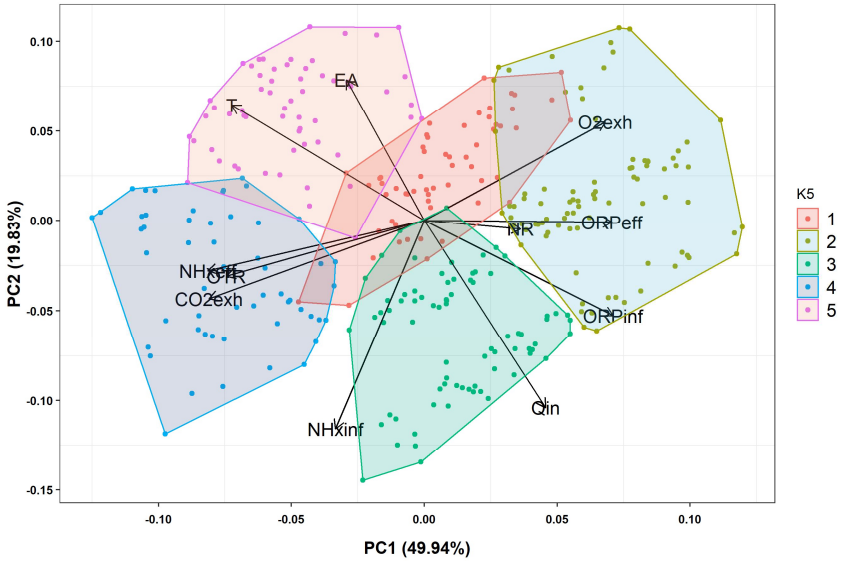
Principal Components

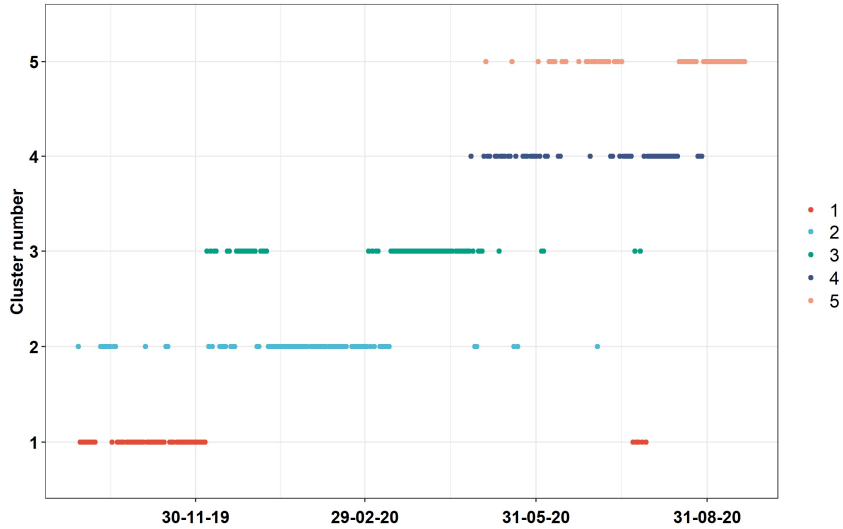




Cluster allocation (k-means)







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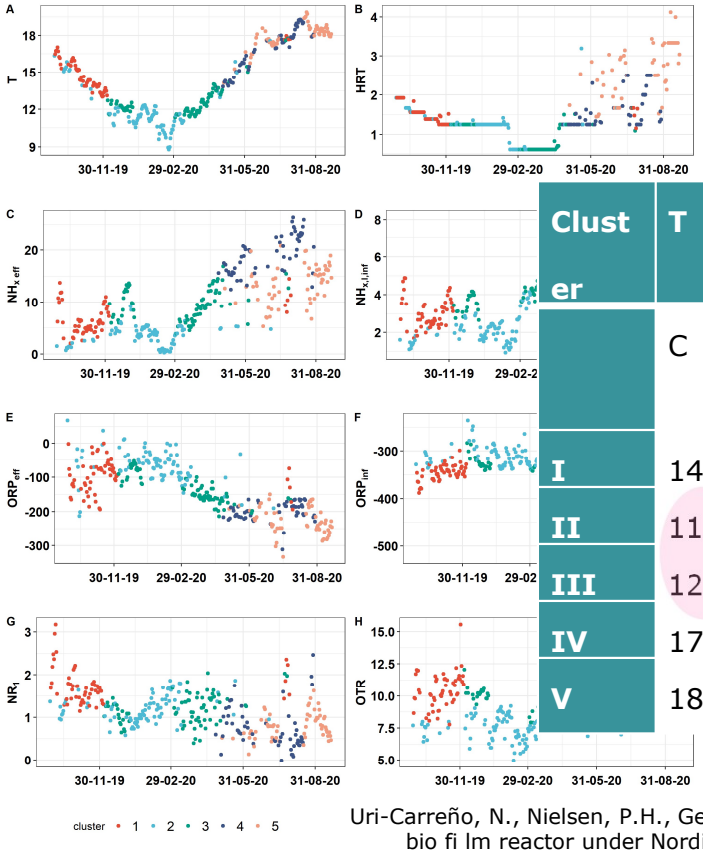
Summary of results



Cluster	T	$NH_{x,l,inf}$	$NH_{x,eff}$	ORP_{inf}	ORP_{eff}	EA	Q_{inf}	$O_{2,exh}$	$CO_{2,exh}$	OTR	NR_1	OTR/NR_1
	C	g N m^{-2} d^{-1}	g N m^{-3}	mV	mV	m^3 d^{-1}	m^3 h^{-1}	%	%	g O_2 m^{-2} d^{-1}	g N m^{-2} d^{-1}	
I	14.4	3.1	6.1	-344	-95	278	17	16.19	2.19	10.17	1.65	6.18
II	11.5	2.1	3.7	-317	-61	0	20	17.42	1.67	7.51	1.18	6.38
III	12.2	4.4	9.3	-340	-148	0	36	16.24	2.44	9.77	1.20	8.12
IV	17.2	4.6	19.3	-395	-199	103	18	15.15	3.18	11.54	0.60	18.99
V	18.1	2.5	14.3	-482	-235	135	9	16.43	2.61	9.79	0.79	12.44

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N_2O emissions

Water Research 124 (2017) 363–371

Contents lists available at ScienceDirect

Water Research

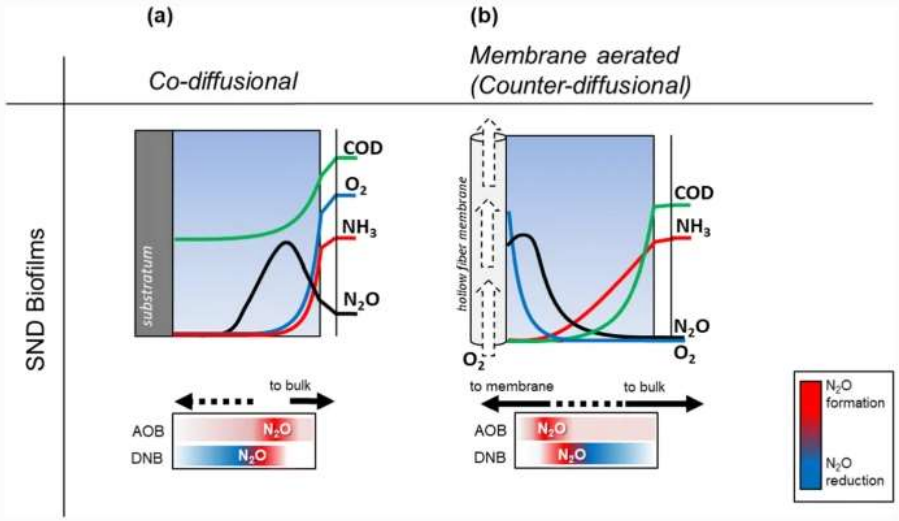
journal homepage: www.elsevier.com/locate/watres

Counter-diffusion biofilms have lower N_2O emissions than co-diffusion biofilms during simultaneous nitrification and denitrification: Insights from depth-profile analysis

Co Thi Kinh [a], Toshikazu Suenaga [a], Tomoyuki Hori [b], Shohei Riya [a], Masaaki Hosomi [a], Barth F. Smets [c], Akihiko Terada [a, *]

[a] Department of Chemical Engineering, Tokyo University of Agriculture and Technology, Naka 2-24-16, Koganei, Tokyo, 184-8588, Japan
[b] Institute for Environmental Management Technology, National Institute of Advanced Industrial Science and Technology (AIST), Onogawa 16-1, Tsukuba, Ibaraki, 305-8569, Japan
[c] Department of Environmental Engineering, Technical University of Denmark, Miljoevej, 2800, Lyngby, Denmark

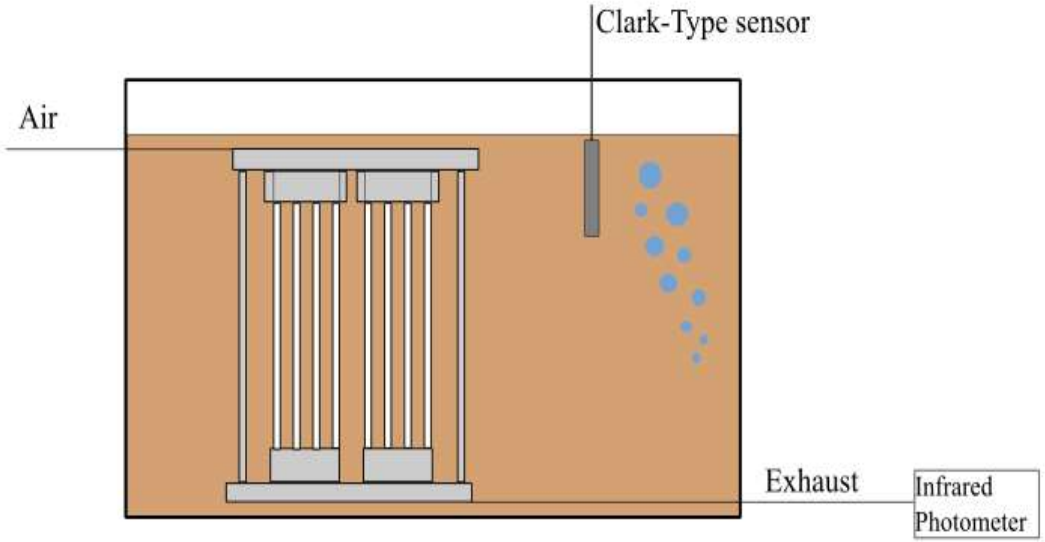
Fig. 7

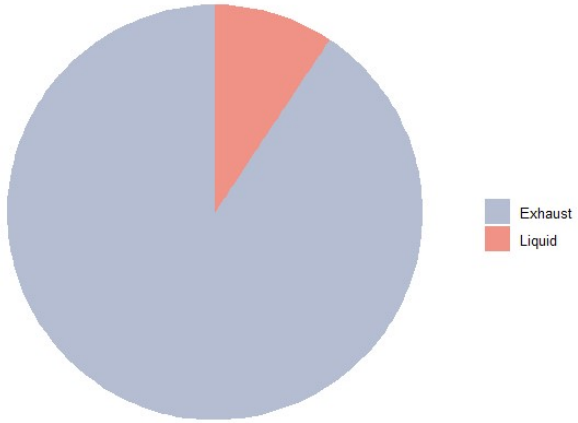


N_2O formation in combined nitrifying/denitrifying biofilms. **a** Co-diffusional and **b** counter-diffusional. Solid black arrow indicates N_2O loss towards either bulk or membrane lumen; dashed black arrow indicates reduction within the biofilm depth. NO_2^- and NO are not shown for clarity

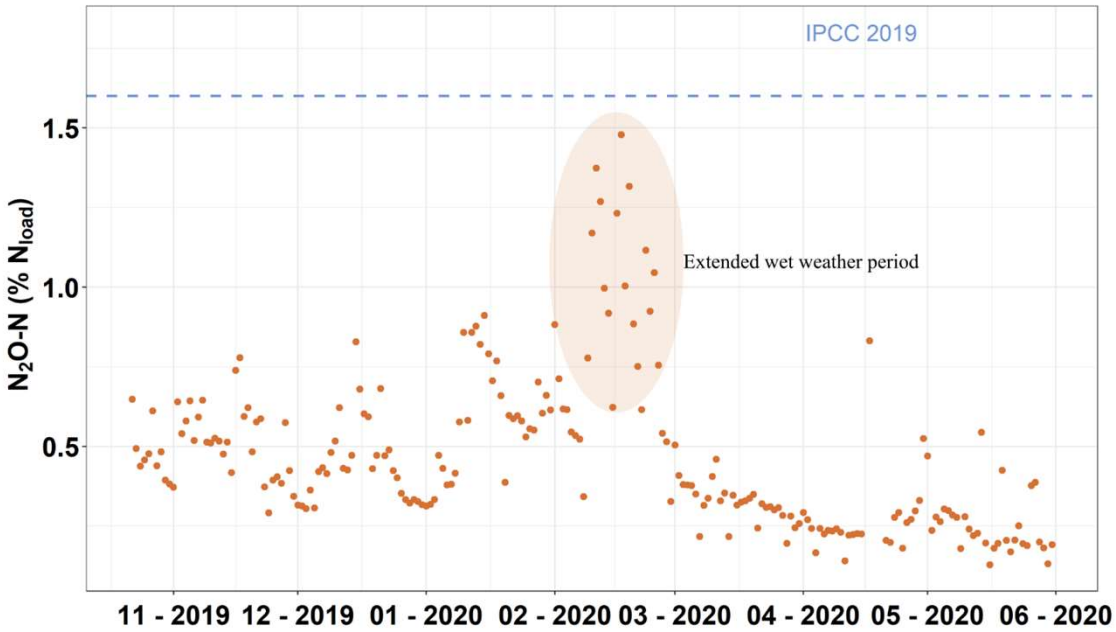
From: Sabba, F., Terada, A., Wells, G., Smets, B. F., & Nerenberg, R. (2018). Nitrous oxide emissions from biofilm processes for wastewater treatment. *Applied Microbiology and Biotechnology*, *102*(22), 9815–9829. https://doi.org/10.1007/s00253-018-9332-7

N_2O emissions predominantly in exhaust

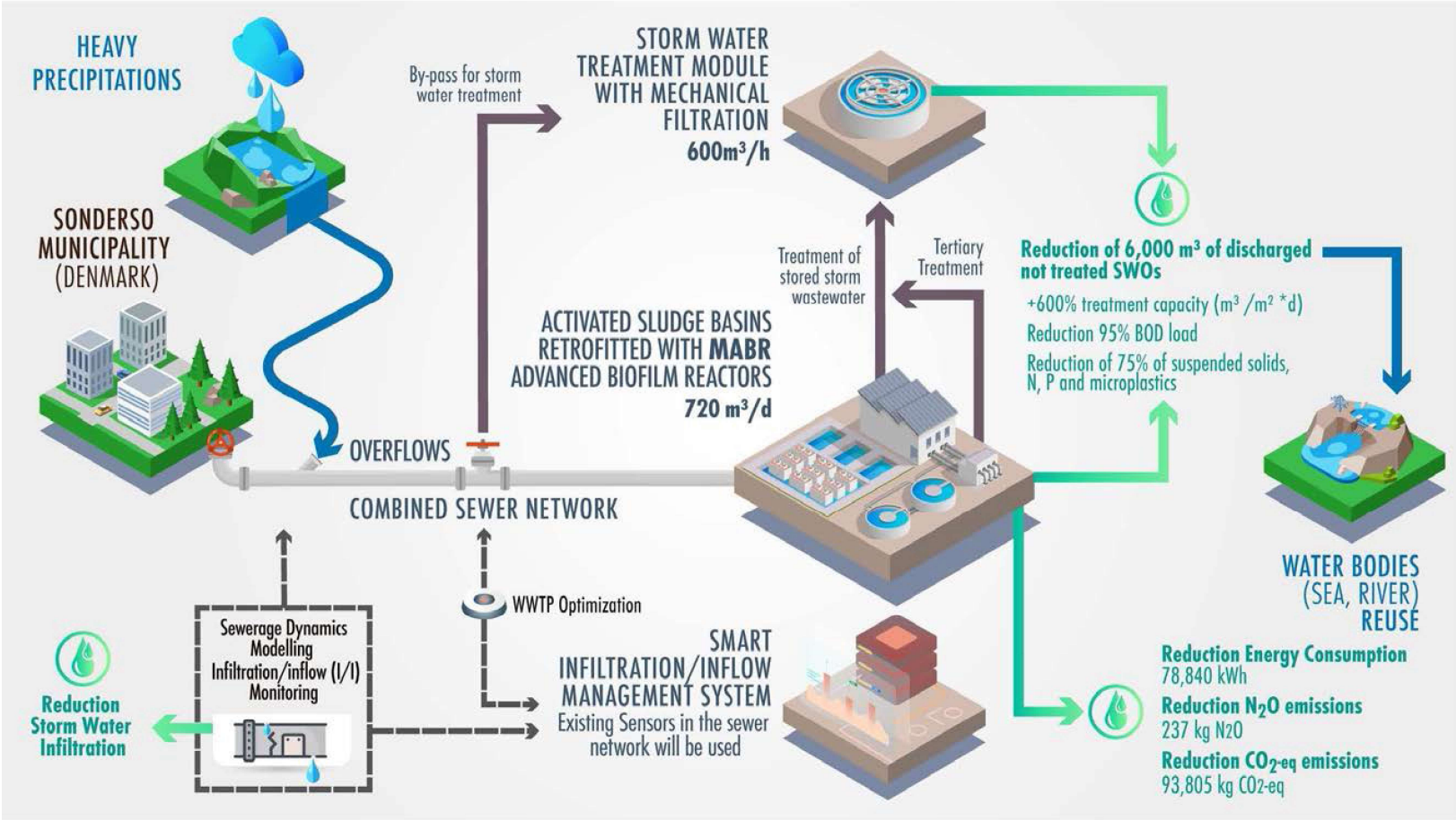




N_2O emission factor- preliminary data



Future: LIFE CCA_ES_001706



NACAT

mudp 2021

NACAT - N_2O Abatement by CAtalytic Treatment

VandCenterSyd Hillerød Forsyning EnviDan

TÅRNBYFORSYNING DTU HALDOR TOPSØE

Conclusions

- Challenges associated to anaerobic sluge feeding
- Significant energy savings
- Stable SND and nitrification rates 1-2 g N/m2/d-1
- Stable operation under wet weather periods
- Potential to achieve significantly lower N_2O emissions
- Future work: Life Reseau Project- larger demonstration

MABR technology

Nerea Uri Carreño
PhD student VCS/DTU

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