NEWEA 2021 Annual Conference

Membrane Aerated Biofilm Reactor (MABR) Technology Offers Resiliency and Sustainability to Nitrogen Removal Challenges

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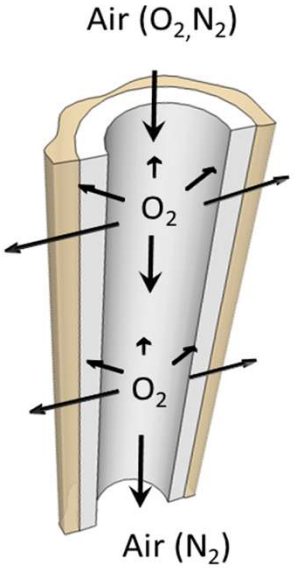
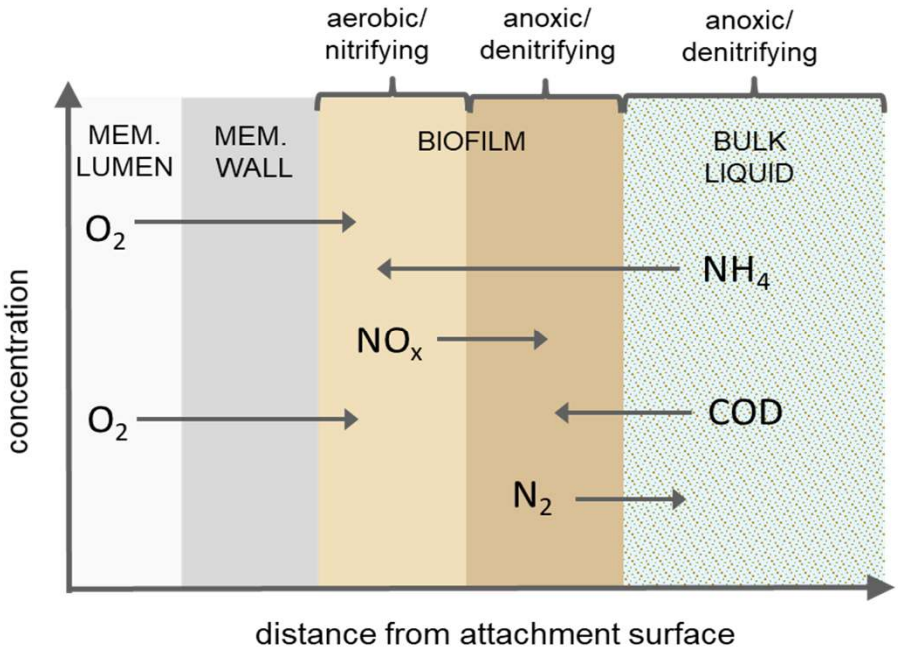
Outline

- Introduction to MABR
- Process Intensification
- Energy Efficiency and Resiliency
- Performance Data
- Summary

what is MABR

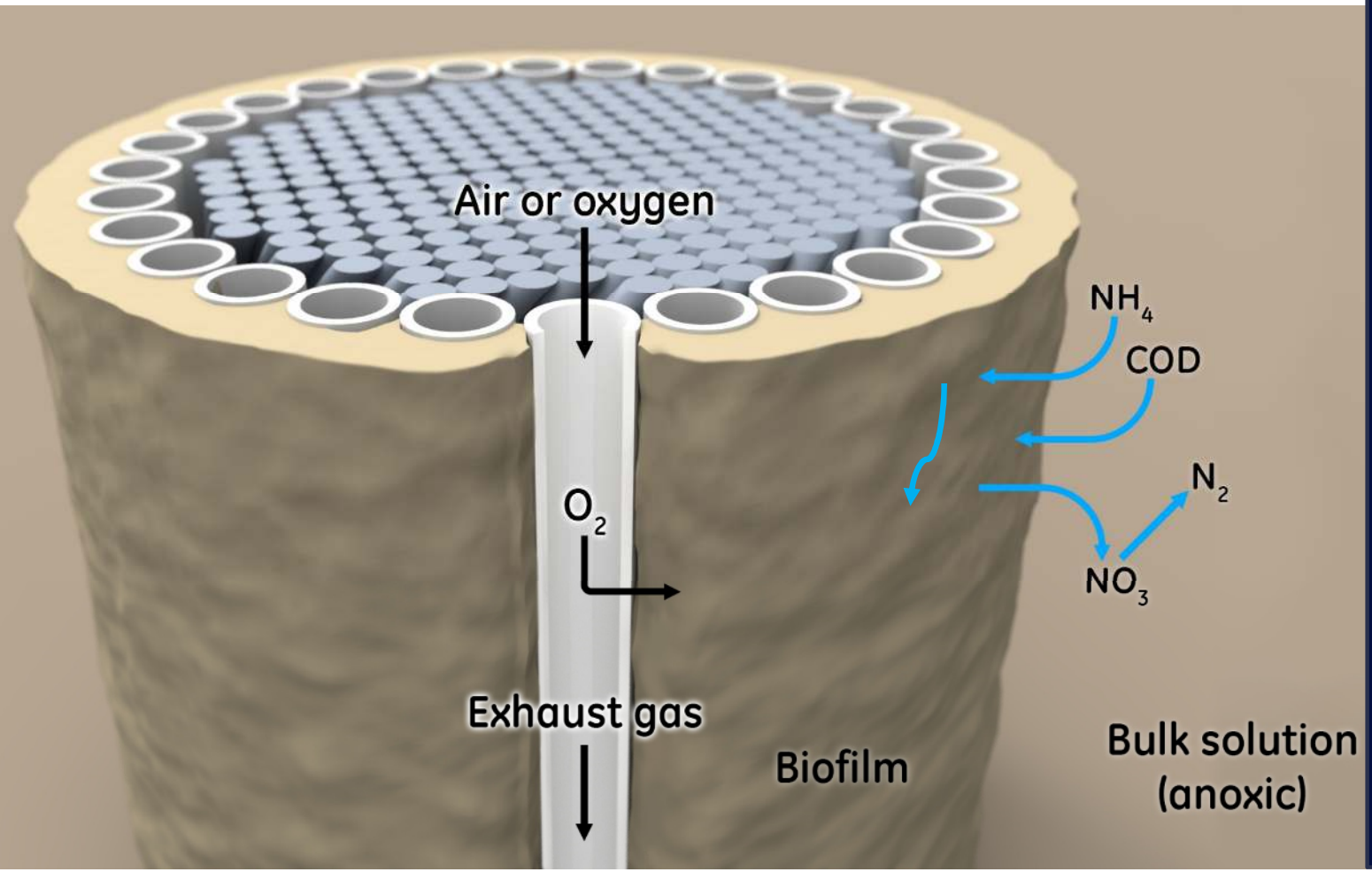




- media-supported biofilm with its own built-in O_2 supply
- counter-diffusional biofilm with “magical” properties

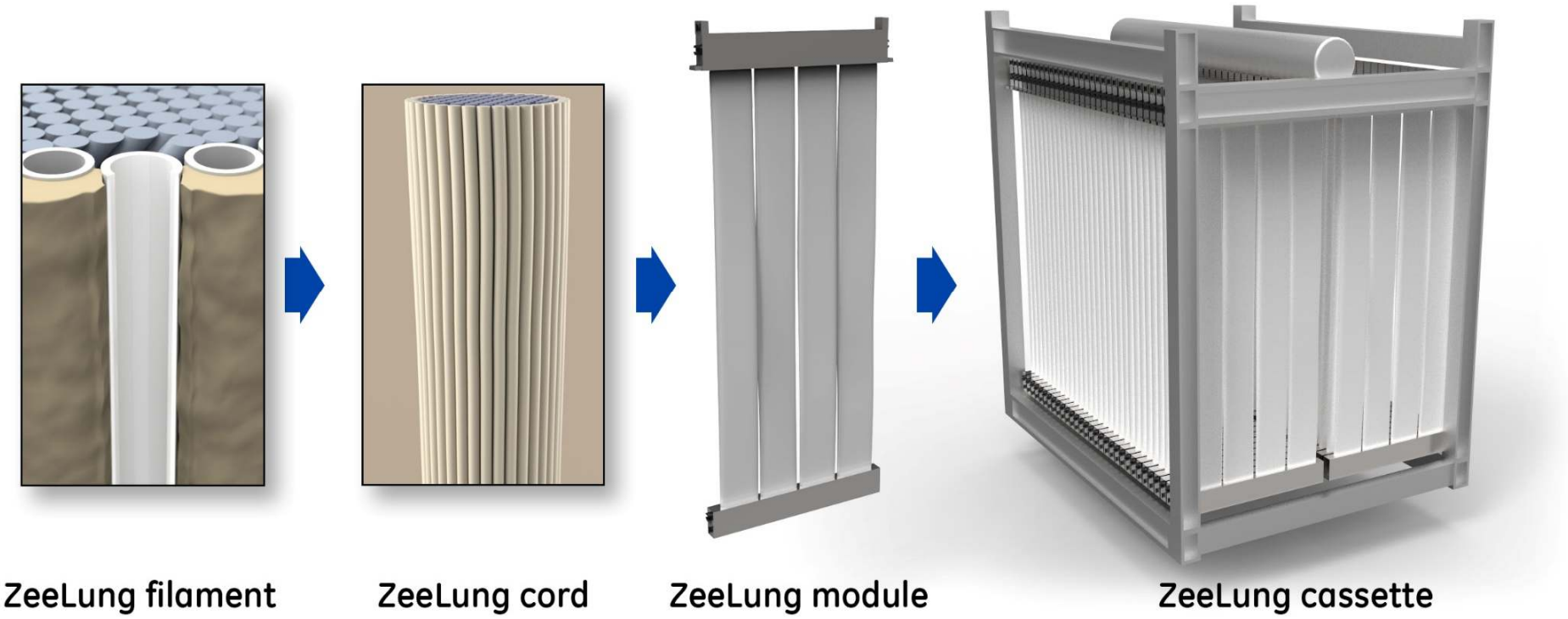
For more information on the unique properties of counter-diffusional biofilms see Downing and Nerenberg (2008) Applied Microbiology and Biotechnology, 81:153–162

MABR process

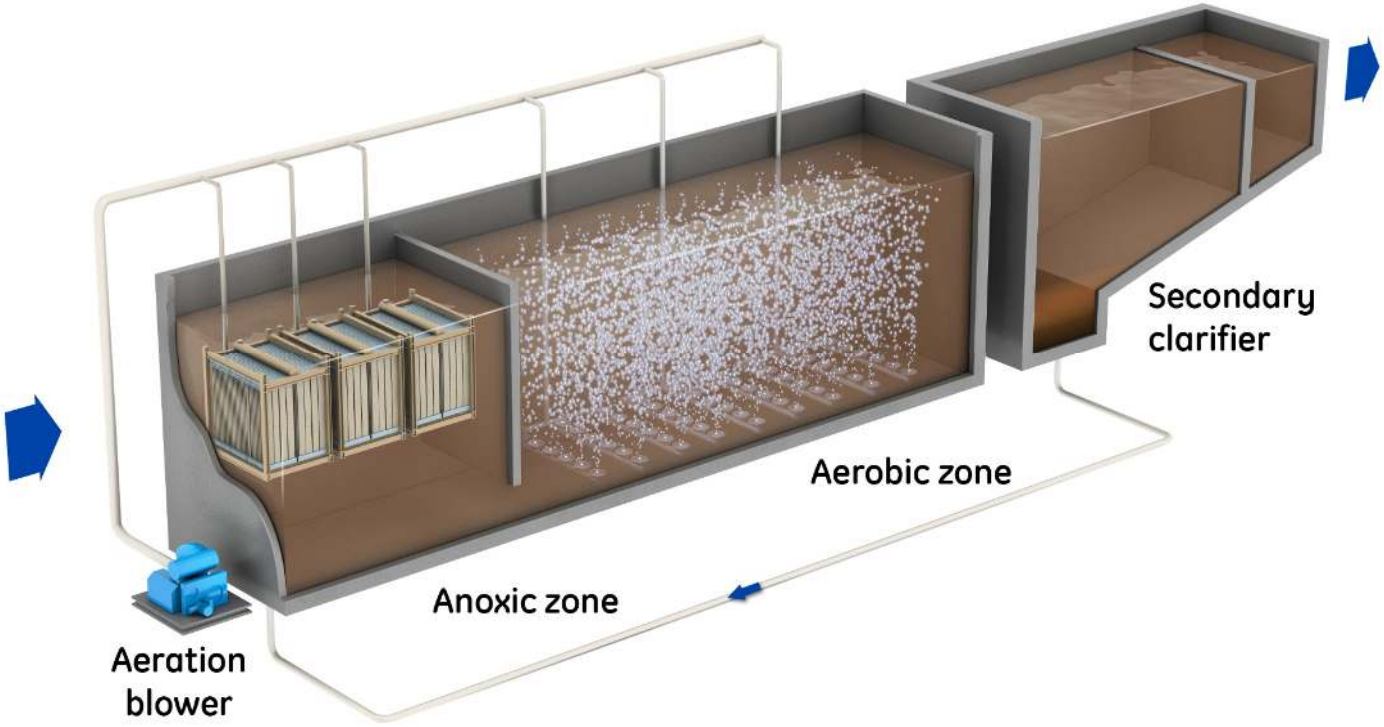


highest efficiency of oxygen transfer by diffusion of O_2 into a biofilm

ZeeLung product



ZeeLung cassettes are installed in the bioreactor



increased biomass inventory in existing volume enables nutrient removal & capacity expansion

Solving treatment challenges

- ✓ increase treatment capacity
- ✓ augment ammonia removal
- ✓ implement nutrients (nitrogen and phosphorus) removal
- ✓ high-strength ammonia streams
- ✓ Reducing operating energy expenses
- ✓ phased, modular implementation
- ✓ resilient treatment

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get more nitrifiers in the system

conventional de-bottlenecking

1. increase aerobic volume

⬇

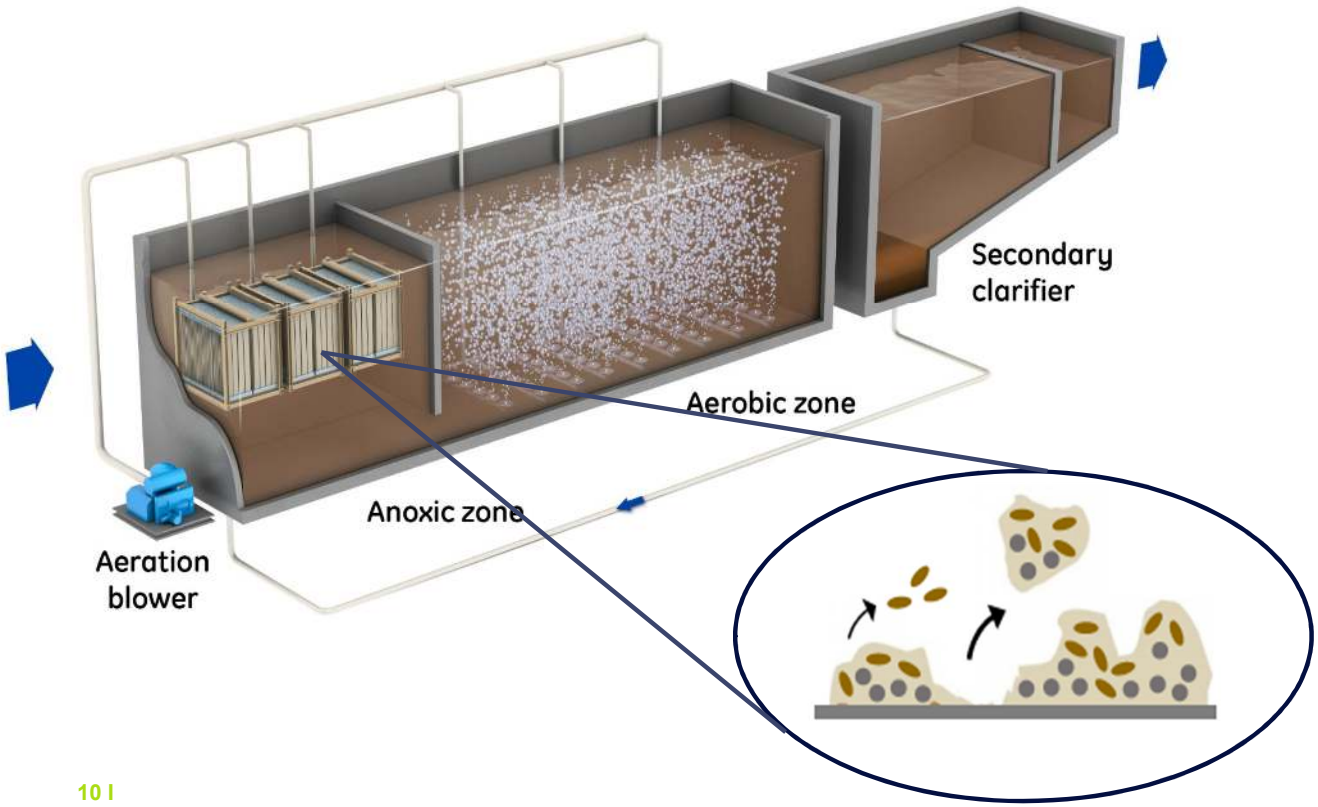
larger bioreactors

2. increase MLSS

⬇

larger clarifiers

process intensification by growing nitrifiers where they would not exist and by reducing aerobic SRT



hybrid system with nitrification in biofilm and suspended biomass

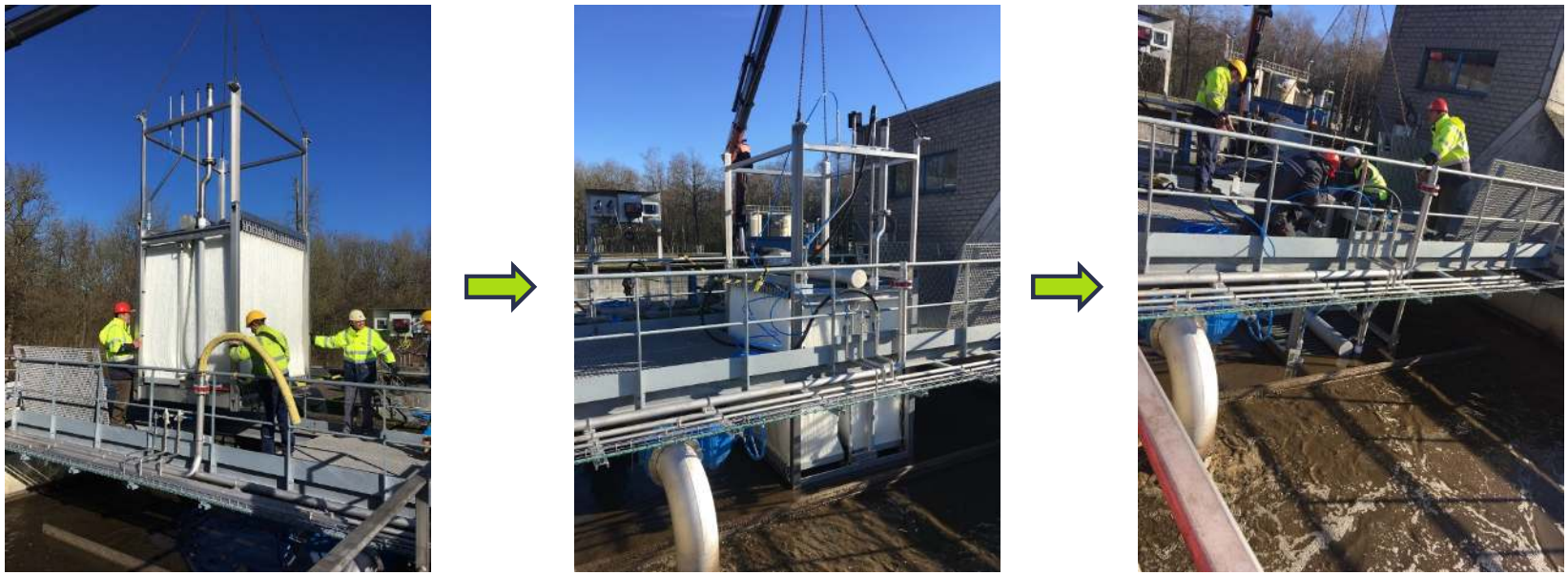
ZeeLung cassettes at the “front” of the process remove ammonia

ZeeLung biofilm is rich in nitrifiers (10X more than suspended biomass)

biofilm nitrification provides seeding of nitrifiers and reduces load to suspended growth… enabling lower aerobic SRT

MABR is a simple solution

- installed in existing tanks
- fast deployment
- no impact on hydraulic gradeline



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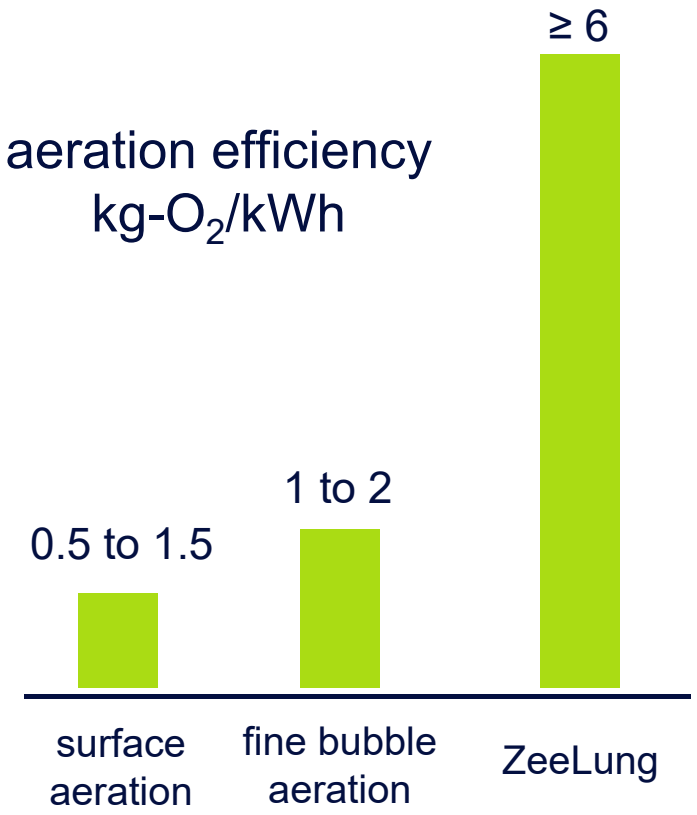
MABR saves energy

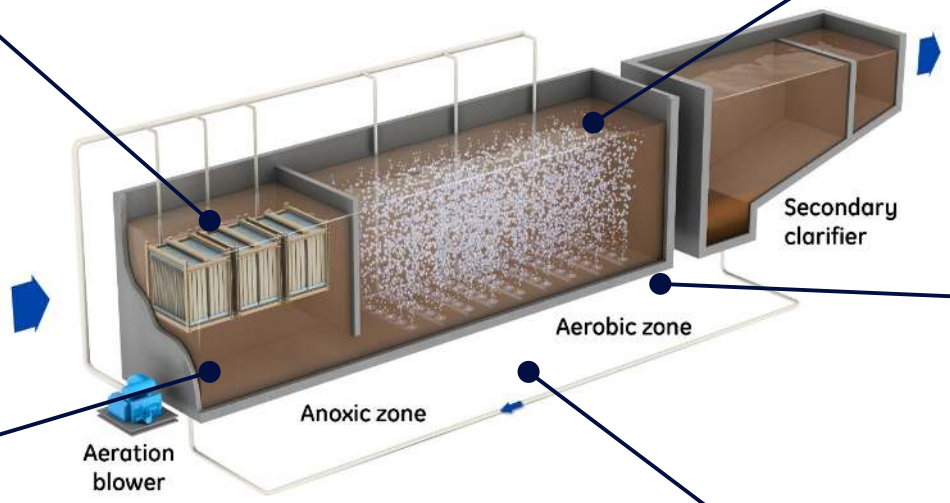
- transfer O_2 without bubbles
- 4X lower energy than bubble aeration
- reduce liquid pumping due to simultaneous nitrification & denitrification



MABR saves more than aeration energy

lower carbonaceous O_2 demand (at reduced SRT)

low energy for O_2 delivered by ZeeLung



lower energy for O_2 delivered by fine bubble aeration due to increased alpha

denitrification credit for SND in ZeeLung zone

no need for IMLR/NRCY pumping

MABR offers process resilience

- attached growth bacteria… not susceptible to washout
- rapid response to influent fluctuations
- stable cold temperature performance

MABR offers

hybrid system – treatment by biofilm and mixed liquor

biofilm is resistant to washout

low-energy process is easily backed-up with standby power

SND and ammonia peak trimming are passive… no reliance on sensors & controls

process resilience

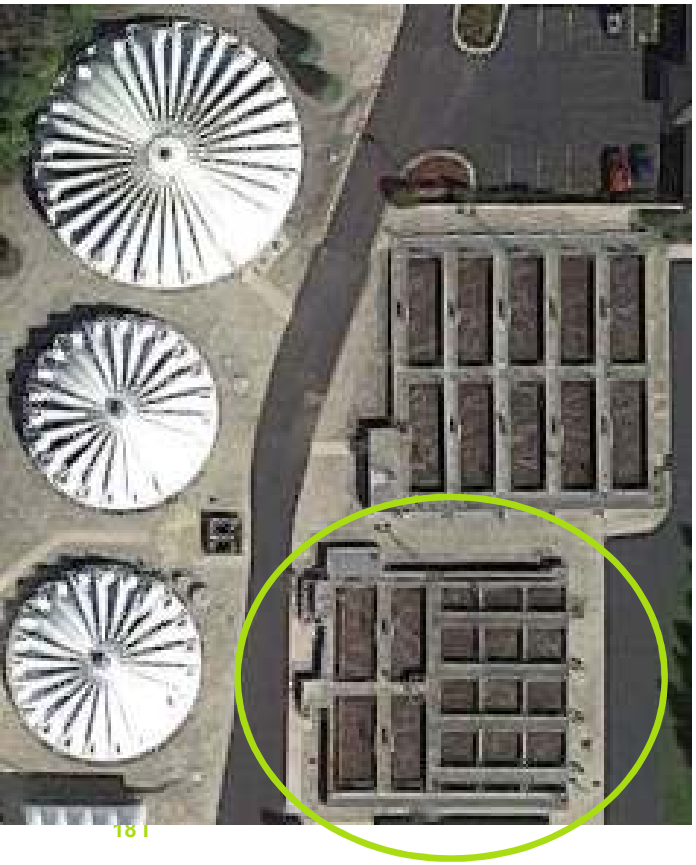
- ✓ ❑ performs well despite sensor or actuator failures
- ✓ ❑ recovers quickly after a shut-down
- ✓ ❑ can withstand extreme weather events
- ✓ ❑ resists biomass washout during high flow or even flooding events
- ✓ ❑ can run using standby power
- ✓ ❑ runs smoothly when the expert operator is on vacation
- ? ❑ runs smoothly when ???????

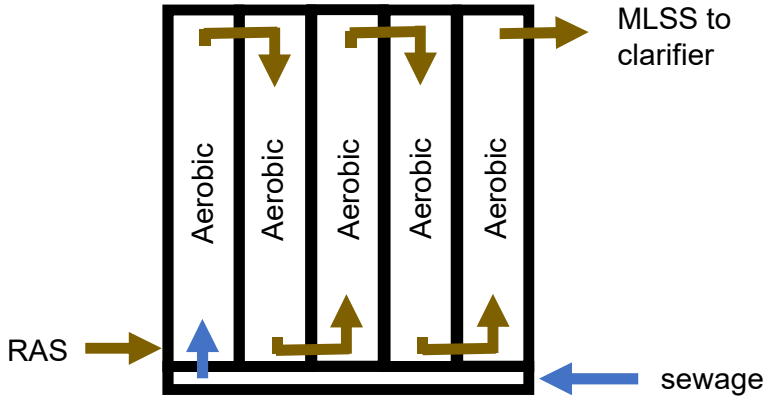
Yorkville-Bristol Sanitary District, IL
customer challenge

- CAS plant
- requires **upgrade** to treat **more load** (PE + industry) & meet **new TP limit**
- **footprint** constrained… CAS alternative requires new liquid line
- **time** constrained… new TP limit pending

Yorkville-Bristol Sanitary District

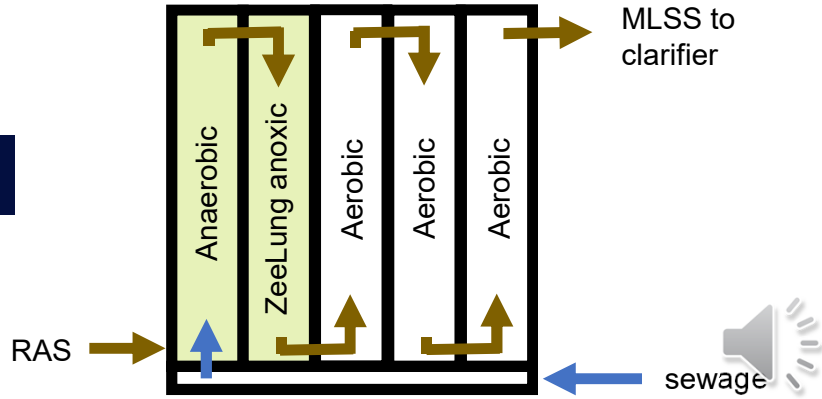
ZeeLung implementation





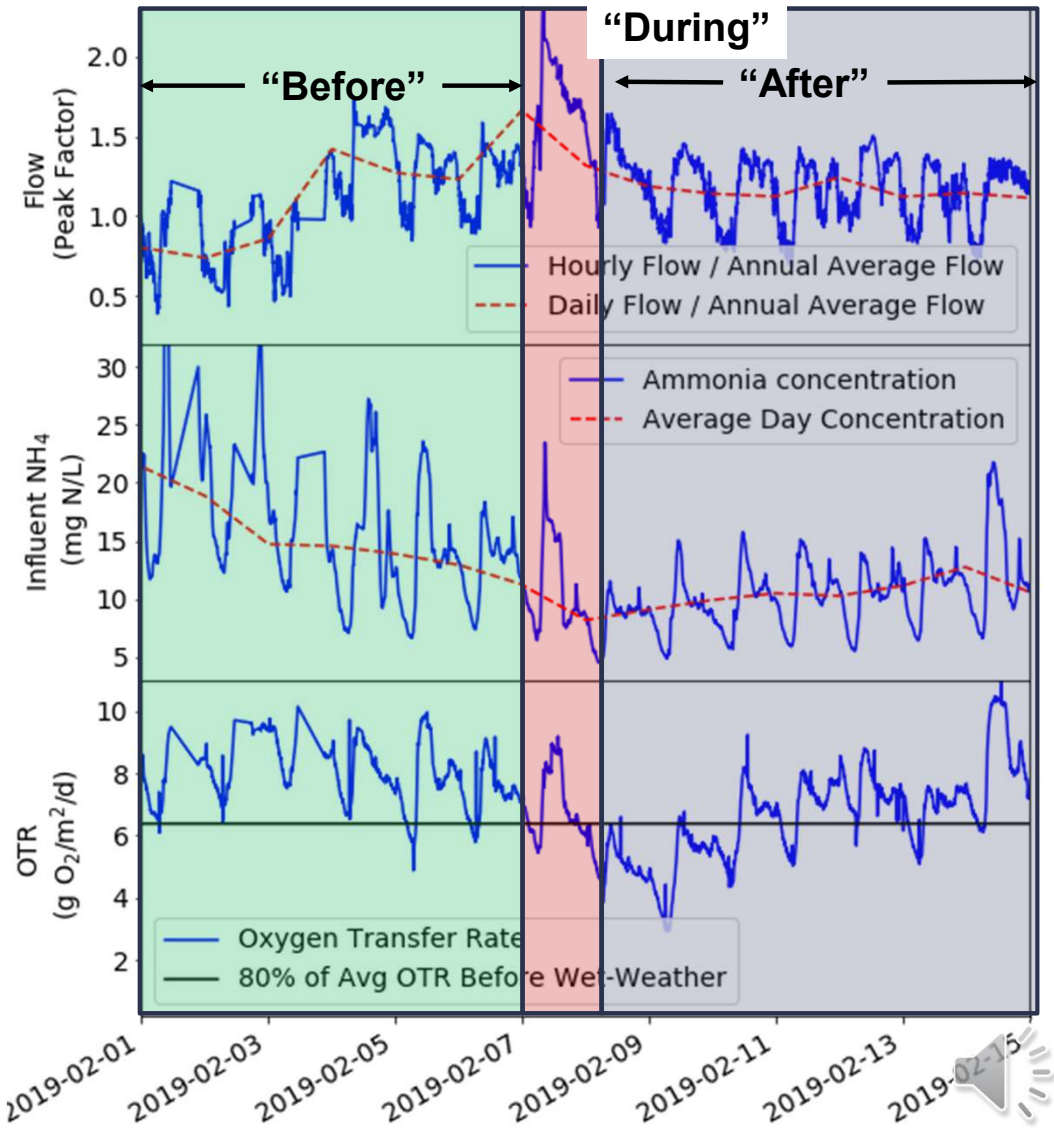
before upgrade

after upgrade



YBSD performance during wet weather

- very little loss of performance during the wet weather event
- performance drops below average the day following event due to weaker wastewater
- performance back to average in two days



Adelaide, ON - extended downtime demonstration

#	Test	Description	Results
1	24-hour shutdown	feed & mixing off for more than 24 h	immediate recovery of performance on startup
2	48-hour shutdown	feed & mixing off for more than 48 h	recovery of performance within 20 minutes of startup
3	24-hour flooding event	feed & mixing off, tank drained and then refilled with potable water to simulate flooding event	recovery of performance within 10 minutes of startup

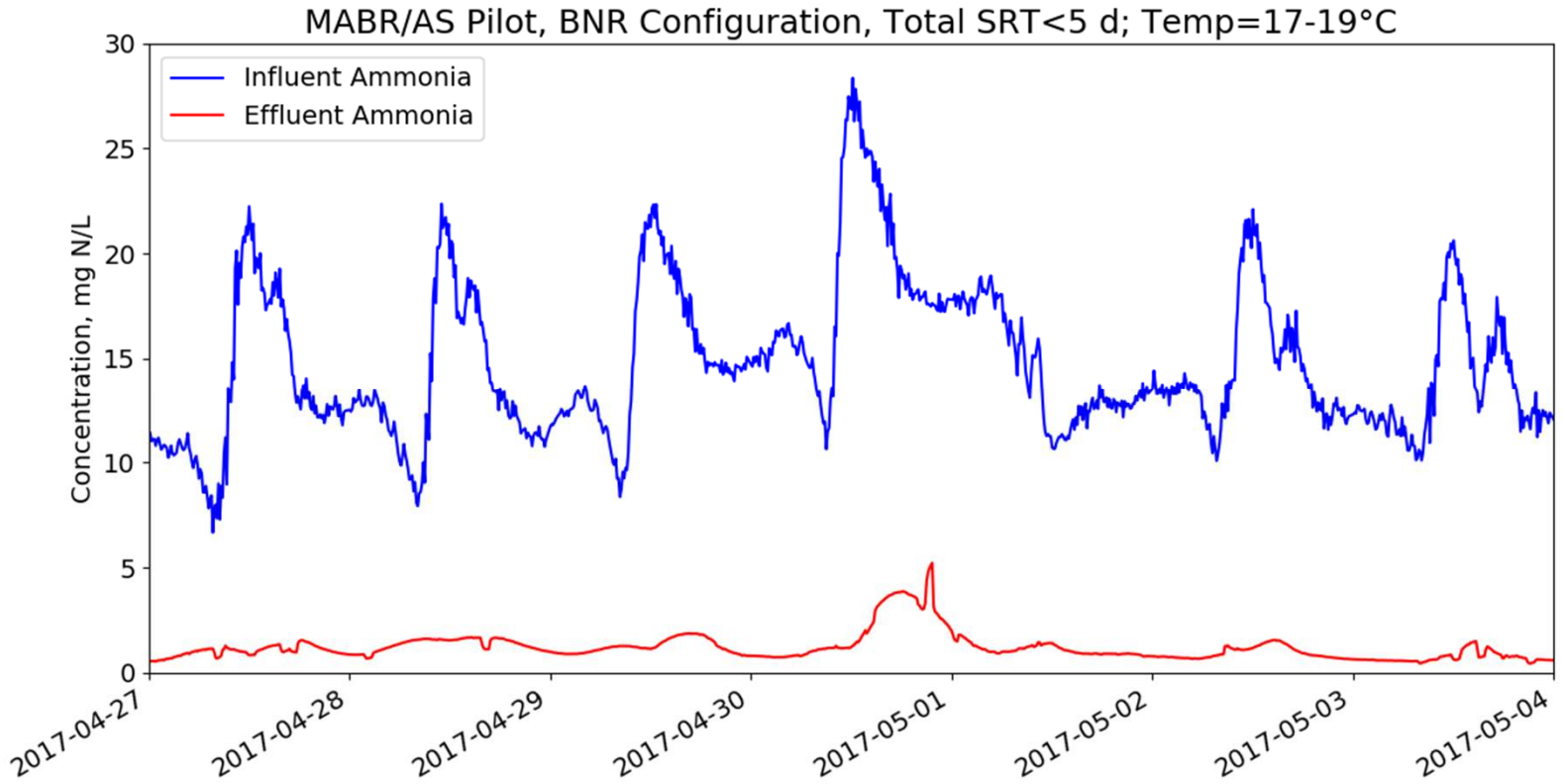
"in the timescales used for wastewater treatment (hours and days), this recovery period can be considered almost immediate"

For more details, see

- Houweling, Kaldate, Peeters, PNCWA, Portland, OR (2019) and

- Shaw et al, MABR- a new choice for resilient wastewater treatment, WEFTEC, Chicago, IL (2019)

Final Effluent Quality

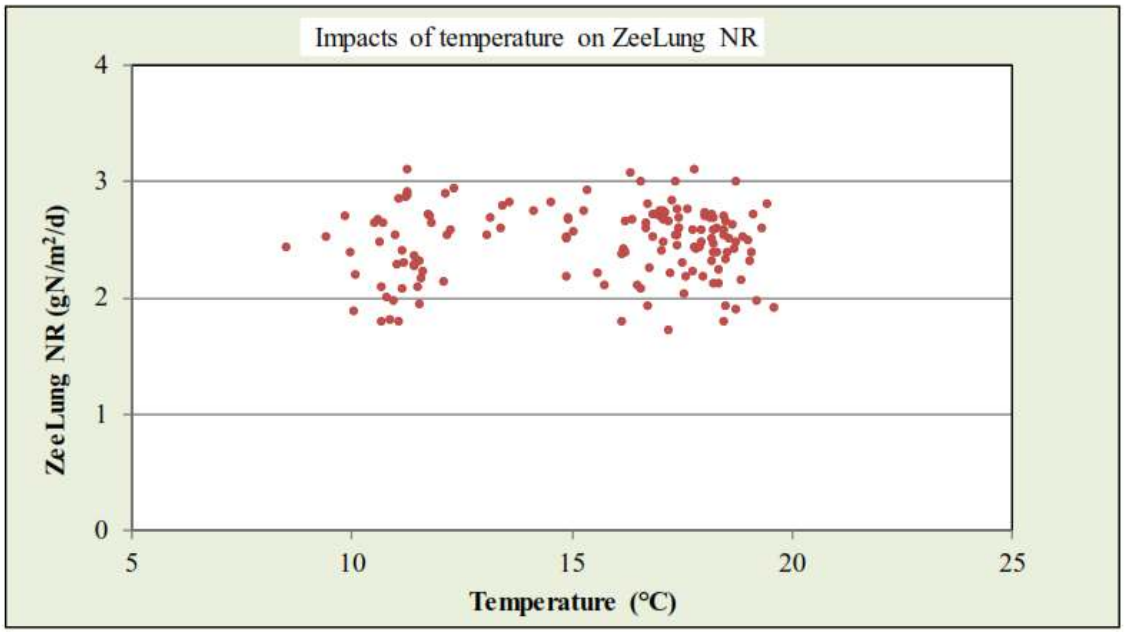


Final Effluent Quality of hybrid MABR/AS system demonstrated through:

- pilot results
- modeling

Resilience to temperature

- Pilot system run in the UK for one year
- Nitrification rates remained consistent despite dropping temperature in winter

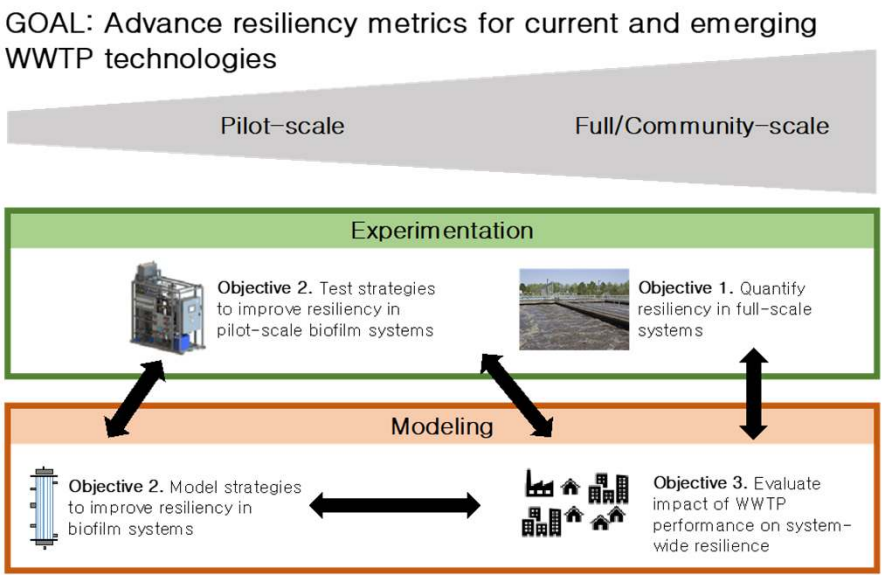


Reference: Sunner et al, MABR as a low-energy compact solution for nutrient removal upgrades – results from a demonstration in the UK , WEFTEC, New Orleans, LA(2018)

MABR Resilience - current work

- resilience is important for wastewater treatment infrastructure

- National Science Foundation funded project to investigate resilience
- includes MABR and MBBR pilots in Houston, TX
- Principle Investigator: Dr. Lauren Stadler, Rice University
- starts early 2020



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MABR performance indicators

Oxygen Transfer Efficiency (OTE):

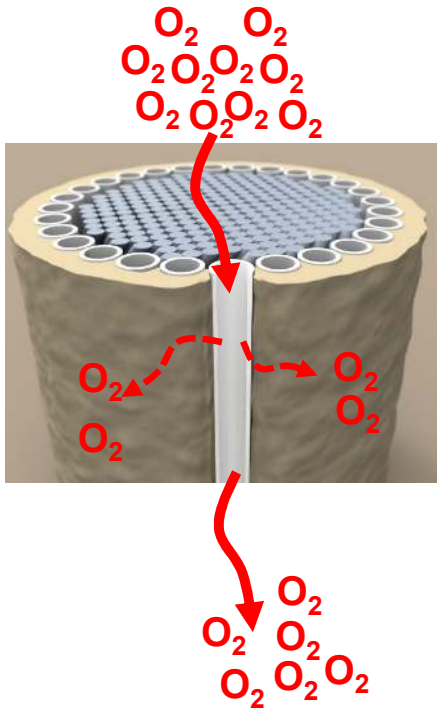
- % of O_2 in blower air that is delivered to the biofilm
- OTE 30-40% compared to 10-12% for Fine Bubble

Oxygen Transfer Rate (OTR):

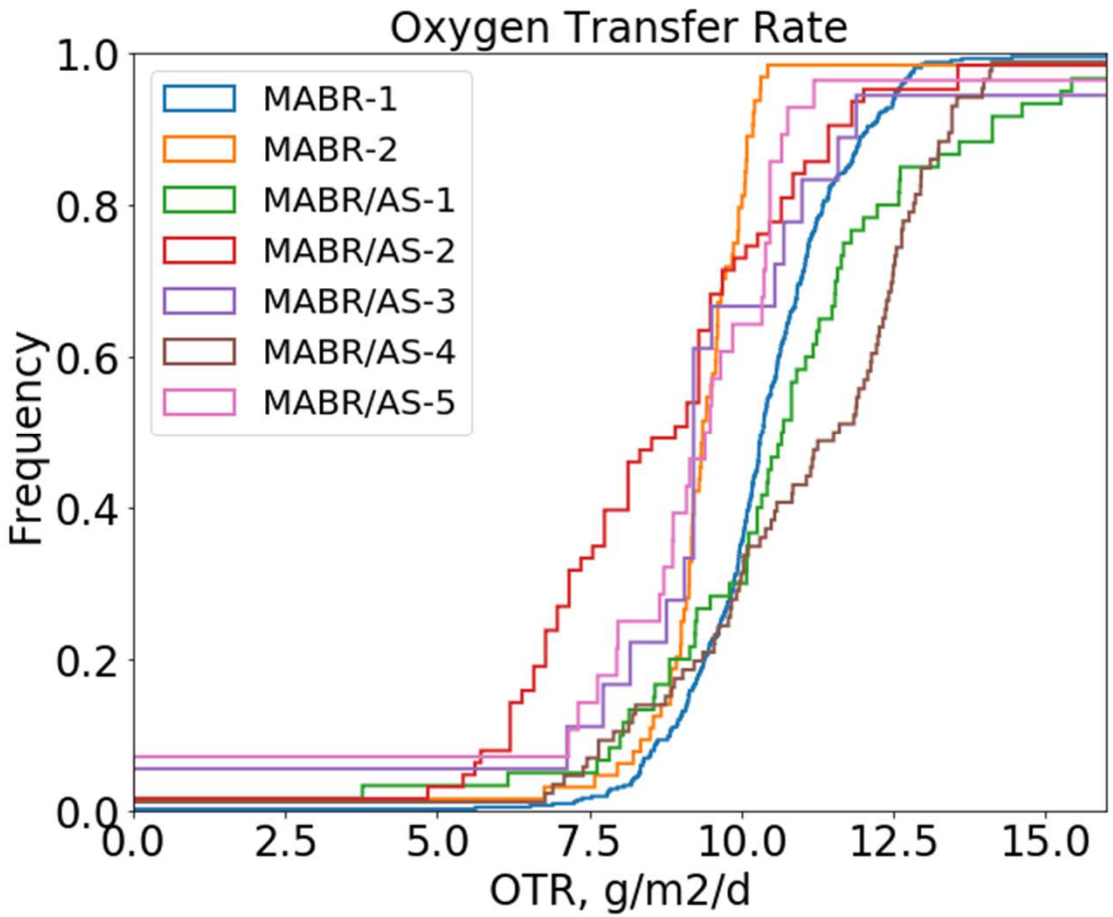
- Calculated from OTE and airflow
- Typically 8-12 g/m^2/d

Nitrification Rate (NR):

- NH_4 removed per unit surface area biofilm
- NR = 1.5-3 compared to NR ≈ 0.5 g/m^2/d for IFAS



Oxygen Transfer Rate (OTR)



Pilot	OTR
25th p.	6.8 to 10
50th p.	7.5 to 11.3
75th p.	8.7 to 12

Chicago MWRD demonstration

drivers for Chicago MWRD

- future P limits… preference to implement biological P removal
- construction of new tanks is costly and disruptive
- nitrification is challenged under stressed (cold) conditions
- commitment to be energy neutral

demo results

- ZeeLung intensifies N removal… potential to enable biological P removal in existing tanks
- N removal not impacted by cold temperatures
- 30% aeration energy savings with 40% potential

0.5 MGD (2 MLD) demo operated June 2015 – June 2016

Summary - Closing Thoughts

- MABR solves big challenges- nutrients, sustainability, footprint
- Benefits include resilience, simplicity and ease of implementation

- MABR is inherently resilient due to:
  - fixed nature of the biofilm (resistant to washout)
  - low energy process easily backed up on standby power

- MABR resilience demonstrated:
  - wet weather events at YBSD, IL
  - shutdown events at Adelaide, ON

- MABR provides SND and ammonia-load peak trimming without any reliance on sensors or actuators

THANK YOU!

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