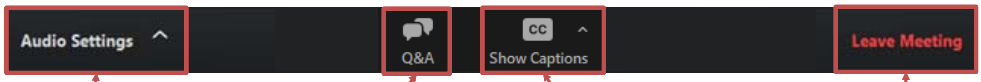
1

How to Participate Today



Audio Settings
Adjust your speaker output (You can also optionally join via phone audio – check the confirmation email for details)

Submit your questions using the Questions pane.

Enable auto-caption feature
(May not be 100% accurate)

Leave the webcast early

A recording will be available for replay shortly after this webcast.

Water Environment Federation
the water quality people

2

RISE
Research and Innovation for Strengthening Engagement

Research & Innovation Forum VIII:
What's all the fuss about MABR?
March 7, 2023 – 11:00-12:30 Eastern

3

Research and Innovation for Strengthening Engagement (RISE)

RISE supports the core value of accelerating adoption of innovative technologies within the water industry, integrating utilities, academics, and consultants in the discussion.

Contact Fidan Karimova (FKarimova@WEF.org) for more information or to join any of these groups

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RISE Focus Groups

Algae-based Treatment Processes
Chair: Craig Just, University of Iowa
Vice Chair: Ron Patel, Hernando County Utilities Department
Vice Chair: Embrey Bronstad, Washington State University

Digester Mixing Technologies and Full-scale Applications
Chair: Ana Pena-Tijerina, Plummer

Hydrothermal Liquefaction
Chair: Craig Just, University of Iowa
Vice Chair: Simon Lobdell, Orange Water and Sewer Authority

Improvements on Pre-digestion Hydrolysis Processes
Chair: Tom Nangle, Brown and Caldwell
Vice Chair: Rashi Gupta, Carollo
Vice Chair: Xavi Fonoll Almansa, Great Lakes Water Authority

Mainstream Carbon Efficient Nitrogen Removal through PdNA
Chair: Stephanie Klaus, Hampton Roads Sanitation District

Membrane Aerated Biofilm Reactor (MABR)
Chair: Jeff Peeters, Suez
Vice Chair: Yueyun (Bridget) Tse, Black & Veatch
Vice Chair: Per Henrik Nielsen, VandCenter Syd

Soft Sensors and Machine Learning Possibilities and Applications
Chair: Aditya Ramamurthy, Kennedy Jenks
Vice Chair: Fenghua Yang, MWRD Greater Chicago
Vice Chair: Jennifer Loudon, Intelligent Water Services

Water Reuse
Chair: Ana Pena-Tijerina, Plummer
Vice Chair: Mahmudul Hasan, Baltimore City Department of Public Works
Vice Chair: Jeff Mosher, Santa Ana Watershed Project Authority

Contact Fidan Karimova (FKarimova@WEF.org) to join one of the groups above

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Future RISE Events

- **March 13** – RISE Red Bull Session on PdNA
- **March 20-22** – WEF Forum 2023 in Cary, NC
- **April 18** – RISE Forum IX: Hydrothermal Liquefaction (HTL)
- **June 5-8** – Innovations in Process Engineering (IPE) in Portland, OR
- **June** – RISE Red Bull Session on Renewable Natural Gas (RNG)

Contact Fidan Karimova (FKarimova@WEF.org) for more information

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Today's Agenda

1. RISE Introduction – **Pusker Regmi, Brown and Caldwell**
2. Introduction – **Jeff Peeters, Veolia Water Technologies and Solutions**
3. Yorkville Bristol Sanitary District – **Cyrus McMains, Executive Director (USA)**
4. eThekwini Water and Sanitation – **Lunga Patso, Process Engineer at MEB Energy (South Africa)**
5. Severn Trent – **Pete Vale, Carbon & Circular Economy Architect (UK)**
6. Watercare Services Limited – **Kevan Brian, Innovation Specialist (New Zealand)**
7. Q&A - **Per Henrik Nielsen, VCS Denmark**

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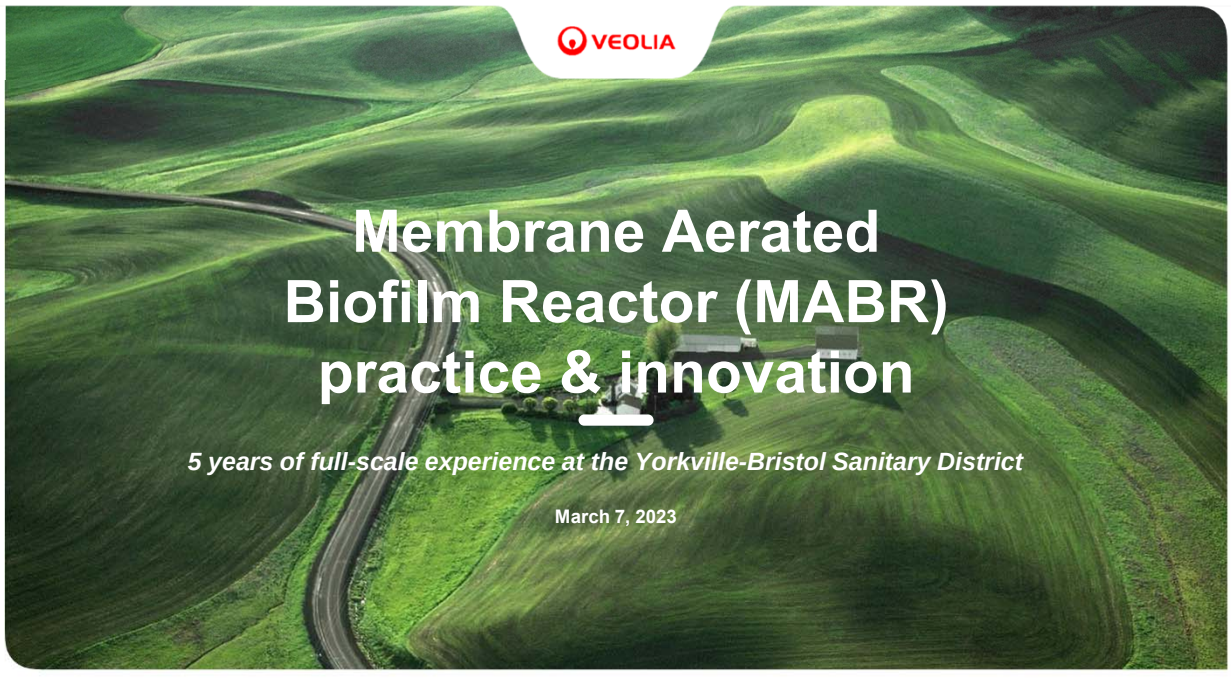

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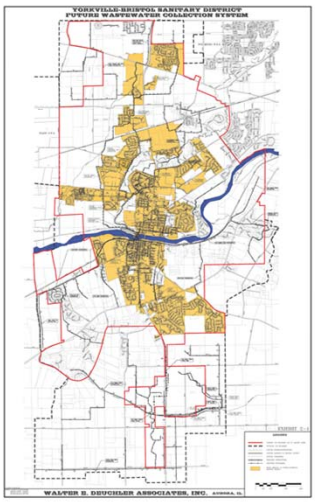
Yorkville-Bristol Sanitary District
PLANT OVERVIEW

- Formed in 1955
- Currently serves approximately 22,000 people
- 33.8 square mile FPA
- 14.3 miles interceptor sewer
- One wastewater treatment facility
  - Built in 1957
  - Expanded last in 2002
  - 3.62 MGD DAF
  - MABR upgrade for Nutrient Removal & Increased BOD capacity in 2017



ZeeLung MABR

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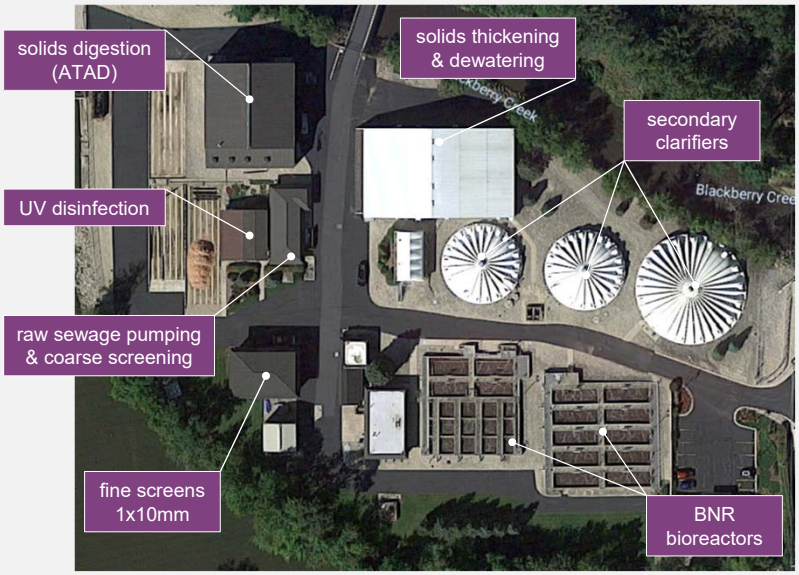
Yorkville-Bristol Sanitary District
PLANT LAYOUT



ZeeLung MABR

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Yorkville-Bristol Sanitary District
MABR UPGRADE PROJECT DRIVERS

- New Total Phosphorus (TP) Effluent Limit
  - Annual Average TP of 1.0 mg/L
- Rapid population increase affect on per capita Influent Loading:
  - BOD increase
    - 2001 Avg. Loading: 157 mg/L
    - 2012 Avg. Loading: 215 mg/L
  - Industrial Dischargers
    - High strength: 10% of BOD capacity
    - Low flow: 1% of Hydraulic capacity

- Site Constraints
  - Existing treatment site is built-out
  - Any significant capacity increase will require construction of a new treatment facility west of Blackberry Creek

ZeeLung MABR

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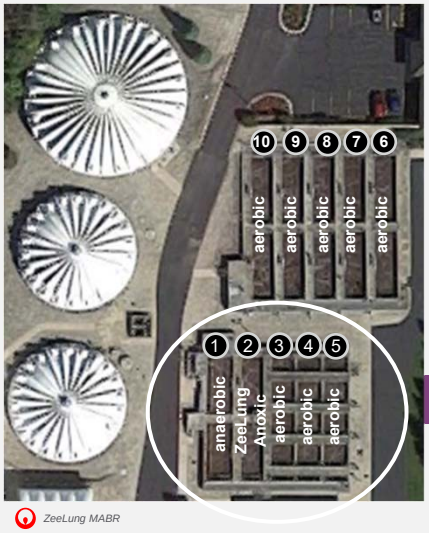
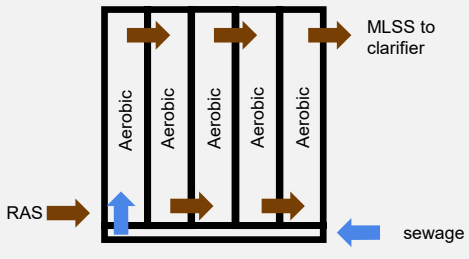
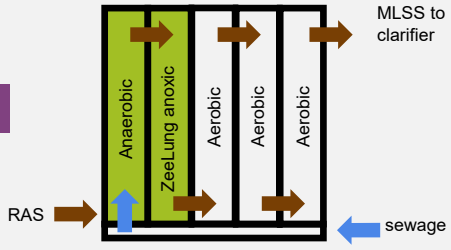
Yorkville-Bristol Sanitary District
ZeeLung MABR IMPLEMENTATION





before upgrade

after upgrade



ZeeLung MABR

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Yorkville-Bristol Sanitary District
IMPACT OF MABR UPGRADE

- increased BOD treatment capacity in existing footprint
- implement with biological P removal
- no net increase in energy consumption

- CAPEX 75% less than building new secondary treatment line
- design & construction in <18 months

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VEOLIA

Performance Results at the Yorkville-Bristol Sanitary District

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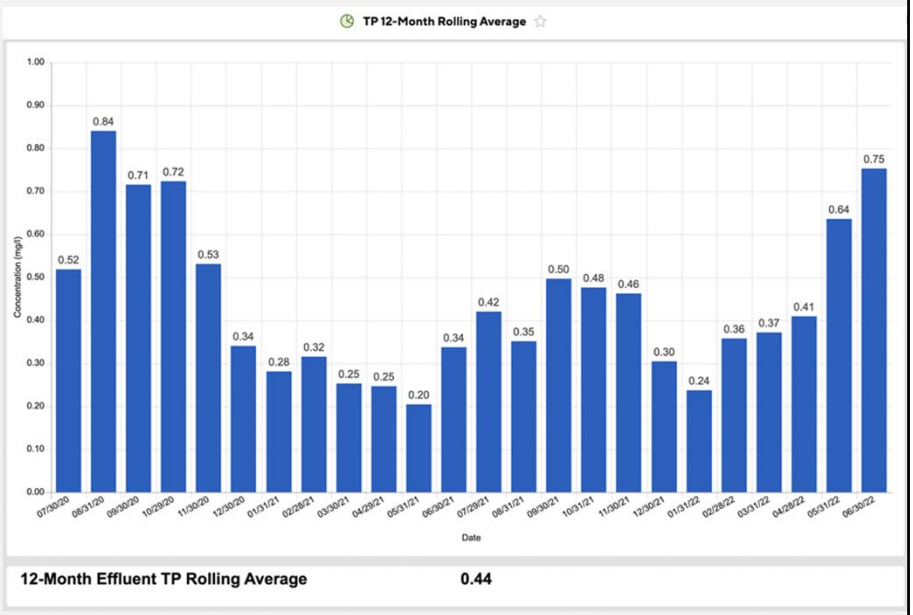
Yorkville-Bristol Sanitary District
PHOSPHOROUS RESULTS



12-Month Effluent TP Rolling Average **0.44**

ZeeLung MABR

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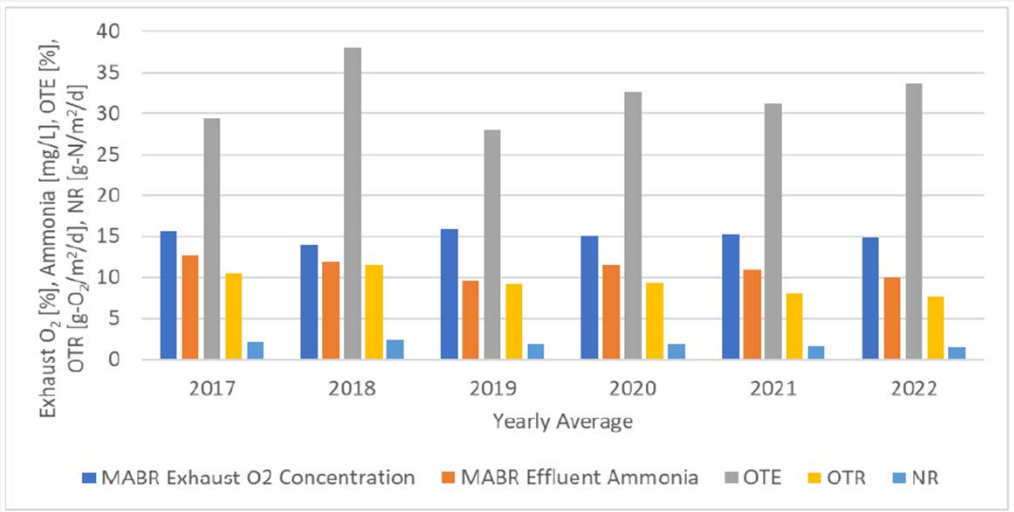
Yorkville-Bristol Sanitary District
ZEELUNG PERFORMANCE



ZeeLung MABR

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Yorkville-Bristol Sanitary District
LESSONS LEARNED AFTER 5 YEARS OF OPERATION

- minimal maintenance - no cleaning, special tools, etc.
- MABR cassettes are resilient, e.g.; industrial load
- air scour frequency/duration is an operations lever
- exhaust O2 data provides valuable insights
- system integration is important, e.g., freeze protection, air supply, scada, mixing

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IS MABR TRANSFORMATIONAL?

- YES!
- a “smarter” intensification solution
  - drop-in, easy implementation
  - low maintenance
  - online process monitoring (exhaust O_2) and control
  - energy reduction
  - … for the right application, this can save utilities $$ and space
- more to come? for example, coupling with other intensification solutions to intensify even further (zeeDENSE)

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MABR Technology

DIRECT POTABLE WASTEWATE REUSE PROJECT

Durban, KZN, South Africa

07 March 2023

21

A Global company, operating in South Africa since 2010, with 20 years experience in the field of Oil & Gas, Water, Telecommunication, Power & Energy.

- Swiss Headquartered. Effective management and implementation of complex projects.
- Extensive know how and proven track record worldwide.
- Exclusive Strategic Business Partnership with a leading worldwide vendors, offering Innovative technology.

A Global company with a global team of engineers, scientists, and professionals passionate about changing the world of water through innovative, sustainable technologies.

- US headquartered. Listed on Australian Stock Exchange (FLC:ASX)
- Leading global company of decentralized water and wastewater treatment solutions.
- Provides water and wastewater treatment solutions across three complementary segments.

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What was the problem to be solved?

- More than half of South Africa's sewage treatment works are failing.
- The recent Green Drop report reveals that wastewater compliance has plummeted since the last report.
- Just **2.3%** WWTWs assessed have qualified for the prestigious Green Drop certification.
- Billions of liters of raw or partially treated waste empties into our rivers and the sea every year.

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What was the problem to be solved?

- South Africa is a water scarce country. It ranks as one of the 30 driest countries in the world with an average rainfall of about 40% less than the annual world average rainfall.
- There is a growing demand for clean water, however local supplies are diminishing due to climate change, population growth, drought, and economic growth.
- South African municipalities are considering ways to make the most of their water resources.

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Why did you choose MABR as the solution?

- Modular, easily expanded to treat higher flows as and when required.
- Reliable high effluent quality at very low consumption of electricity.
- Simple to operate by non-skilled operators.
- Low chemicals consumption.
- Very low noise and odour free operation.
- Low maintenance requirements.
- No membrane backwash or chemical cleaning of the membrane.
- Membrane life expectancy of over 20 years.
- Operating costs up to 50% lower than with conventional treatment.

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Why did you choose MABR as the solution?

- Evaluate MABR Technology's effectiveness for biological treatment of wastewater in South Africa.
- Compare MABR and Conventional Activated Sludge process performance, OPEX, and sludge production.
- MABR can be used to upgrade municipal treatment facilities to reach higher effluent standards and volumes using the existing reactor.

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Challenges

- COVID-19 travel restrictions made it challenging for project managers from abroad to visit the site.
- July 2021 civil unrest in KZN made it challenging for MEB's O&M personnel to visit the site, the plant was monitored and operated remotely for system optimisation.
- South Africa power crisis i.e. plant operation being affected by ongoing load-shedding.

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What are the top 3 lessons you've learned (good & bad)?

- MABR's effluent quality meets highest regulatory standards enabling sustainable reuse.
- MABR highly effective biofilm process protects from load shocks and low temperature.
- MABR biofilms are different.
- MABR process is based on Ammonia removal, it's essential and nothing will happen without it.
- Not relevant for removal of Nitrate only (fertilizers / cooling towers / other).

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Why do you think the technology has the potential to be transformational?

- Full effluent quality compliance with significant energy savings.
- Much more energy efficient, energy prices in South Africa keeps on rising.
- No need for high energy air scouring, supplemental mixing and periodic chemical cleaning.
- Simple to operate, maintain, and upgrade.
- Small footprint and minimal civil works.
- Existing WWTPs continue to struggle to comply with no capacity for expansion.
- Customized to customer's needs and requirements.

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Performance

- Secondary effluent quality meets the General Limits requirements of the National Water Act (1998) for discharge of wastewater into a water resource.
- Secondary effluent meets the requirements of the National Water Act (1998) for irrigation of any land or property up to 2000 cubic meters.

Parameter	Units	Influent	Effluent	General Limits	Removal
NH4	mg/l	44	0.57	6	99%
NO3	mg/l	<0.50	<0.50	15	-
COD	mg/l	2775	35	75	99%
BOD	mg/l	1320	18	-	99%
TSS	mg/l	3300	7.0	25	100%
TP	mg/l	45	5.7*	10	87%
TKN	mg/l	176	<5.0	-	>97

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Influent vs Effluent

33

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THANK YOU!

The Boulevard, 19 Park lane
Parkside, Umhlanga
4319 , South Africa

Tel: +27 (31) 100 1200
Email: info@meb.sg

www.meb.sg

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MABR at Spernal WwTP, UK

7th March 2023
Pete Vale

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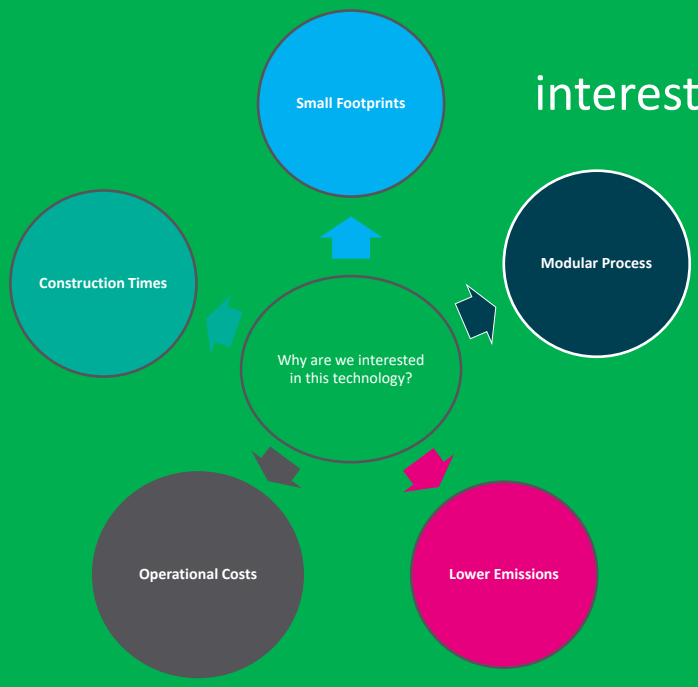
Why are ST interested in MABR



SEVERN TRENT

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EARLY WORK (MINWORTH WWTP)

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ST Classification: OFFICIAL SENSITIVE

Development of the Oxymem MABR process at Minworth STW 2013 - 2015

Version 1 – 2013

Demonstrator (500PE)

- 2014 - 2015
- 70m^3/d

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ST Classification: OFFICIAL SENSITIVE

MABR TRIALS AT OUR INNOVATION CENTRE (STW SPERNAL)

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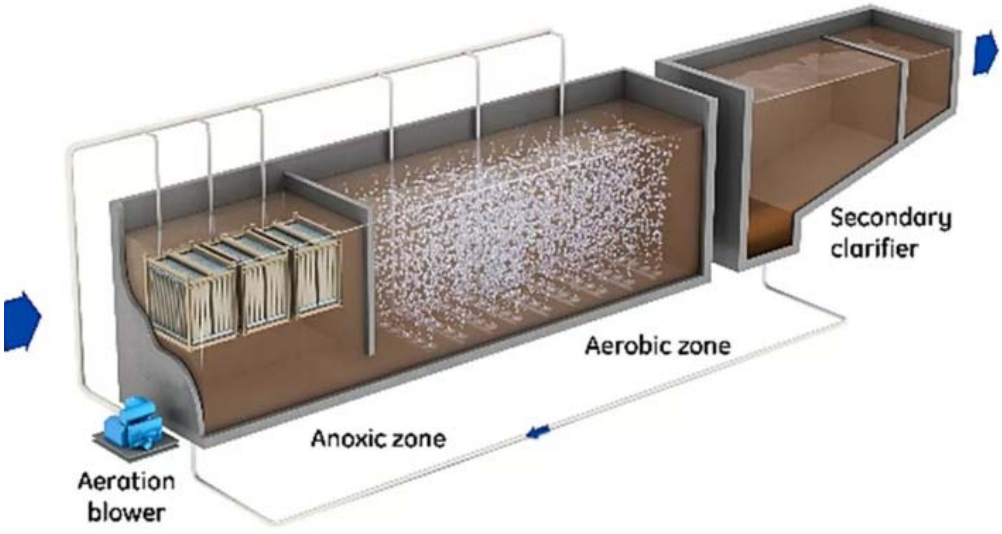
Configuration



Typical hybrid MABR process configuration

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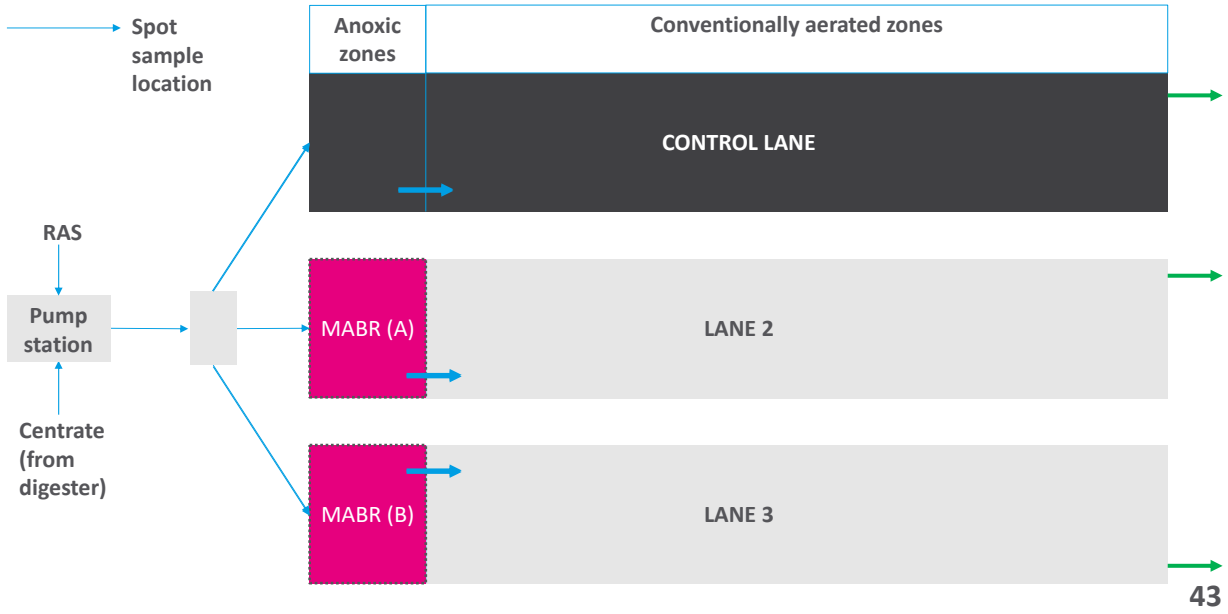
TRIAL SETUP



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INSTALLATION – OXYMEM

Installed in July 2020.

10 units – 14,520m^2 of membrane - in Lane 3.

OXYMEM
a DuPont brand

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INSTALLATION – ZEELUNG VEOLIA WTS

Installed in October 2020.

5 units – 9,600m^2 of membrane - in Lane 2.

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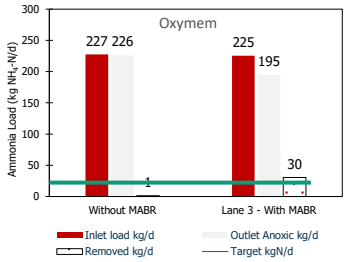
ST Classification: OFFICIAL SENSITIVE

TRIAL OBJECTIVES AND FINDINGS

1. Analyse ammonia reduction across the anoxic zones of the MABR lanes.
2. Calculate a nitrification rate for each MABR installation.
3. Report Oxygen Transfer Rate for each MABR installation
4. Evaluate the impact of MABR installation on denitrification
5. Evaluate the potential of the MABR for balancing ammonia loads to the ASP (peak lopping).



	Lane 1	Lane 2	Lane 3	Lane 2 (A)	Lane 3 (B)
	Ammonia removed kg/d	Ammonia removed kg/d	Ammonia removed kg/d	Ammonia removed gNH_3-N/m^2.d	Ammonia removed gNH_3-N /m^2.d
Average	17.8	28.3	42.3	**2.9**	**2.9**
Stdev	30.6	31.9	27.5	3.3	1.9
95%ile	78.0	83.4	93.5	8.7	6.4
n	79.0	79.0	79.0	79.0	79.0
Difference from control lane (kg/d)	-	10.5	24.5		
Ammonia load removed as % of influent load	8%	13%	19%		

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CONCLUSIONS FROM THE TRIAL

1

Pollutant removal

Demonstrated technology increases ammonia removal

2

Ease to install and operate

Relatively straightforward

Short maturation time

Membrane Aerated Biofilm Reactor

3

Future work

Energy usage and aeration optimisation

Process emissions – monitoring N_2O emissions to see MABR reduces these

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ACKNOWLEDGEMENTS

OXYMEM
a DuPont brand

VEOLIA

WONDERFUL ON TAP

SEVERN TRENT

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THANK YOU FOR LISTENING

QUESTIONS?

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Boosting Nitrogen Removal –
Pilot trials with a Pure MABR

Presented by: Kevan Brian & Nadine Oschmann

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Presentation Overview

- Contributors/Acknowledgements
- Background
- What is an MABR?
- Why we ran a pilot
- Pilot overview and results
- What next?

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Contributors/Acknowledgements

- Dr Jeff Peeters (Veolia WTS – Ontario Canada)
- Matt Reeve (Veolia WTS - Ontario Canada)
- Nadine Oschmann (Veolia WTS – NSW)
- Dr Dwight Houweling (Dynamtia – Quebec Canada)
- Dr Nerea Uni Carreno (Vand Center Syd – Copenhagen Demark)
- Dr Alzbeta Bouskova (NZ)

VandCenterSyd
DIT VAND · VORES ELEMENT

dynamita
PROCESS MODELING

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Background

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What we were looking for

We wanted a process that was consistent with 40/20/20 principles – and our journey to net zero emissions:

- Something that uses less carbon to build
- Could be built offsite (safer/faster)
- Repeatable – can build many using the same design
- Low energy consumption
- Low N2O emissions
- Needs less site preparation (faster/safer/cheaper)

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What MABR Offers

- Compact process
- Can be built in shallow steel tanks
- Uses 3-5 times less aeration energy than activated sludge
- Reported as having lower N2O emissions than activated sludge

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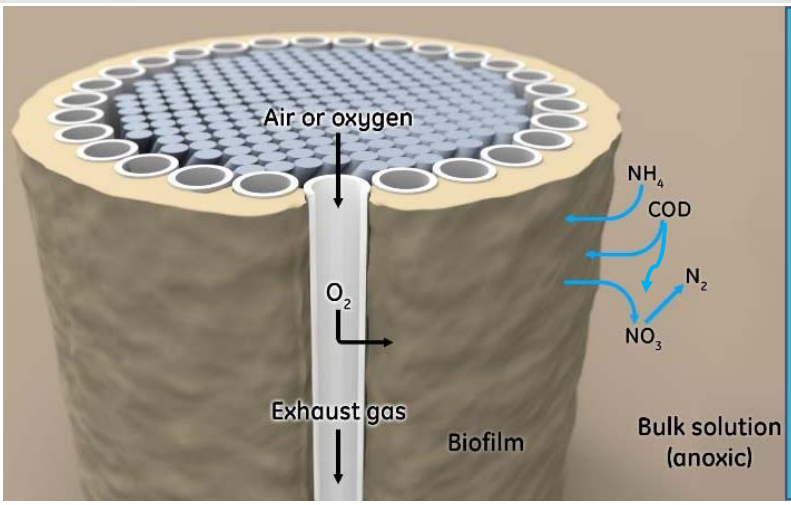
What is MABR?



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

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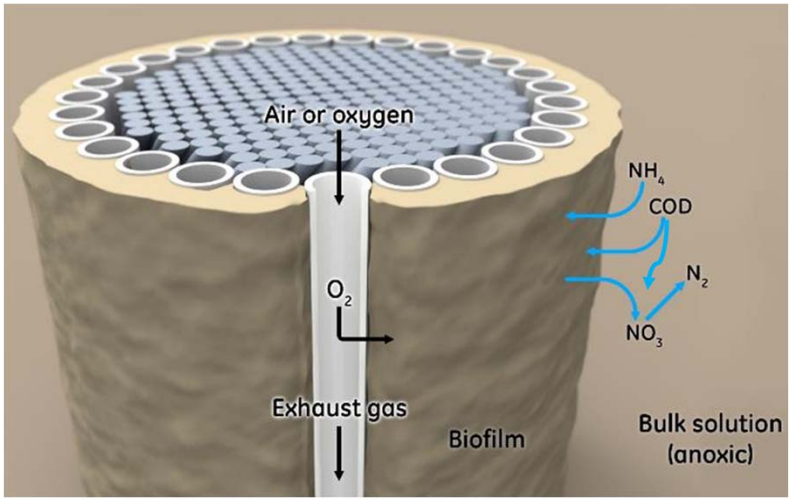
What is MABR?



- Bugs grow on membrane fibre (looks like hollow spaghetti)
- Oxygen diffuses through the membrane into the biofilm
- Biofilm grows on the outside of the membrane
- It's NOT a filter
- It's NOT an aeration diffuser
- No backwash
- No CIP or chemical cleaning

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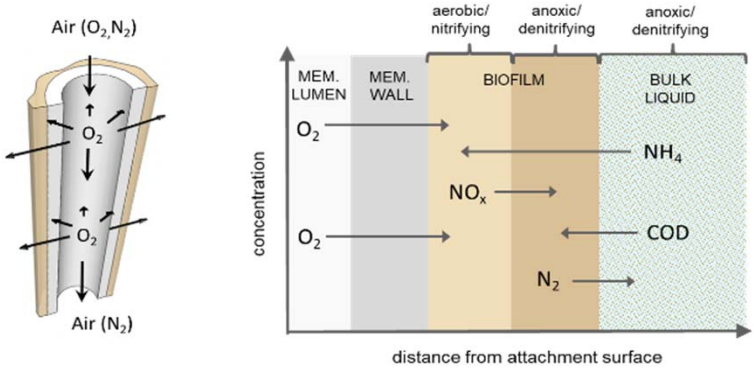
What is MABR?



- 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

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What is MABR?

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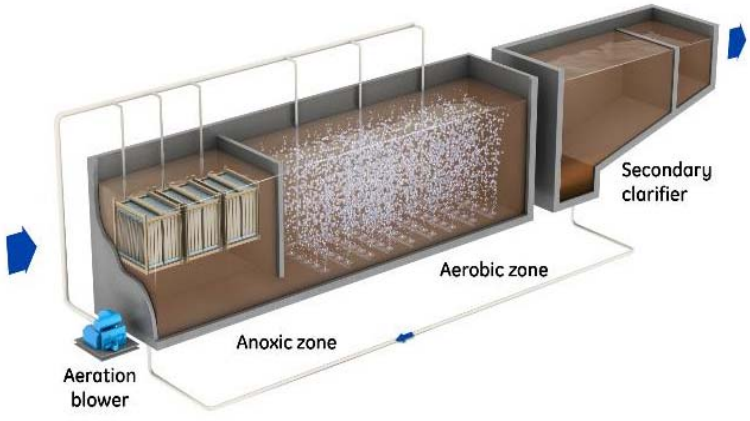
What is MABR?



- Typical application of MABR is to increase capacity of activated sludge.
- Pure MABR has no mixed liquor, no recycle and only has a biofilm for treatment
- This mode is very new (we are the first to try it at this scale)
- Ideal as a one pass process for lagoons to remove nitrogen

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Why Pilot?

- Test if we could get the process to work as Pure MABR
- Measure aeration efficiency
- Measure N20 Emissions
- Determine how difficult (or easy) MABR is to operate

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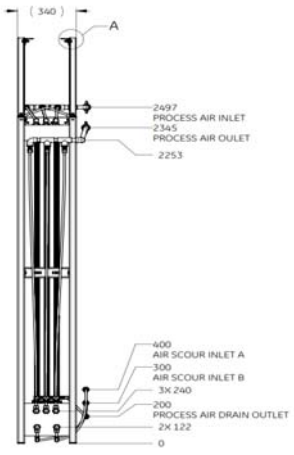
Pilot Plant Set up



- 3 ZeeLung Modules
- 120m2 ZeeLung area
- Pilot influent flow 6-11m3/d
- Process airflow 5L/min or 0.55Nm3/hr
- Offgas Oxygen monitored continuously
- Air supply via compressed air
- Inlet Pressure ~ 0.7bar
- Exhaust Pressure - 0.25-0.3bar

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Monitoring

- Daily Inflow
- Inlet and Outlet Ammonia
- Inlet and Outlet Nitrate/nitrite
- Inlet and Outlet COD, CODf, CODff, TSS,VSS
- Exhaust gas Oxygen for OTE%
- Exhaust gas CO2 & N2O
- Process air flow and pressure
- Scour and mixing air rates and frequency

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Results

Is MABR easy to Operate? – Yes it is! Even this guy can run it!

- no DO probes
- No recycles
- No SRT control
- No settling

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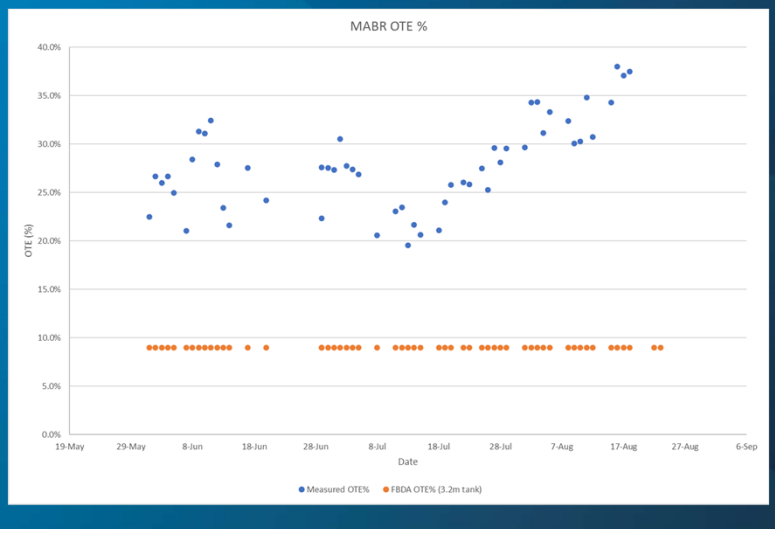
Results



Higher OTE% =
Less Power for aeration

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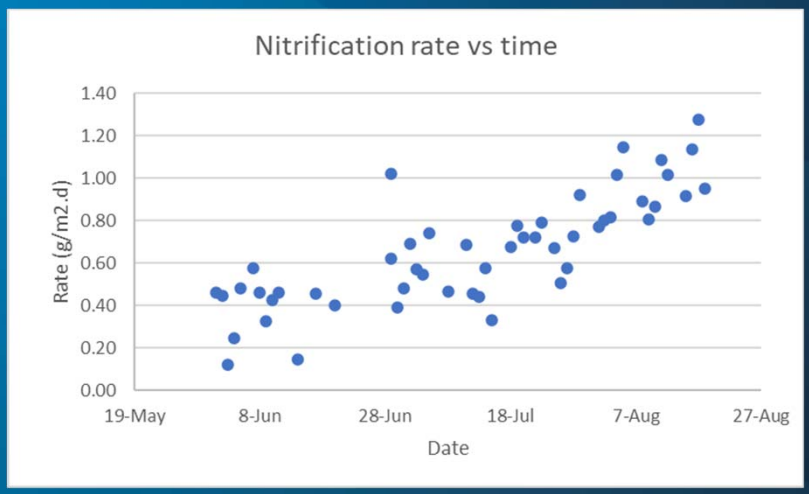
Results



Nitrification – It Works!
Rates lower than
expected but still OK

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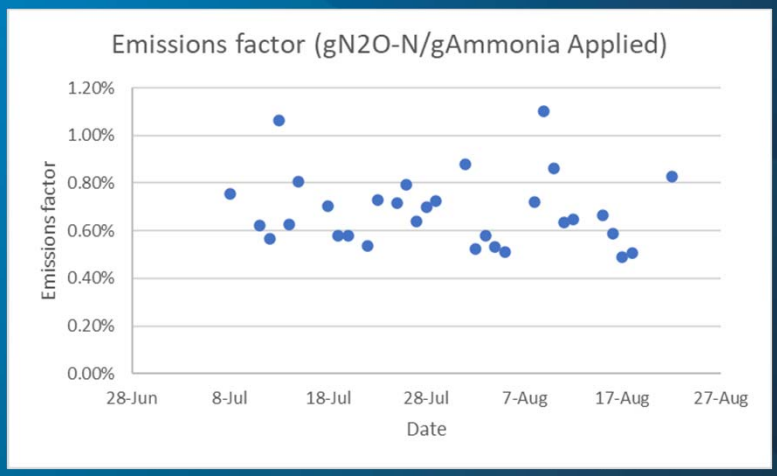
Results



Emission Rates lower than IPCC Factor for high rate systems

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Future Work

- Based on results of this trial the first Pure MABR in the world* of this scale is being built in Helensville – finished end of 2022
- Te Kauwhata – Hybrid plant in design
- Several others being considered
- More results to publish on N2O, operating parameters, sulphur cycle

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Boosting Nitrogen Removal – Pilot trials with a Pure MABR

Presented by: Kevan Brian & Nadine Oschmann

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