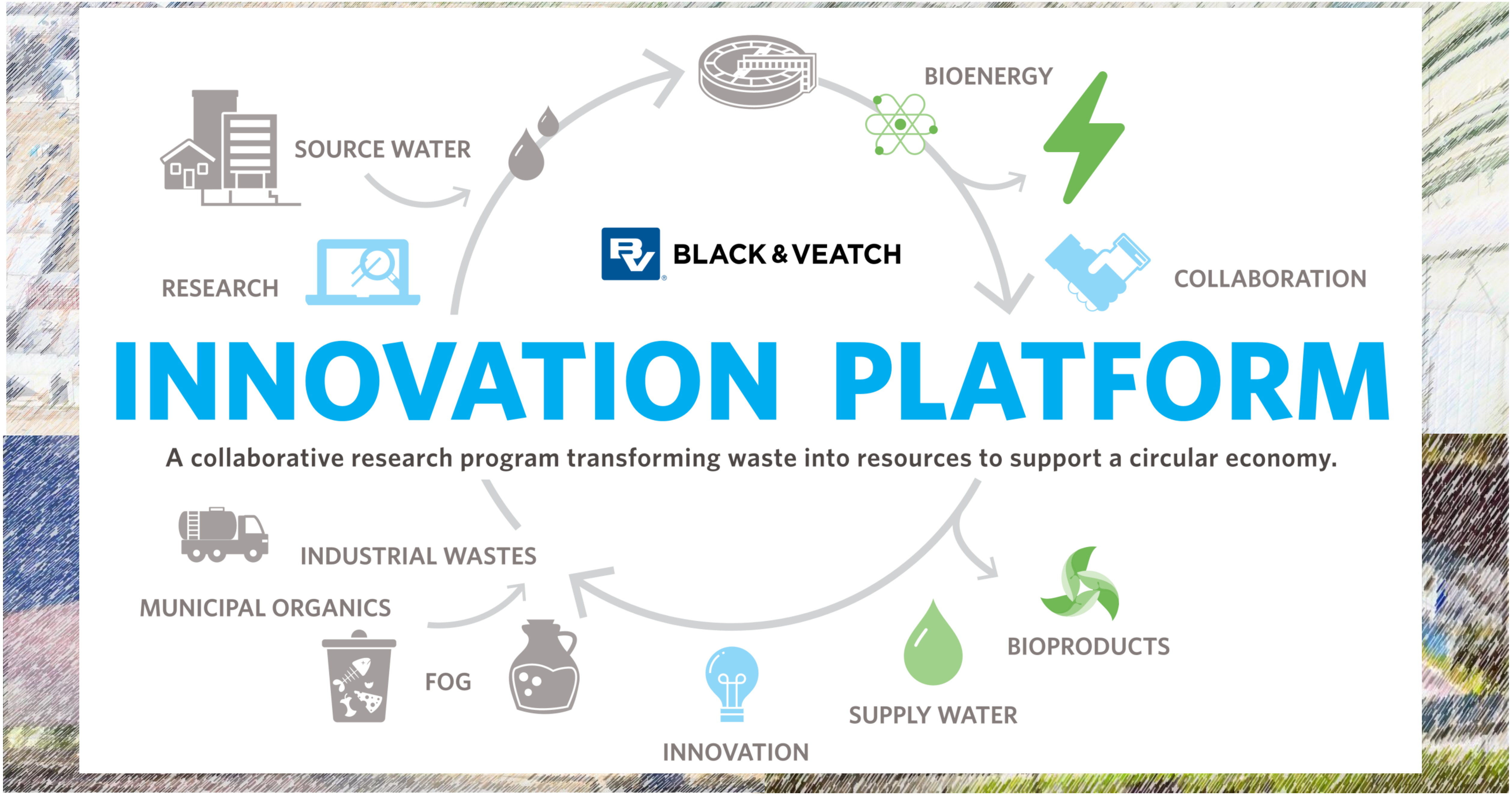
Biological Nutrient Removal
Sacramento Regional Sanitation District
Sacramento, CA, USA
161 mgd

Phosphorus Recovery
Metropolitan Water Reclamation District
Chicago, IL, USA
800 mgd

Indirect Potable Reuse
Ground Water Replenishment System
Orange County Water District
100 mgd

Biological Nutrient Removal (SND-MBR)
Ulu Pandan Demonstration Plant
Singapore PUB
12.5 MLD

Sandeep Sathyamoorthy
Principal Process & Innovation Leader
Black & Veatch


BIOENERGY
SOURCE WATER
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RESEARCH
COLLABORATION
INNOVATION PLATFORM
A collaborative research program transforming waste into resources to support a circular economy.
INDUSTRIAL WASTES
MUNICIPAL ORGANICS
BIOPRODUCTS
FOG
SUPPLY WATER
INNOVATION




An Introduction to the Membrane Aerated Biofilm Reactor (MABR) Technology

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Principal Process & Innovation Leader
Black & Veatch

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Value Proposition of MABR technology

- Support **total nitrogen removal** in the **same tank**
- **Retrofit existing aeration tanks** and achieve **process intensification**

→ **Reduce CAPEX**

- Achieve efficient oxygen transfer rates
- Reduce internal recycle pumping
- Reduce **supplemental** biodegradable organic **carbon requirements** for denitrification

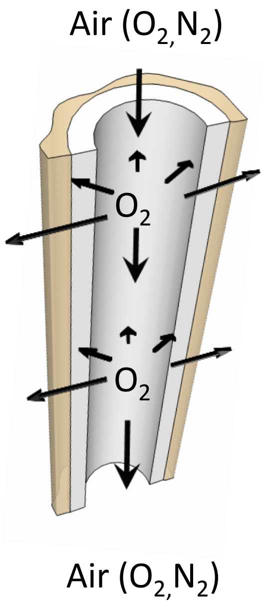
→ **Reduce CAPEX AND OPEX**

The MABR supports biofilm growth on oxygen-supplying membranes.

MEMBRANES

- *Dense, hydrophobic material*
- *Hollow fiber or flat sheet configuration*

AIR DELIVERY

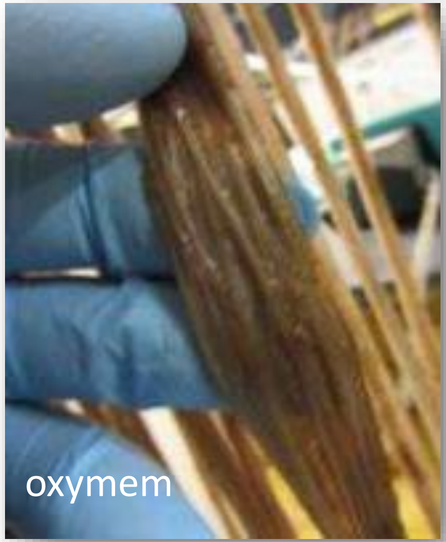


Flow-through mode

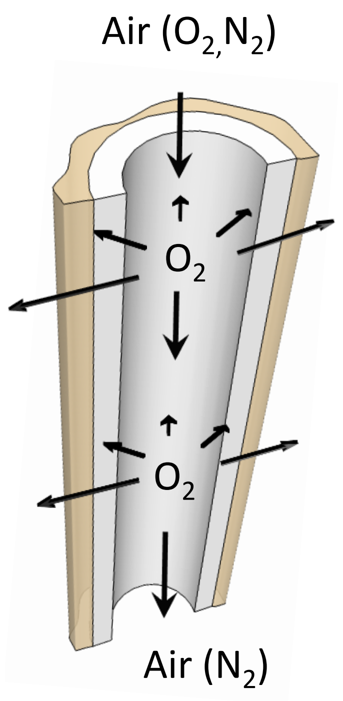
SUBSTRATE

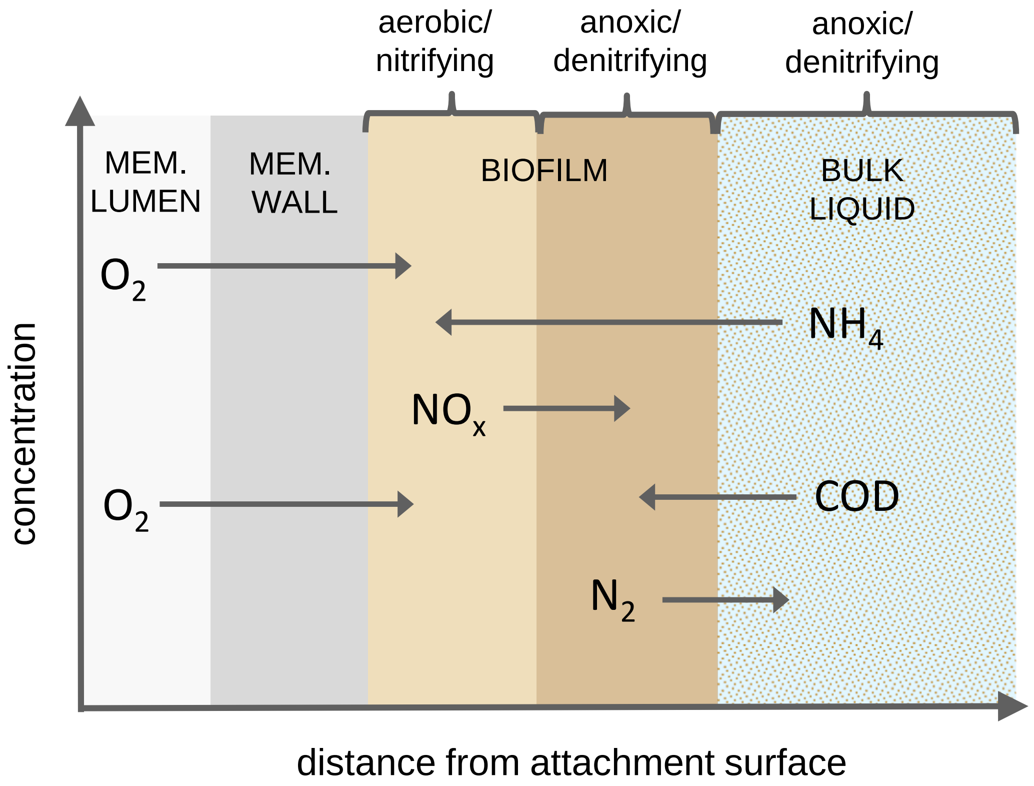
- *COD*
- *Ammonia (NH_4-N)*

“Breathing” Biofilms!



The MABR supports total nitrogen removal.

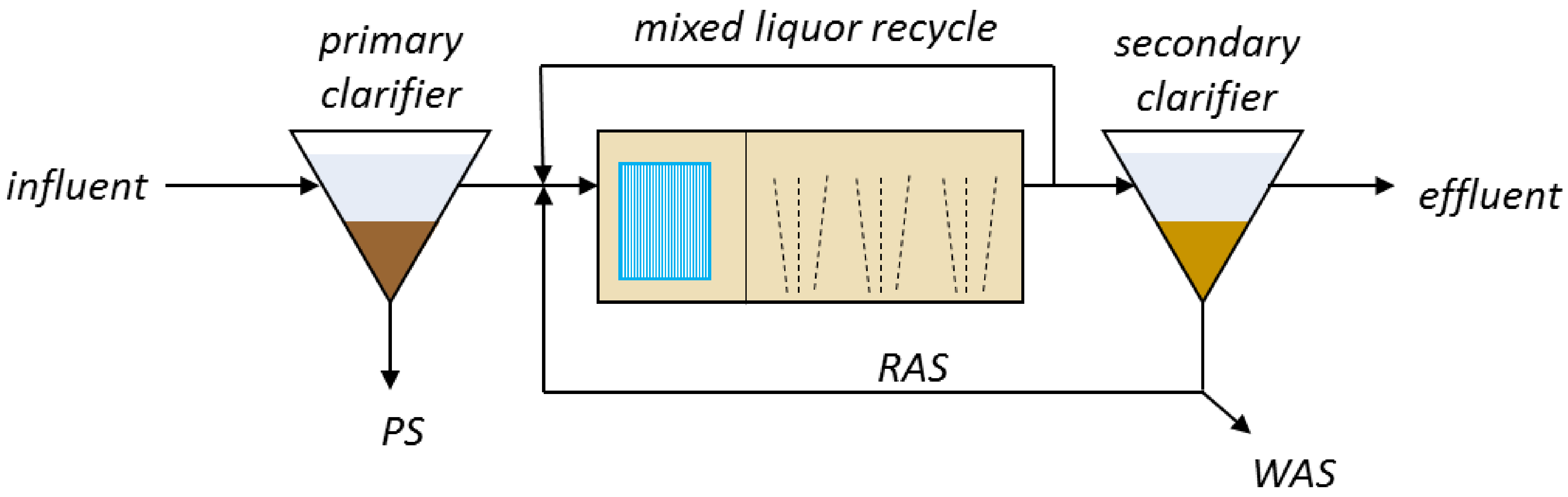




Oxygen is consumed within the biofilm, supporting anoxic conditions for denitrification in outer biofilm and/or bulk liquid.

The MABR intensifies conventional activated sludge processes.

MABR-MLE



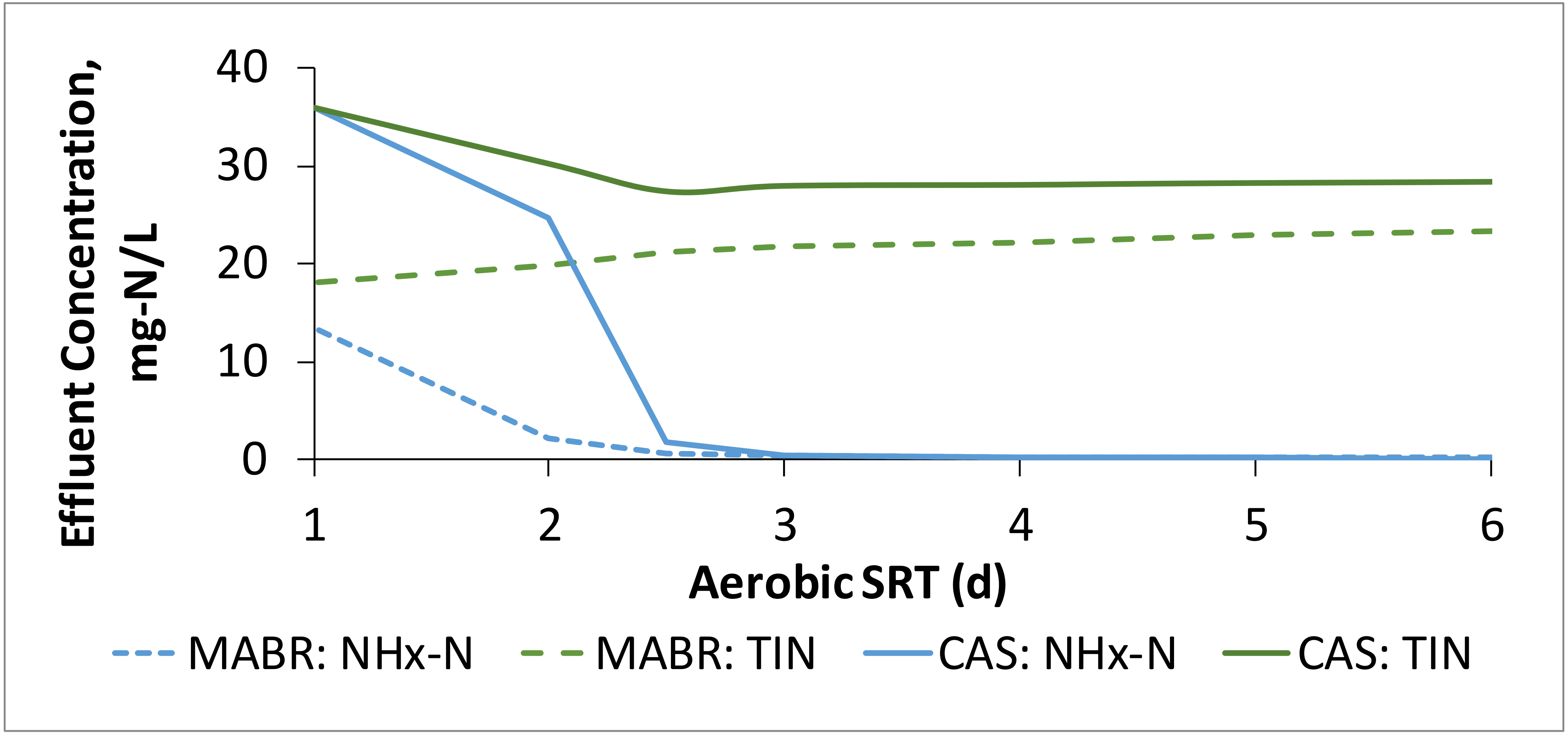
rule of thumb

COD Oxidation: COD + O_2 → CO_2

Nitrification: NH_4-N + O_2 → NO_3-N

Denitrification: COD + NO_3-N → N_2

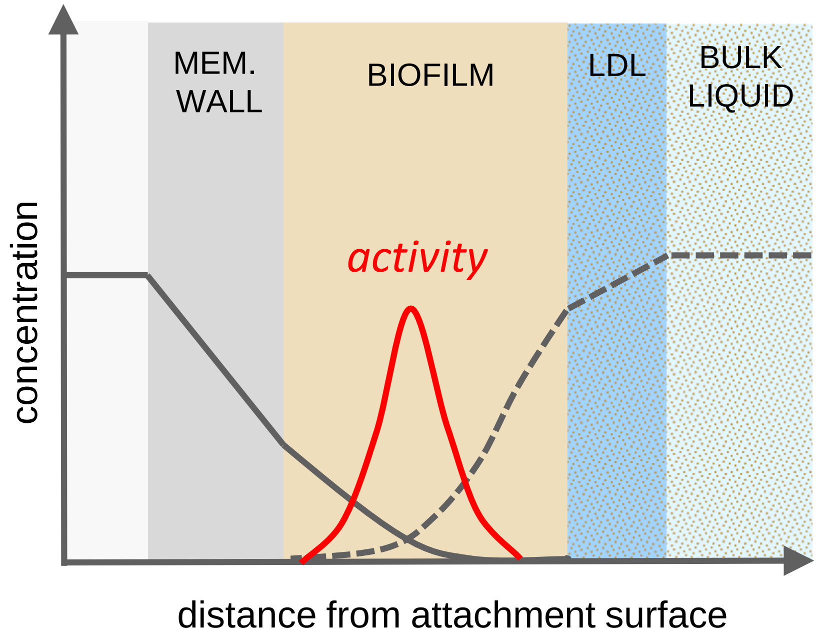
Process Intensification
Lower Ammonia-N achieved at lower SRT.
Reduce SRT, reduce aeration basin volume requirements



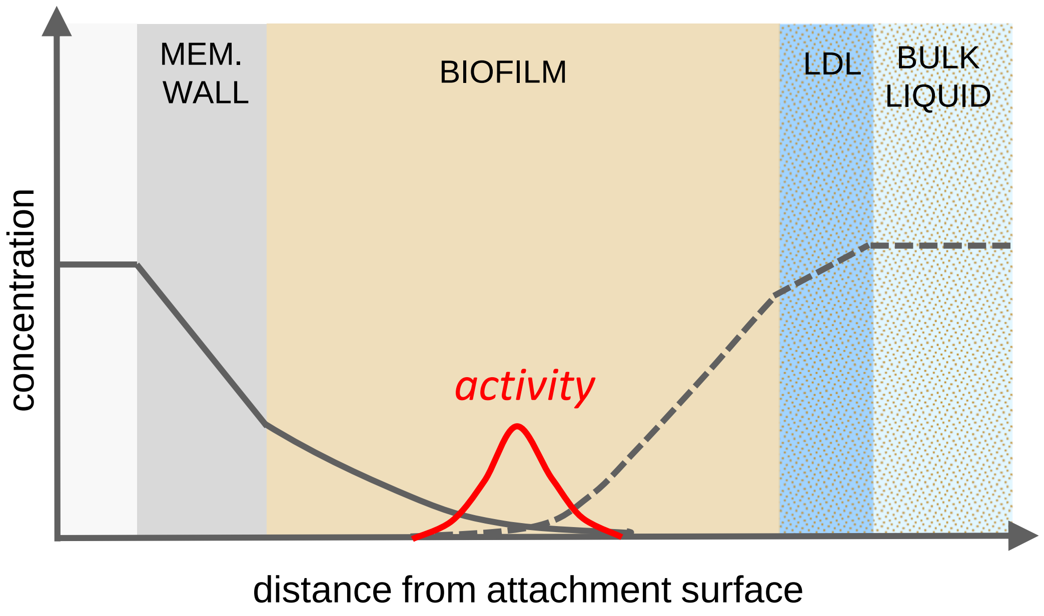
MABR Challenges

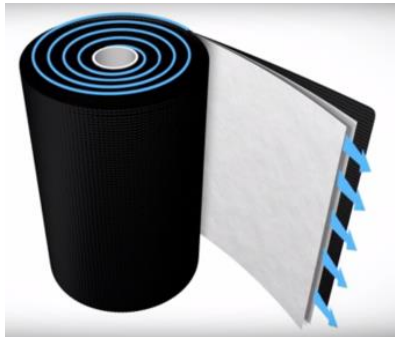
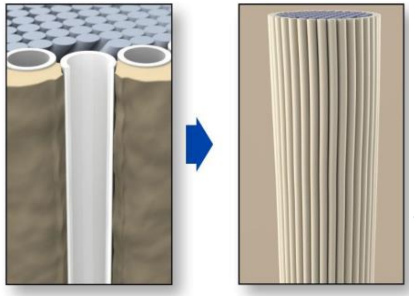
Biofilm management is critical to good performance.

Support biofilm…

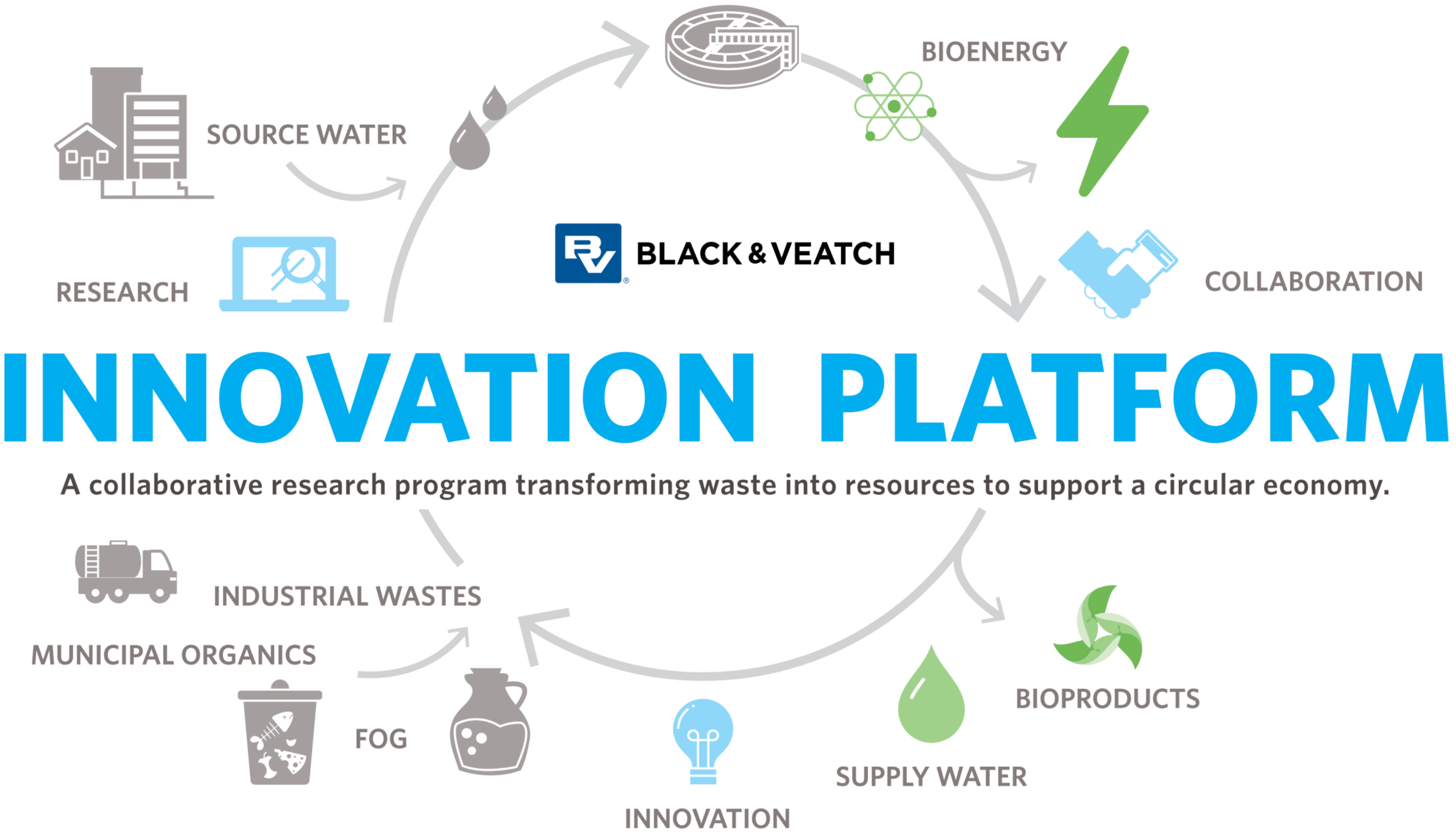


but not too much.



Technology Provider	System Configuration	Typical Applications	Current Facilities
fluence 	Spiral-wound Modules Mixing via Bubble Pulses 	Decentralized Treatment, Remote or Developing Areas New Steel Modules Allow for Aeration Basin Retrofit	85,000 gpd Hospital WW(Ethiopia) 35,000 gpd Dairy WW (Israel) Stanford University Pilot (CA)
suez ZeeLung™ 	Hollow Fiber Membranes ZeeLeed™ Modules within Cassettes Mixing & Scour via Aeration Grid  ZeeLung filament ZeeLung cord	Retrofitting Existing Aeration Basins	3.6 MGD WWTP (Yorkville, IL) 2.3 MGD WWTP Anoxic Zone (Schilde, Belgium) Multiple Pilot Scale Applications including Black & Veatch Pilot in Hayward, CA
OXYMEM SMART AERATION 	Hollow Fiber Membranes offered in Cassette, Package, or Standalone Options Biofilm control via air scour 	Retrofit Existing Aeration Basins Food, Beverage, and Dairy Applications Landfill Leachate Treatment	*Not available in US due to SUEZ patent Pilot and Demonstations in UK, Brazil, and Spain 4,000-40,000 gpd

A Pilot Scale Evaluation of MABR technology for Biological Nutrient Removal Process Intensification



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HAYWARD

SUEZ environnement

Black & Veatch: Sandeep Sathyamoorthy
Samik Bagchi
Kelly Gordon

Suez: Dwight Houweling
Dan Coutts

Hayward: Feng Cheng
David Donovon
Farid Ramezanzadeh

Research Objectives and Questions

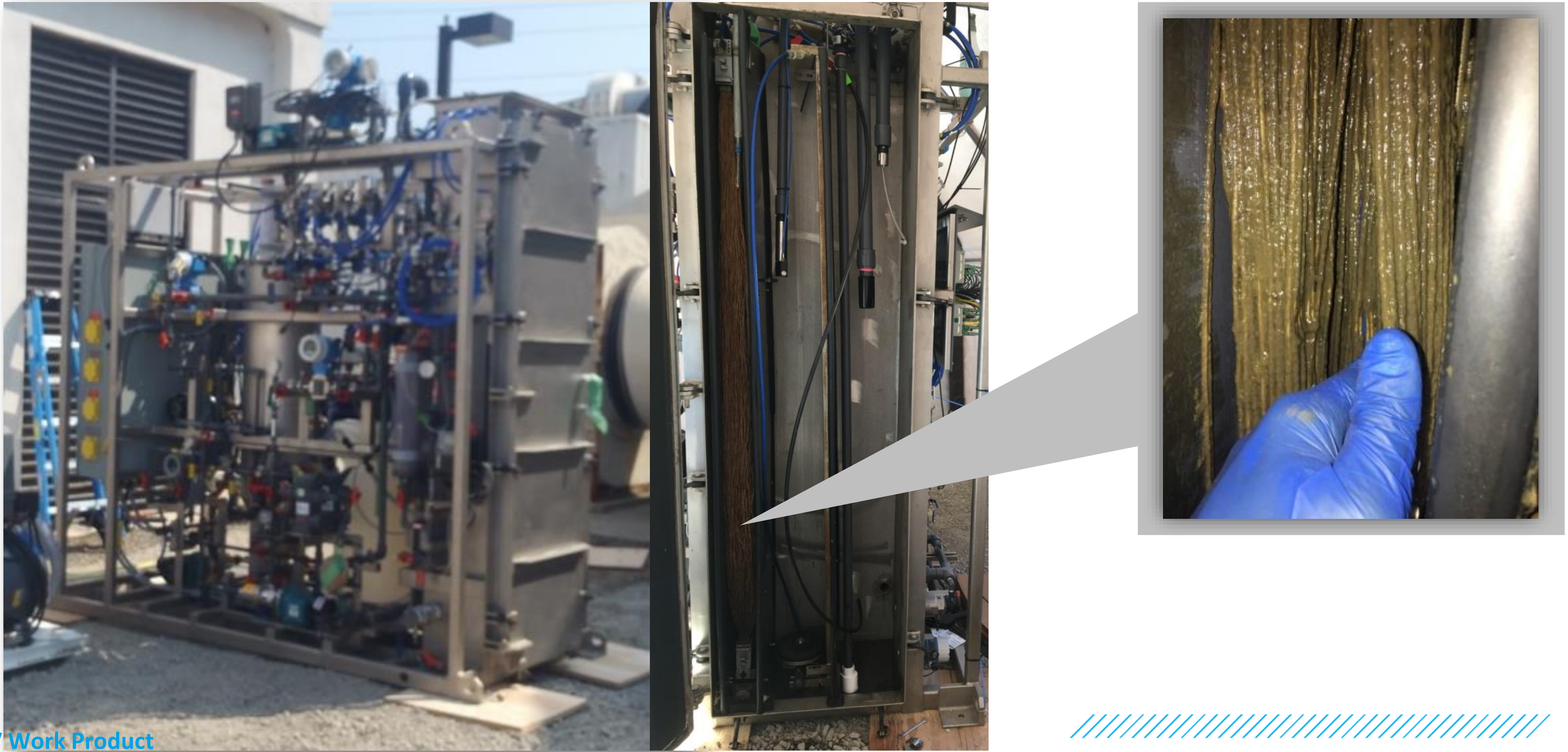
*Evaluate the **aerobic solids retention time** (SRT) required to achieve nitrification in an MABR-SG compared with a Suspended Growth BNR configuration*

- Nitrification occurs in the biofilm => less nitrification "*work*" in the suspended growth
- Seeding (i.e., bioaugmentation) from biofilm to suspended growth

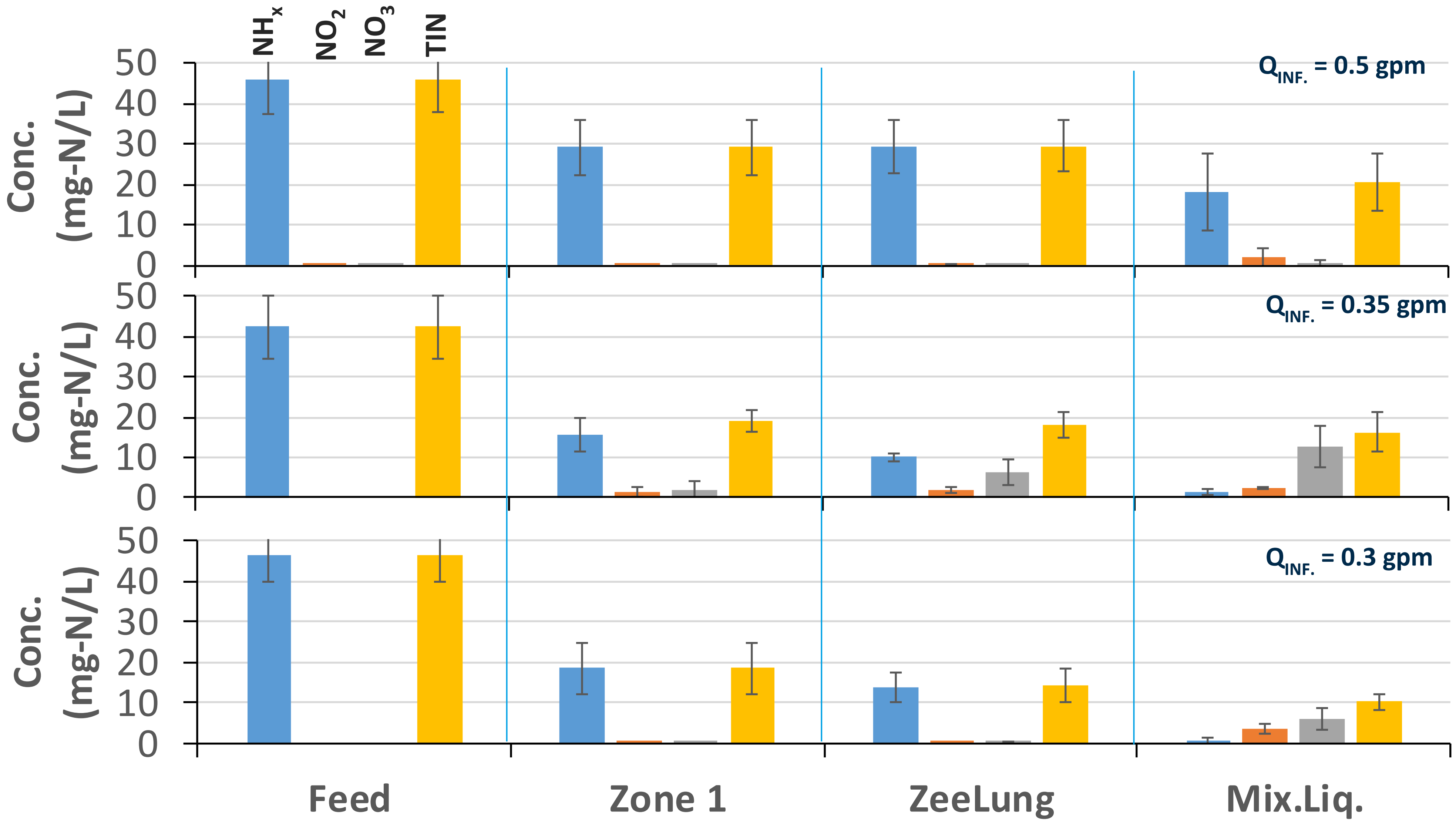
*Assess the impact of the **organic carbon loading and influent COD/N ratio** on MABR nitrogen removal performance*

- High BOD results in excessive heterotrophic growth in the biofilm => increases diffusional limitation
- Higher C/N ratio influences competition between HET & AOB/NOB within the biofilm

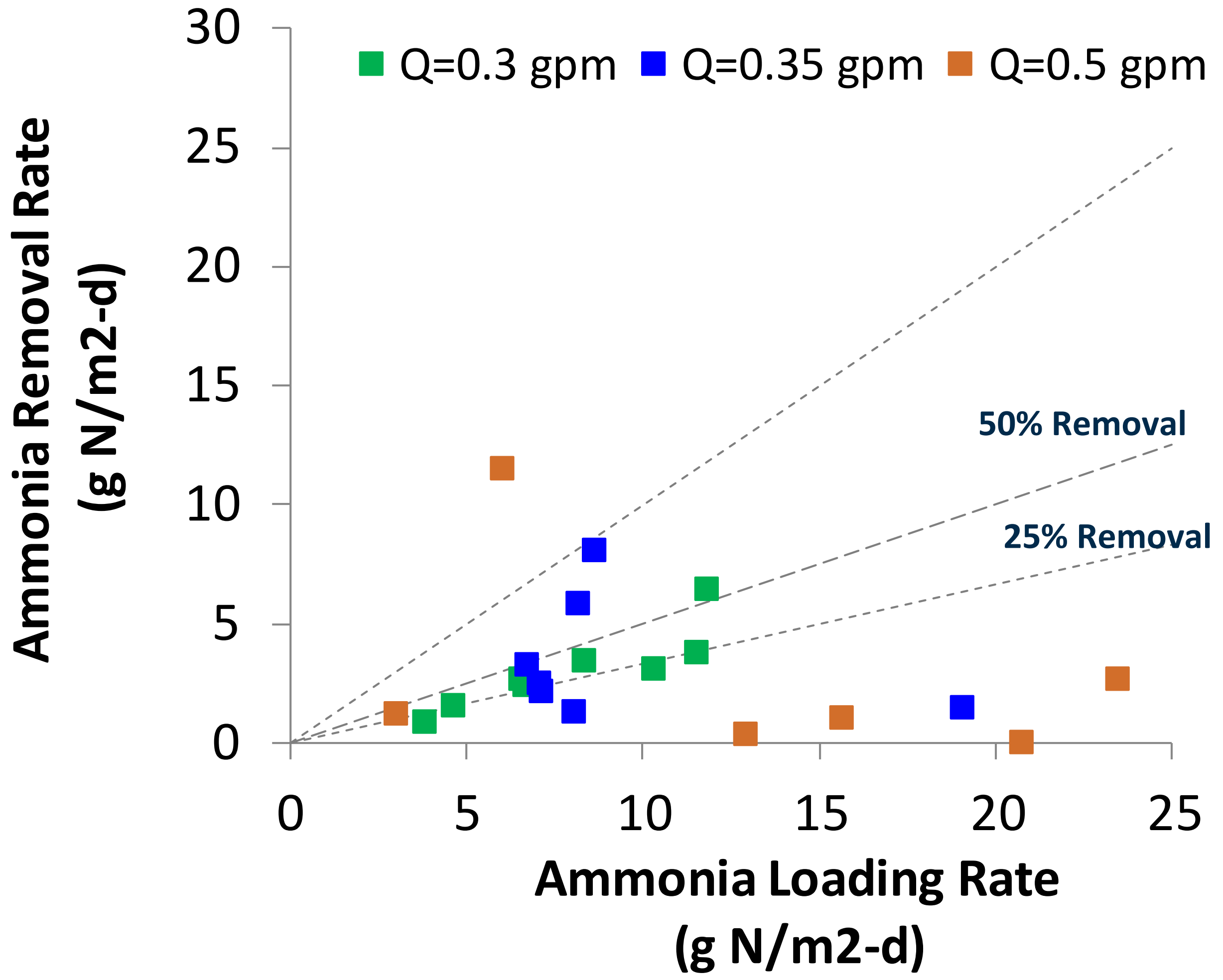
MABR Pilot

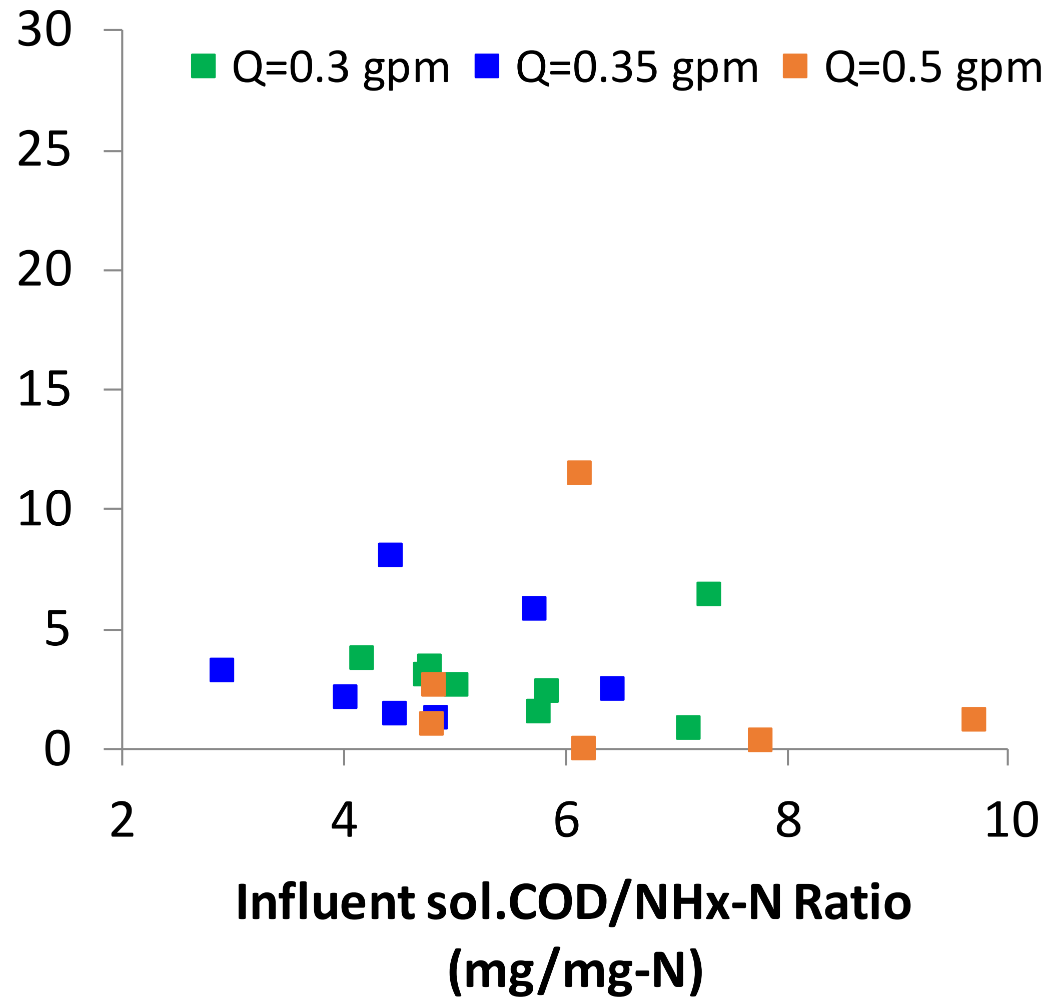


Initial Operation at fixed influent flow



Ammonia Removal across the MABR when influent flow is fixed





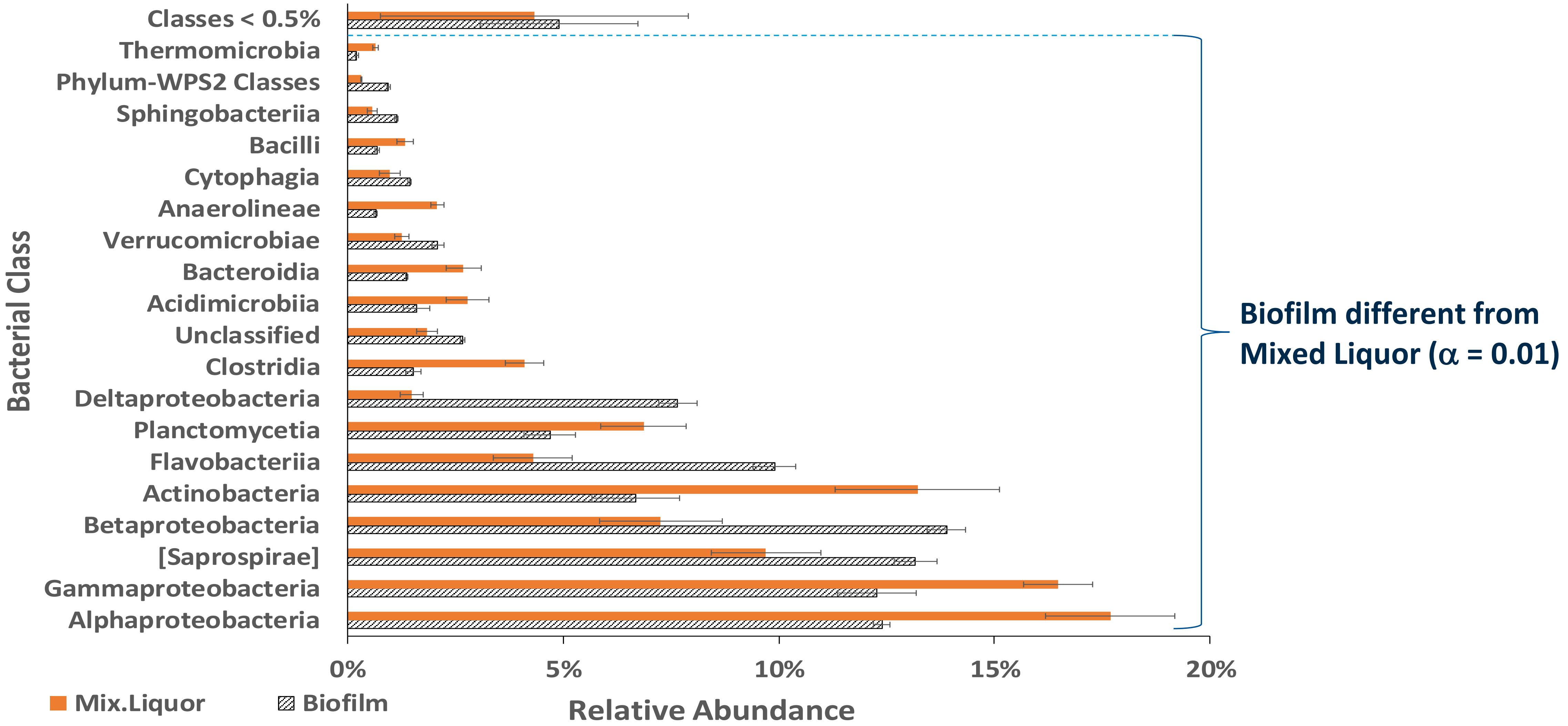
A look at the MABR film

HIGHER LOADING CONDITIONS
(Sol. COD Loading ~40 g/m^2.d)

LOWER LOADING CONDITIONS
(Sol. COD Loading ~20 g/m^2.d)

Comparing microbial communities

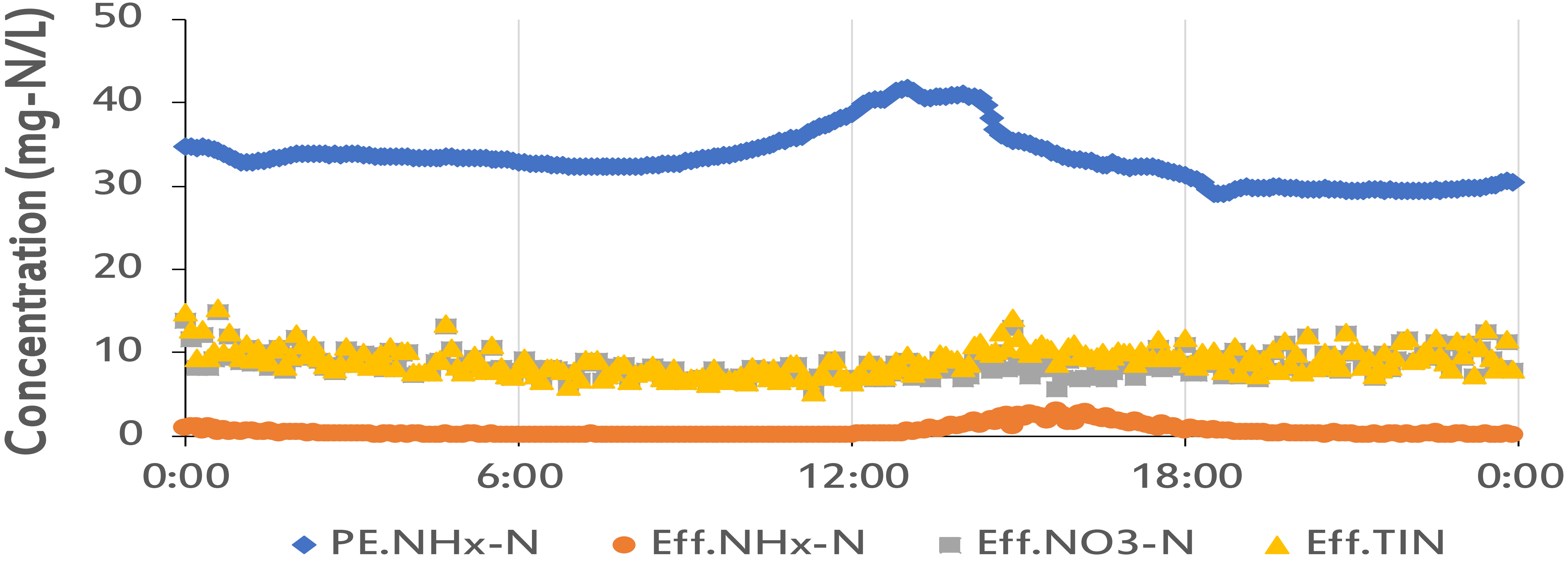
Classes Rel.Abun. ≥ 0.5%
Triplicate analyses



Effective Nitrogen Removal at relatively low Aerobic SRT

Influent = Diurnal Flow (matching Hayward WPCF pattern (avg. = 0.4 gpm)
RAS = 60%xQ_{INF}
MLR = 200% x Q_{INF}

Temp. ~ 18-19 °C
MLSS ~ 1,600 mg/L
$SRT_{SUSP.GR}$ ~ 4 d



Preliminary Discussion

- Managing COD load and COD/N ratio into MABR zone is important to maximize utility of the film
- Biofilm management is important to efficacious operation/performance
- Total nitrogen removal can be achieved at SRTs typically lower than CAS system

- Stay tuned…more on application of this innovative technology at WEFTEC and CWEA

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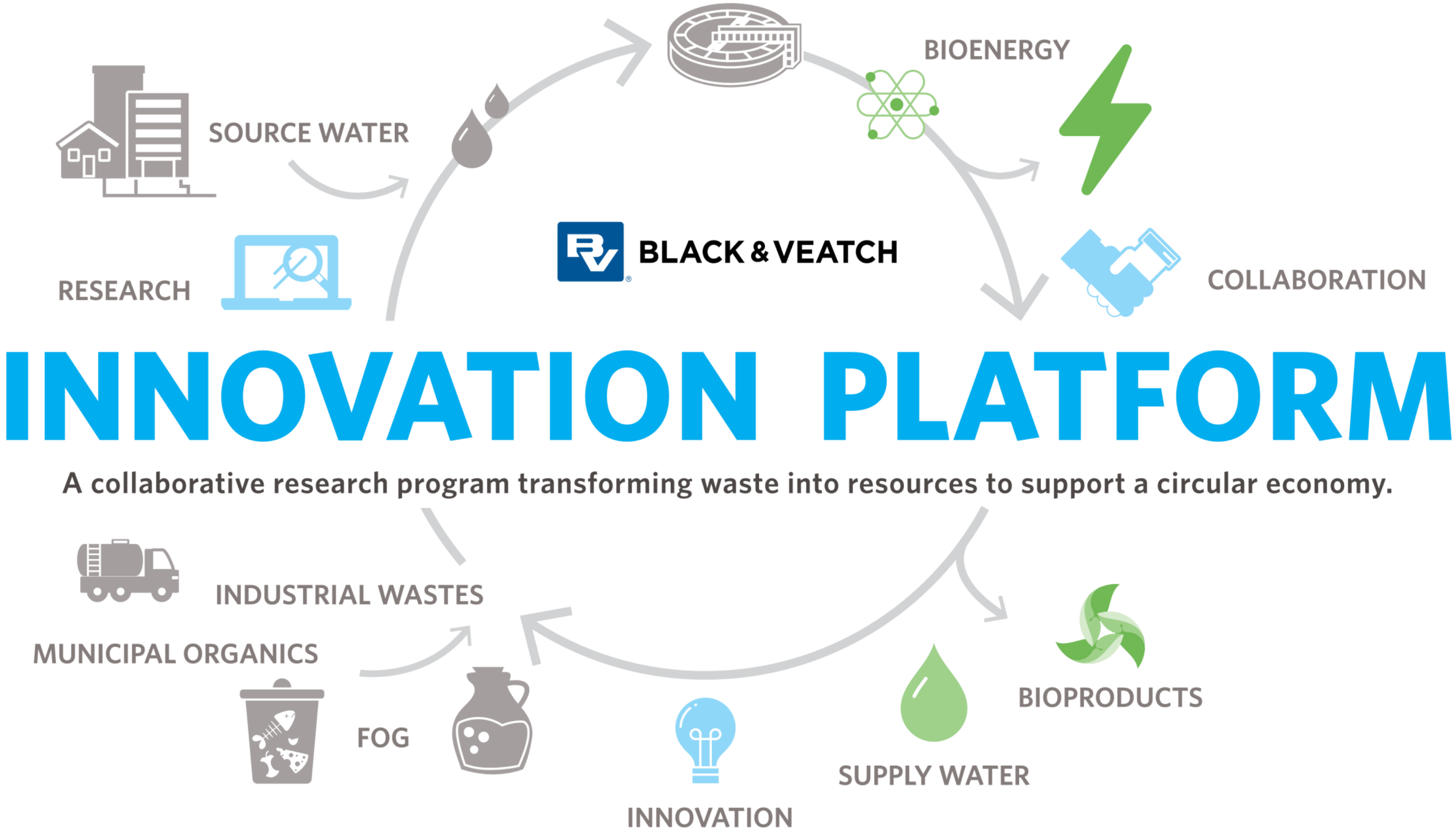

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