Membranes with New Biology

VEOLIA

Today's Presenter

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VEOLIA

Agenda

1 Wastewater Intensification

2 memDENSE MBR

3 Case Study: Detroit Lakes

4 Summary

Wastewater Intensification

Wastewater Intensification
TWO CORE SOLUTIONS

ZeeLung™   **MABR**

process intensification
GHG reduction

MABR:
Membrane Aerated Biofilm
Reactor

Separator = Settling

zeeDENSE™ reference
since 2022

ZeeWeed™   **MBR**

sensitive discharge water
reuse

MBR:
Membrane Bioreactor

Separator = Filtration

memDENSE™ reference
since 2023

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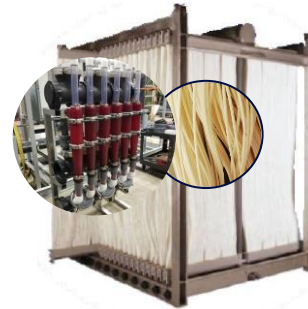# Membranes + Densified Activated Sludge (DAS)
UNLOCKING TECHNOLOGY POTENTIAL

zeeDENSE™ reference
since 2022

zeeDENSE™ MABR

super intensification of activated sludge

MABR + DAS

superior loading & settling

memDENSE™ reference
since 2023

memDENSE™ MBR

selective wasting for MBR
tailored Mixed Liquor characteristics unlock MBR potential

MBR + DAS

superior filterability

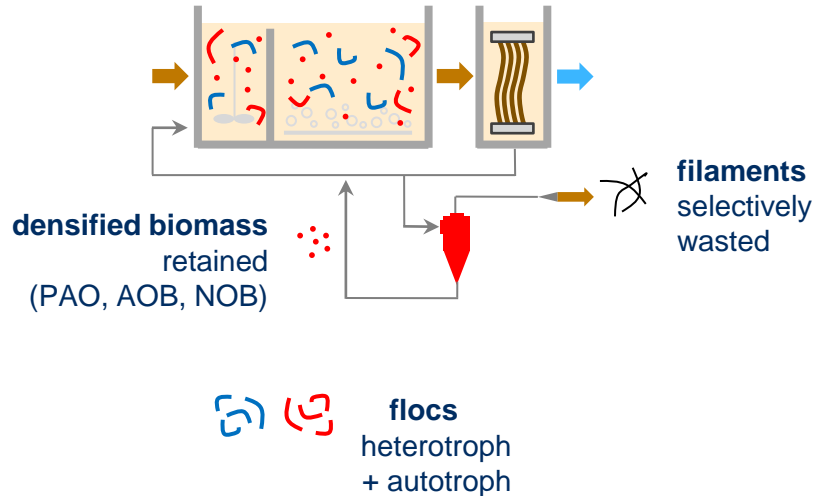VEOLIA

MBR + DAS = memDENSE
EFFICIENT COUPLING, 2 MAIN PRINCIPLES

memDENSE MBR

tailored MLSS characteristics unlock MBR potential

densified biomass retained (PAO, AOB, NOB)

filaments selectively wasted

flocs heterotroph + autotroph

SELECTIVE WASTING

removal of light biomass fraction
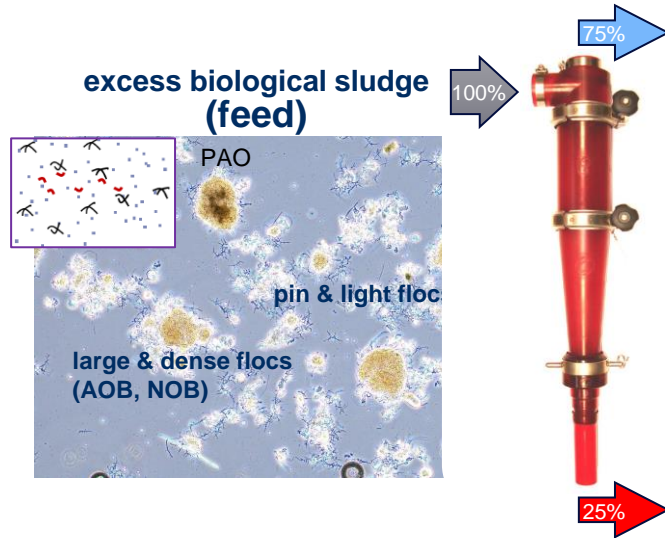- foulants, colloids, pin floc
- nuisance bacteria, filaments

DENSIFICATION

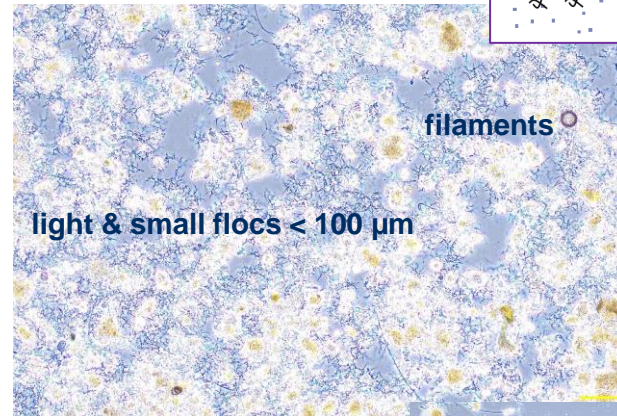**retention of dense biomass fraction**
- improved filterability
- nutrient removal specialists
  - PAO = Polyphosphate-accumulating organisms
  - AOB = Ammonia-oxidizing bacteria
  - NOB = Nitrite-oxidizing bacteria

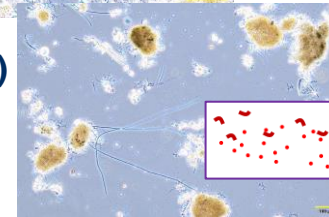# memDENSE MBR
SELECTIVE WASTING & SLUDGE DENSIFICATION

excess biological sludge (feed)

PAO

pin & light floc

large & dense flocs (AOB, NOB)

100%

75%

25%

overflow (OF)

filaments

light & small flocs < 100 μm

filament wash-out

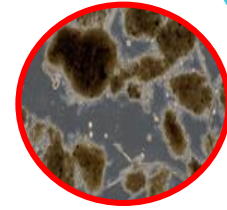**underflow** (UF)

dense flocs > 200 μm
PAOs (dark)
Nitrifiers (AOB, NOB)

memDENSE MBR
4 SYNERGISTIC FUNCTIONS

- **de-selection/retention**   filaments **wash-out**, PAOs & AOBs **augmentation**

- **separation**   **wash-out of poor** filterable **materials** (low TTF, super fine cTOC, cCOD …)

- **bioselection**   bioreactor configuration has **direct impact on microbial morphology architecture**
(feast/famine, rbCOD, COD bleeding, ORP/DO profiles…)

- **redirection**   **fast growing organism leave** OF to sludge line **as SRT uncoupling of flocs/granules** ↑

and numerous benefits…

memDENSE MBR
at City of Detroit Lakes
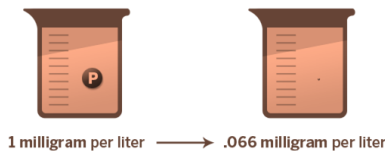
City of Detroit Lakes, Minnesota

Phosphorus | target: 0.066 mg/L

Approach:
- Biological w/ chemical trim
- Chemical on centrate return

Nitrogen | target: 7 or 10 mg/L

Approach:
- Biological

POPULATION: 10,100 (2023)

Vacation Destination Summer Population 50%+

WE Fest Country Music Festival

400+ lakes

1-mile long sand beach

94%

1 milligram per liter ⟶ .066 milligram per liter

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City of Detroit Lakes MBR
WHY IMPLEMENT DENSIFICATION

Solving challenges

- **Significant foaming**

- **Seasonal permeability struggles**
  - Spring melt high flows
  - Multiple events challenge the system: Surfactant, Oil, WWF Peak
- **Strengthen phosphorus removal**
  - BioP plant with 0.066 mg/L discharge limit
  - Increase PAO resiliency to chemical cleans

- **Increase resilience to seasonal changes**
  - Steep temperature drop, spring melt/precipitation
  - **Winter (temp), spring (high flows) & summer (tourism) different operation regimes**

memDENSE MBR at Detroit Lakes
18+ MONTHS EXPERIENCE

MT
Oxic
Anoxic
Anaerobic

memDENSE installation at Detroit Lakes, MN, USA

1.2 MGD (4,550 m³/d) ADF, 5 MGD (19,000 m³/d) PHF

- **Waterline**:
    - Equalization tank,
    - Pre-treatment (grit removal)
    - **ZeeWeed-MBR (A2O)**, UV disinfection

- **Sludge Line**:
    - **Membrane thickener** (ZeeWeed),
    - Aerobic digestion,
    - Dewatering by centrifuge
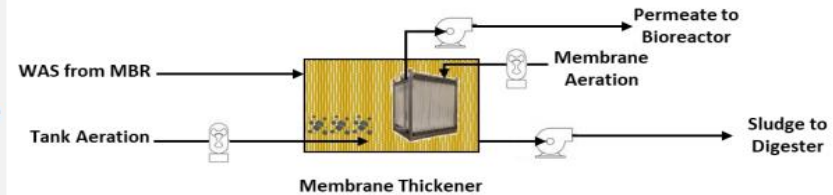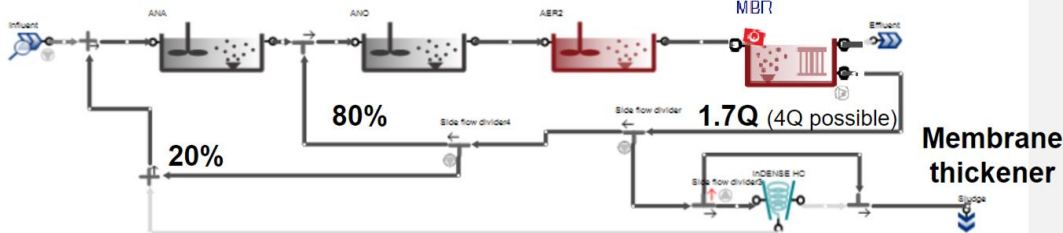
memDENSE MBR
PROCESS OPERATION
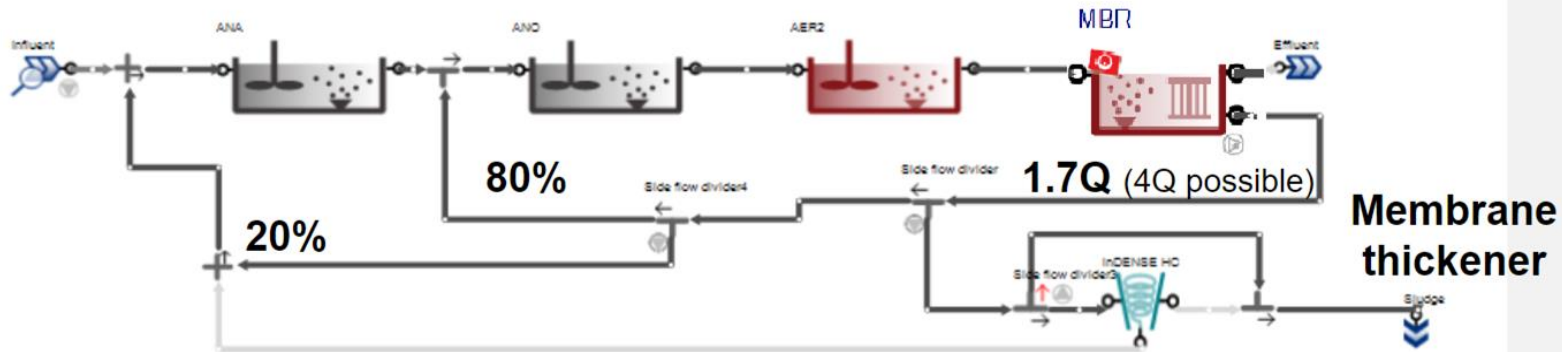
Biology	Total SRT (days)	Aerobic SRT (days)	F/M (kgBOD/kgVS/d)
	15-25	9-10	0.05

memDENSE MBR
1.5-YEAR LOOK BACK ON PERFORMANCE

January 2023 to today (2024)

- **Filaments washed-out**, foam disappeared

- **SVI ↓ to 50 mL/g**, TTF & CST followed!

- **TTF ↓ (<50), permeability ↑** by 30-55% in same flux conditions (↓TMP)

- Oxygen transfer improved (↓ kWh/kgNr)

- Mixed liquor microbial matrix shifted, **DI ↑ (from 35 to 65-80%)**

- **Membrane resistance ↓ 32%** (cake resistance ↓ 68%)

- ↓ **50% Chem-P** consumption (BioP boost)

- ↓ **20% Chemical Membrane** Recovery Cleaning (CIP)

In-progress

- Correlate permeability & validate flux over time

- Study resistance and pore blocking as function of Densification Index (DI%)

memDENSE MBR
SELECTIVE WASTING

Before
April 2022

After memDENSE implementation
since January 2024

**foam
disappeared**

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MBR CAS ▶ memDENSE MBR
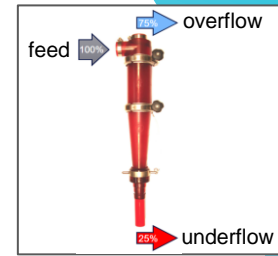## MACROSCOPIC MIXED LIQUOR CHANGE
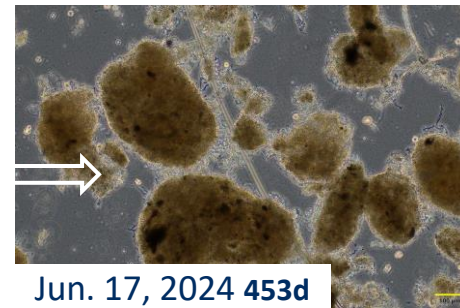

before
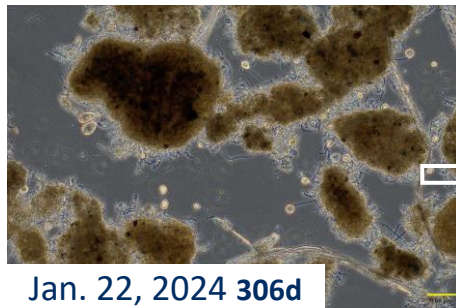**mem**DENSE
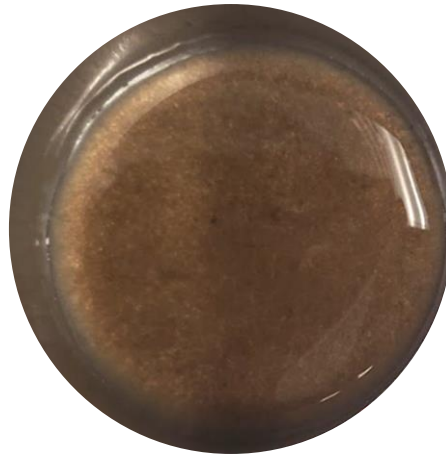
memDENSE
start-up
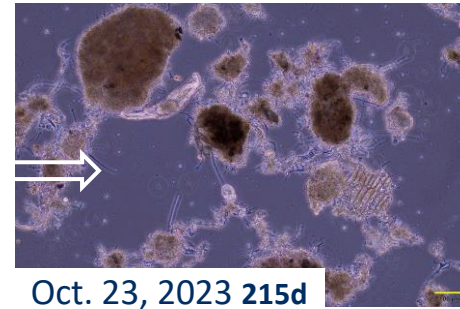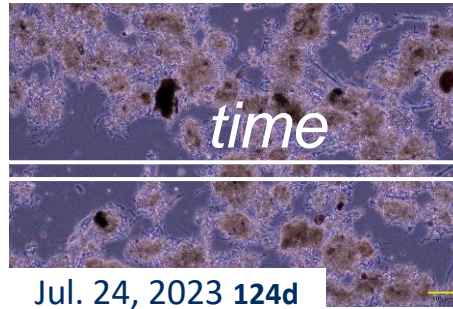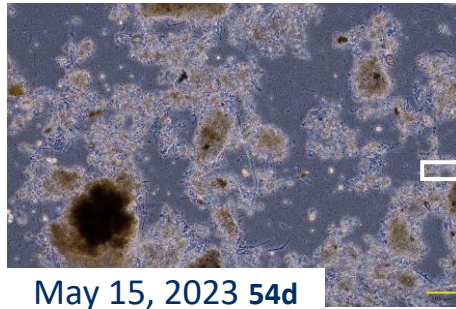
after
memDENSE
(early steady-state)

MBR CAS ▶ memDENSE MBR
MORPHOLOGY

memDENSE Biology - Microscope follow-up - Underflow

May 15, 2023 **54d** — *time* — Jul. 24, 2023 **124d** — Oct. 23, 2023 **215d**

Jan. 22, 2024 **306d** — *time* — Mar. 25, 2024 **369d** — Jun. 17, 2024 **453d**
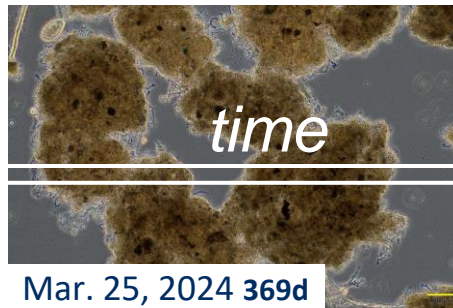
Demonstration Results

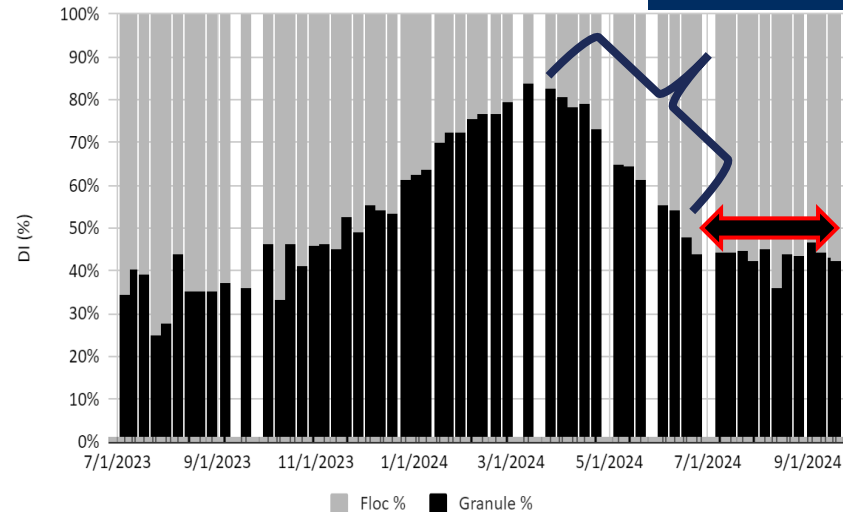# Densification Index
DI CONTROL

$$DI = \frac{\sum Total\ Suspended\ Solids > 200\ \mu m}{\sum Total\ Suspended\ Solids}\ \%$$

Floc vs Granule Fraction

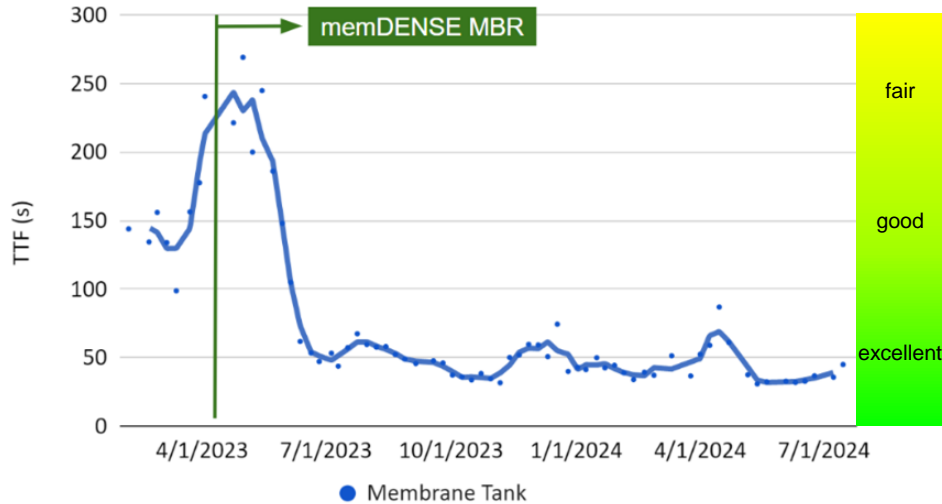**supplemental wasting used to stabilize DI**

40% supplemental wasting

Steady state
25% supplemental
75% through memDENSE

Floc %   Granule %

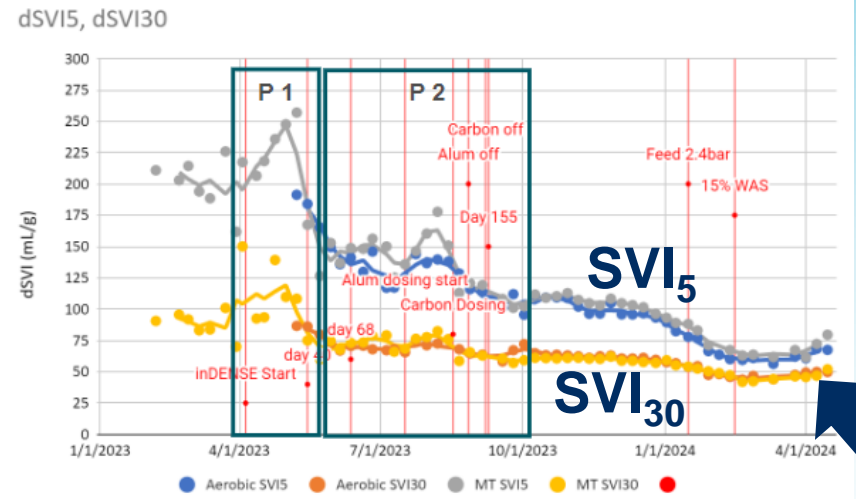# MBR CAS ▸ memDENSE MBR
IMPROVED SLUDGE FILTERABILITY

Densification retains bacteria with excellent filtering characteristics: more interstitial fluid, more tightly-bound EPS
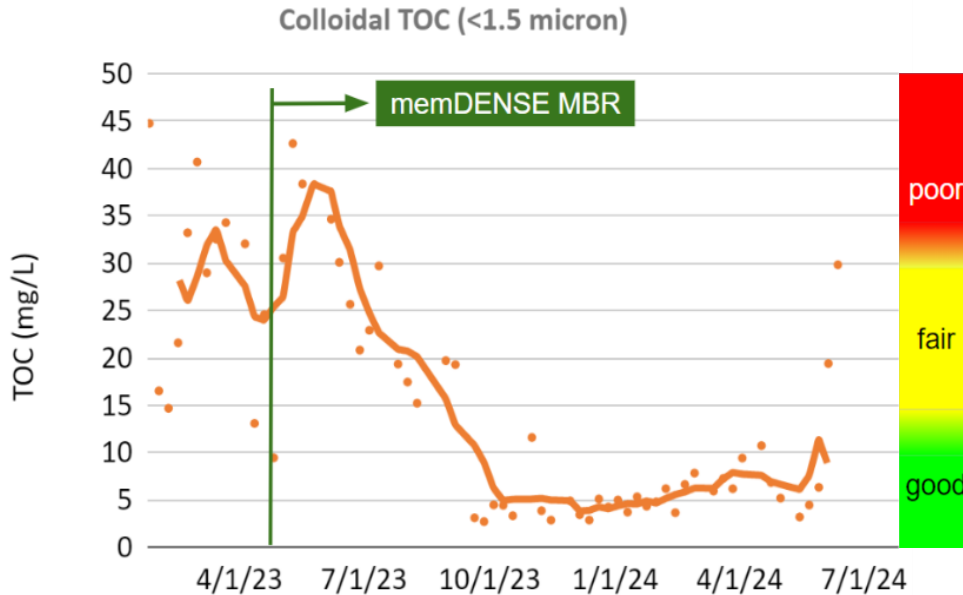
TTF stabilized at **50 sec**

TTF drop synchronized with steep SVI drop improving mixed liquor properties & resilience to feed changes

SVI$_{30}$ stabilized at **50 mL/g**

memDENSE MBR
REMOVAL OF COLLOIDAL MATERIAL (sCOD, TOC)
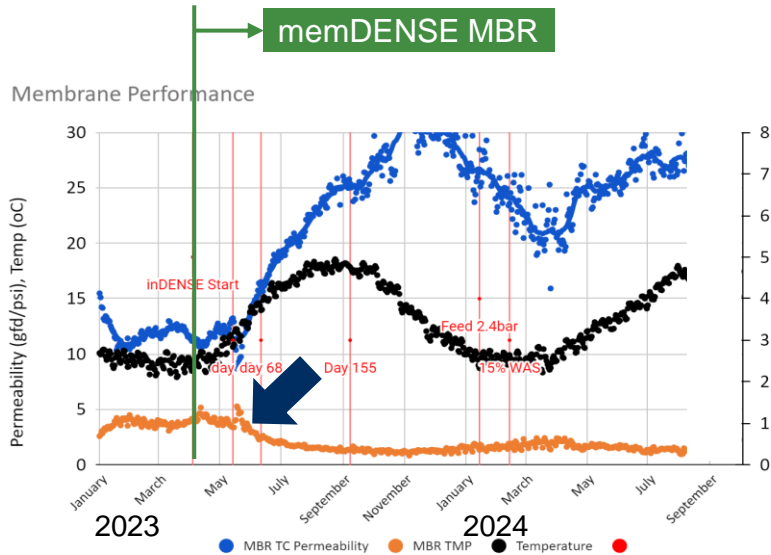

Colloidal TOC (<1.5 micron)

↓**83% colloidal TOC**

↓**57% colloidal COD**
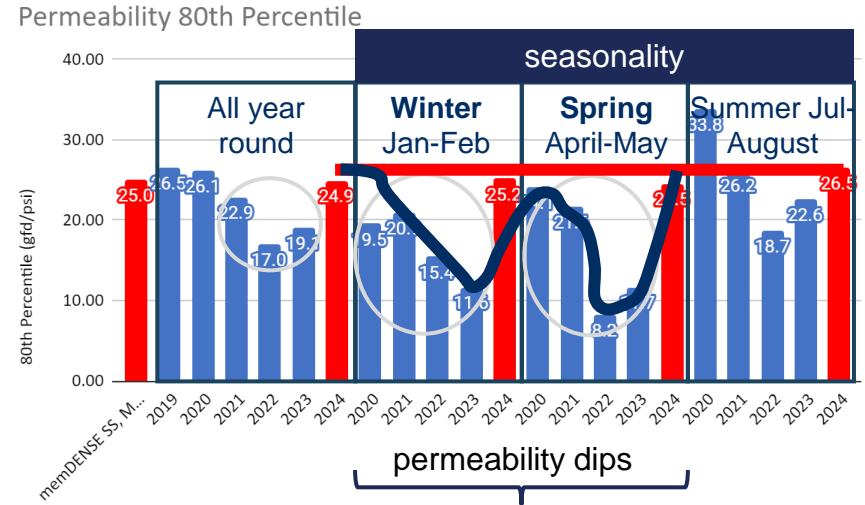
- Reduced fouling
- Reduced cleaning

memDENSE MBR
IMPROVED TMP & PERMEABILITY

better filtering characteristics
↓ **TMP** & ↑ **permeability**

DAS solved W effect

permeability stable all year round
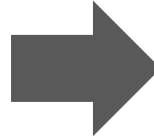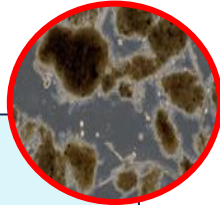with memDENSE MBR

Summary

memDENSE MBR
SUMMARY

BIOLOGICAL PERFORMANCE

- nuisance foam elimination
- increased resilience (biologically stable)
- morphology change
- more interstitial fluid
- inventory change (bioP optimization, AOB/NOBs)

MEMBRANE PERFORMANCE

- reduced fouling
- reduced cleaning
- increased sludge filterability
- increased oxygen transfer efficiency
- increased permeability
- optimized performance over the life of the membranes

Acknowledgements

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- Drew Downhour

THANK YOU

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Water Environment Federation®
the water quality people®

Sponsored eShowcase:

memDENSE™ MBR: How densification improves
MBR performance at the City of Detroit Lakes

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