
memDENSE™ MBR
Paving the way for efficient membrane performance at City of Detroit Lakes
City of Detroit Lakes
SEH
VEOLIA

TODAY'S PRESENTERS

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Lead Researcher
Veolia

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SEH Inc

AGENDA

1. Technology Overview
2. Implementation
3. Demonstration Results
4. Operations Experience
5. Next Steps
6. Summary

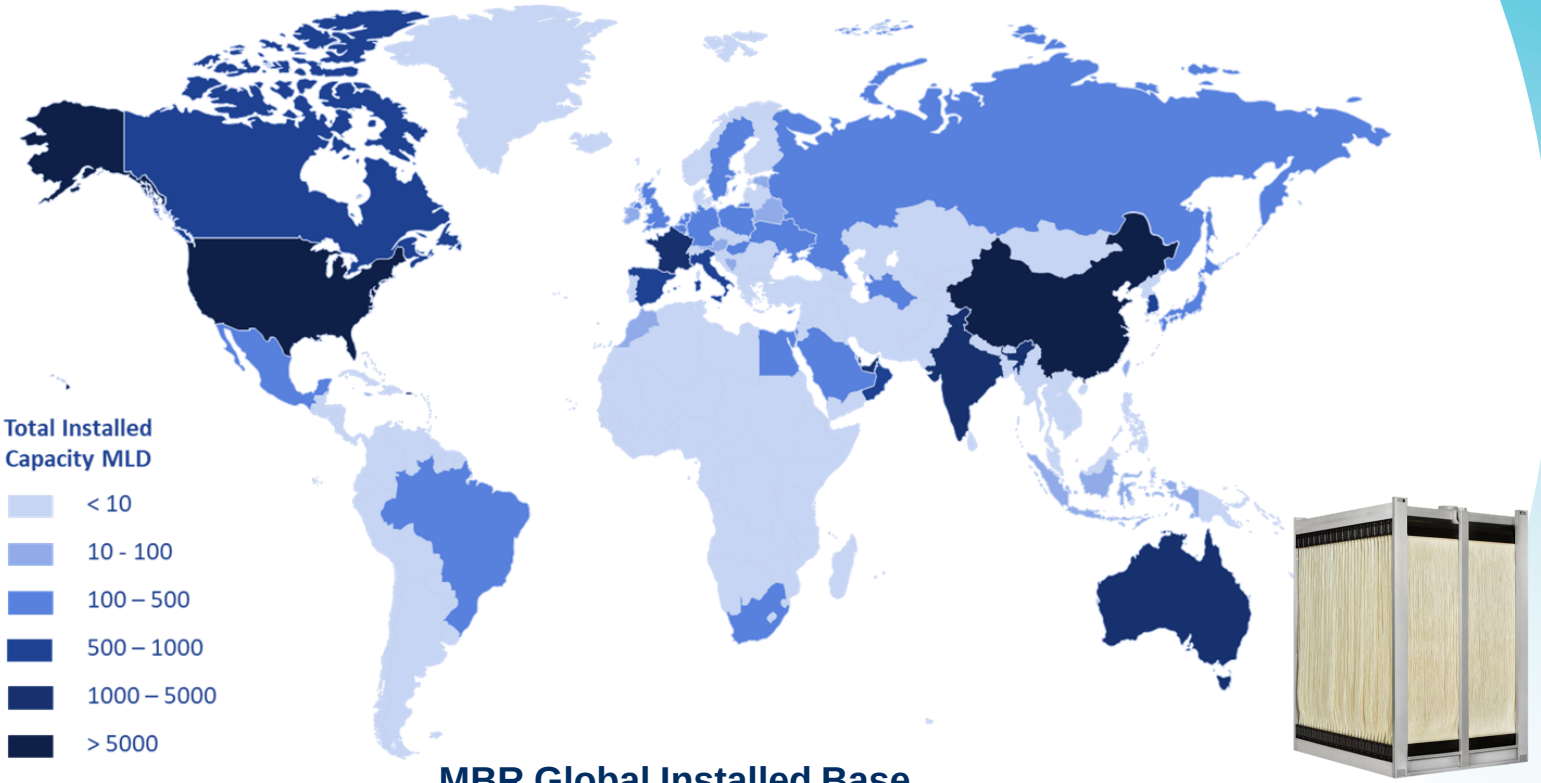
memDENSE MBR

TECHNOLOGY OVERVIEW

VEOLIA

MEMBRANE BIOREACTOR

Delivering superior quality in the smallest footprint



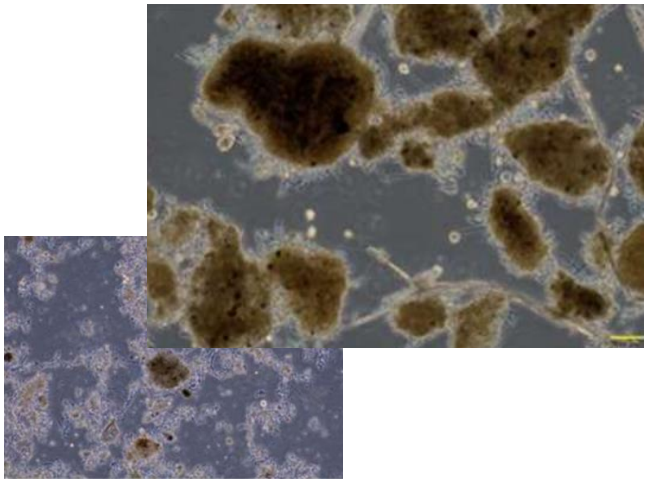
MBR Global Installed Base

mem**DENSE** MBR **reduces operating cost** by tailoring mixed liquor characteristics to **optimize membrane & biological performance**

memDENSE MBR

Combining 2 proven technologies

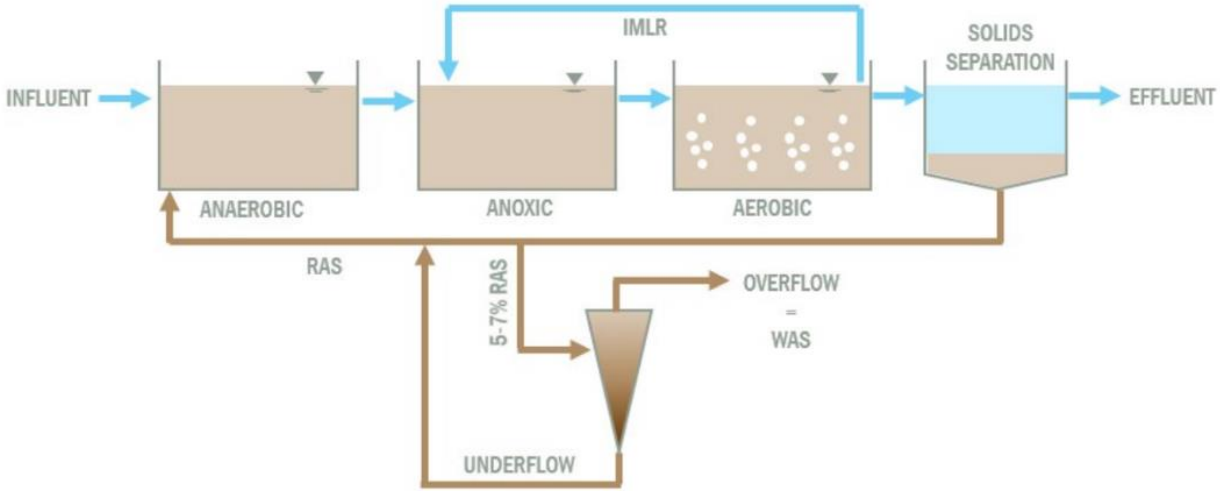
ZeeWeed™ MBR + **Densification**

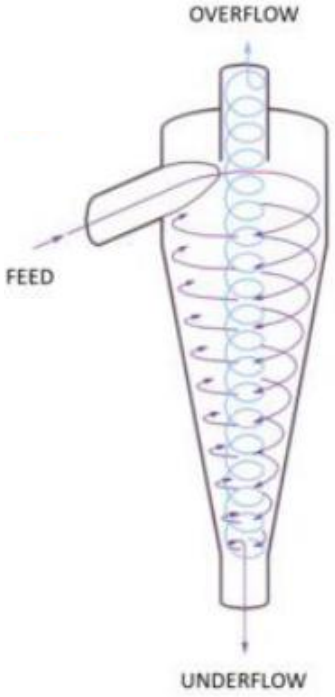


DENSIFICATION

What is it?

Select dense, desirable sludge to **improve solids settling**



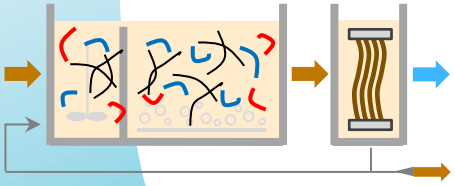


From WRF Project 5130 - A State of Knowledge: Exploring the Densification Continuum

CONVENTIONAL MBR vs. memDENSE MBR

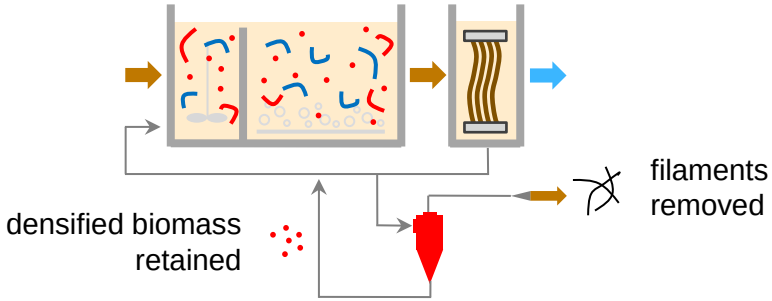
CONVENTIONAL MBR

uncontrolled MLSS characteristics limit MBR performance



memDENSE MBR

tailored MLSS characteristics unlock MBR potential



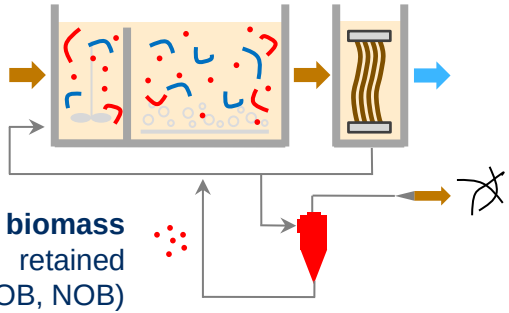
filaments flocs densified biomass

memDENSE MBR

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

SUPPORTING RESEARCH

Densification & granulation with MBR

bridging size, fraction & pore blocking w/ membrane filtration

Donnaz et al, 2020 showed that **biomass densification improves sludge settling of clarifiers** w/ bio aggregates **size distribution 200 - 500 um (1000 max)**

Nogushi et al, 2018 showed that **MBR mixed liquor quality can be enhanced by hydrocyclone**. MBR performance improved with hydrocyclone, due to **removal in Overflow of lighter flocs and colloidal fraction from the mixed liquor**

Wenxiang Zhang et al, 2018 demonstrated the **existence of a critical AGS size (1~1.2 mm) above which membrane fouling is increased and pore blocking higher than cake layer**

research background on densification & AGS with MBR

- more stable & lower fine colloids with HC

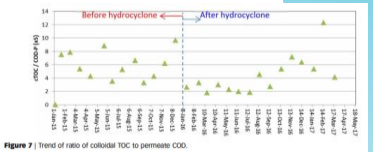


Figure 7 | Trend of ratio of colloidal TOC to permeate COD.

- less membrane CIP with HC

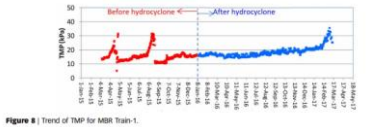
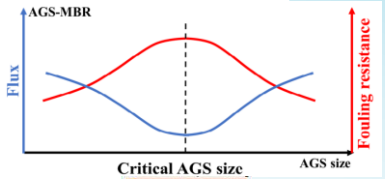
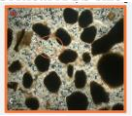


Figure 8 | Trend of TMP for MBR Train-1.

WE TARGET: lower fouling rate < 0.7-1.0 mm diameter d90 = DENSIFICATION

- **higher fouling rate > 1-1.2 mm,**
- **more fines = more pore blocking**





memDENSE MBR

IMPLEMENTATION AT CITY OF DETROIT LAKES

VEOLIA

CITY OF DETROIT LAKES, MINNESOTA

Phosphorus | target: 0.066 mg/L

Approach:

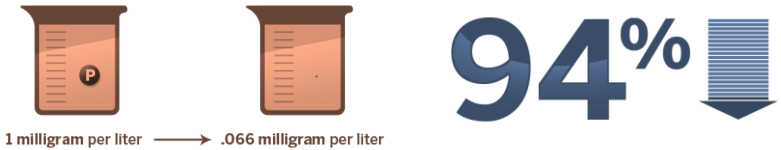
- Biological w/Chemical Trim
- Chemical

Nitrogen | target: 7 or 10 mg/L

Approach:

- Biological

POPULATION:
10,100 (2023)



94%

CITY OF DETROIT LAKES MBR

Why implement densification?

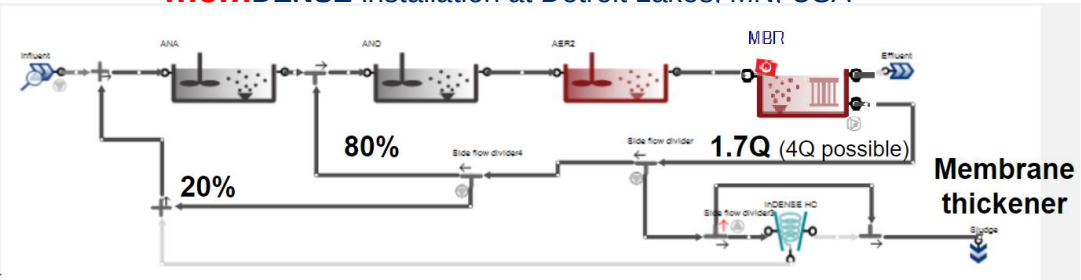
Improving Performance

- **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

memDENSE installation at Detroit Lakes, MN, USA



1.2 MGD ADF, 5 MGD PHF

- **Waterline**:
  - Equalization tank
  - Pretreatment (grit removal)
  - **ZeeWeed-MBR (A2O),** UV disinfection
- **Sludge Line**:
  - **Membrane thickener** (ZeeWeed)
  - Aerobic digestion
  - Dewatering by centrifuge

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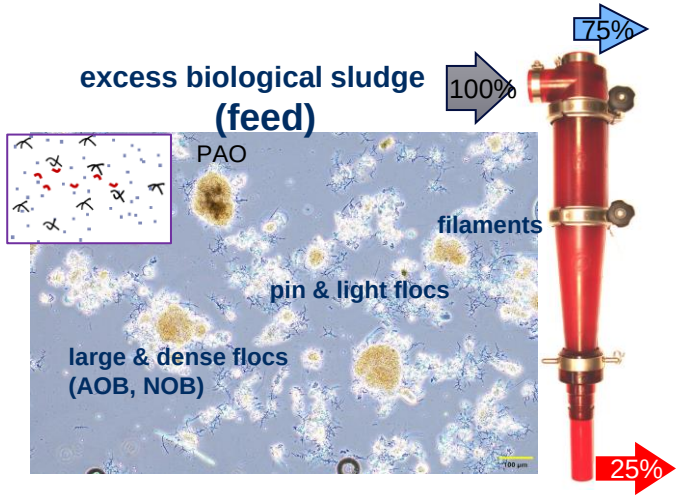
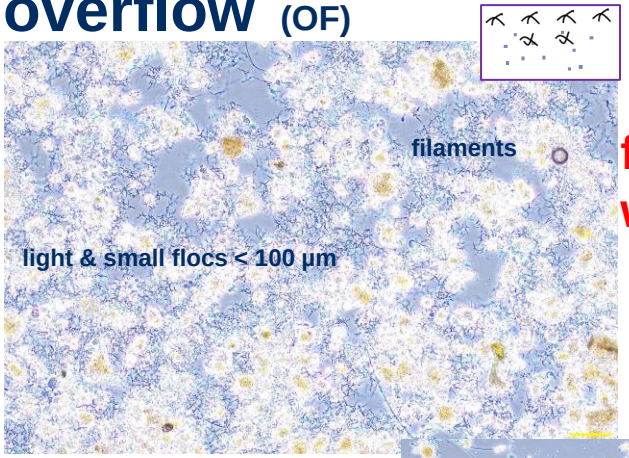
Selective wasting & sludge densification



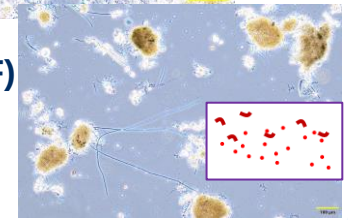
overflow (OF)



filaments wash-out

underflow (UF)

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



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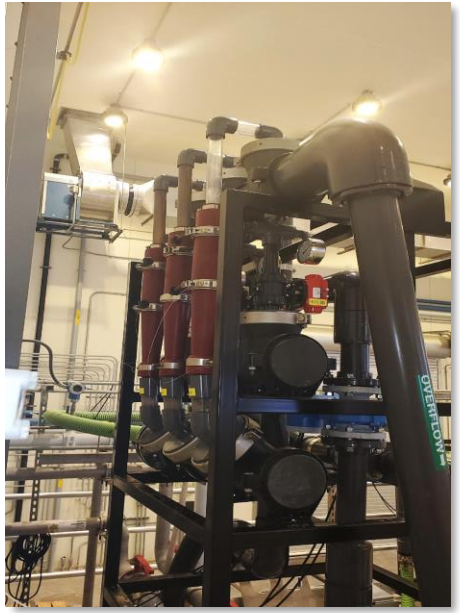
1.5-year look back on performance

January 2023 to today (2024)

- **Filaments washed-out**, foam disappeared
- Densification increased **(DI ↑ from 35 to 65-80%)**
- **Reduced SVI ↓ to 50 mL/g**
- **Reduced TTF ↓ (<50), better permeability**
- ↓ **50%** Chem-P consumption (BioP boost)
- ↓ **20%** Membrane cleaning chemicals

In-progress

- Oxygen transfer improvement
- Benefits to sludge treatment and handling
- Optimizing densification



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Selective wasting

Before
April 2022

After memDENSE implementation
since January 2024

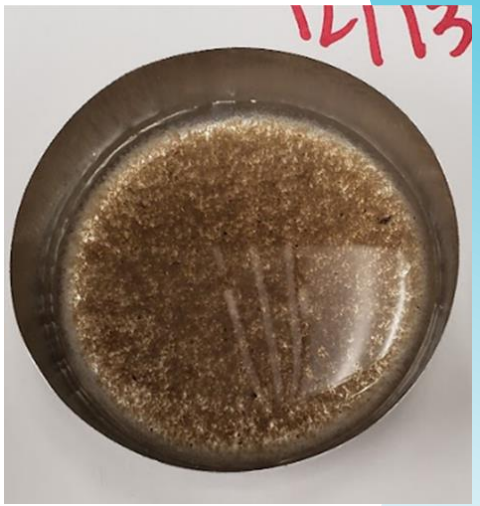
foam disappeared

memDENSE MBR

Macroscopic mixed liquor change

before
memDENSE

start-up



after
memDENSE
early steady-state

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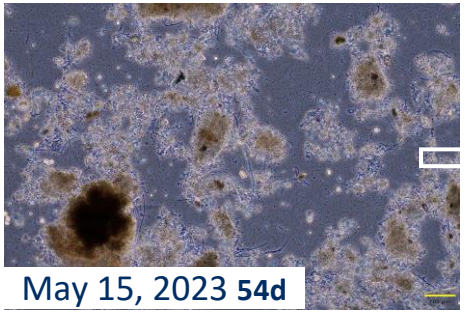
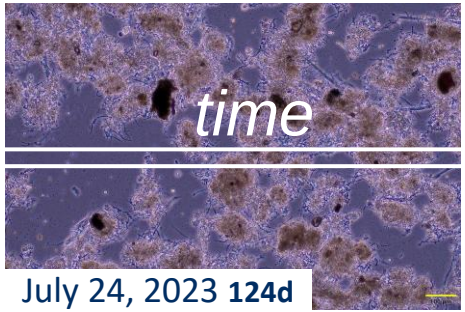
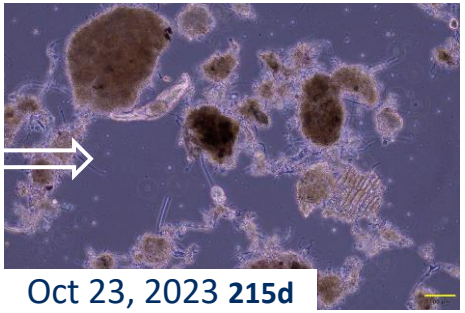
Morphology

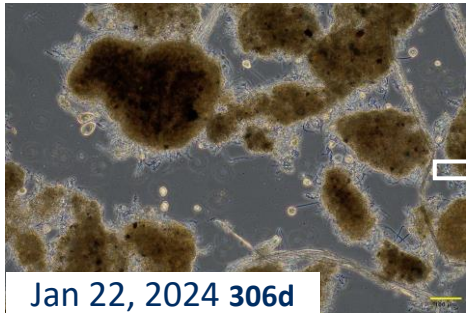
memDENSE Biology - Microscope follow-up - Underflow

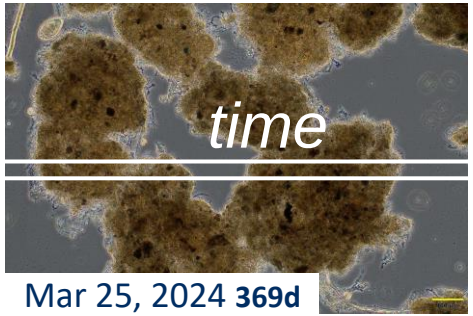

May 15, 2023 **54d**



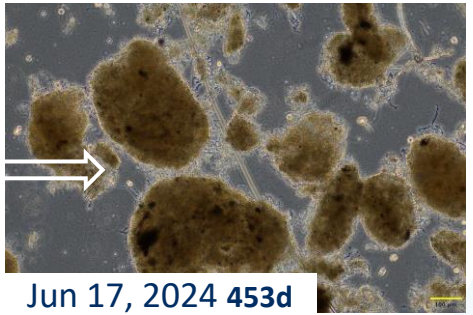
July 24, 2023 **124d**


Oct 23, 2023 **215d**


Jan 22, 2024 **306d**



Mar 25, 2024 **369d**


Jun 17, 2024 **453d**

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DEMONSTRATION RESULTS

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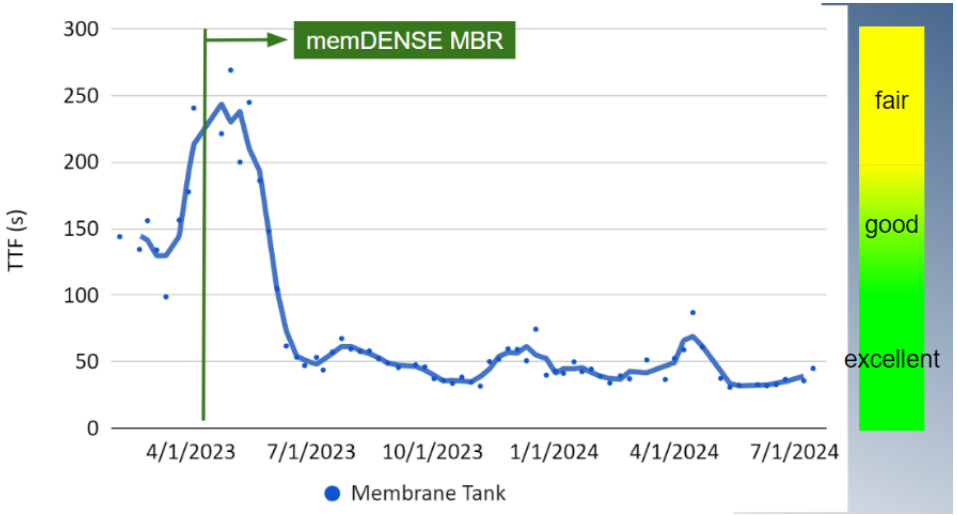
Improved sludge filterability

TTF stabilized at **50 sec**



Time-to-filter (TTF):

- Measurement of the mixed liquor cake layer
- Better cake layer = easier to filter

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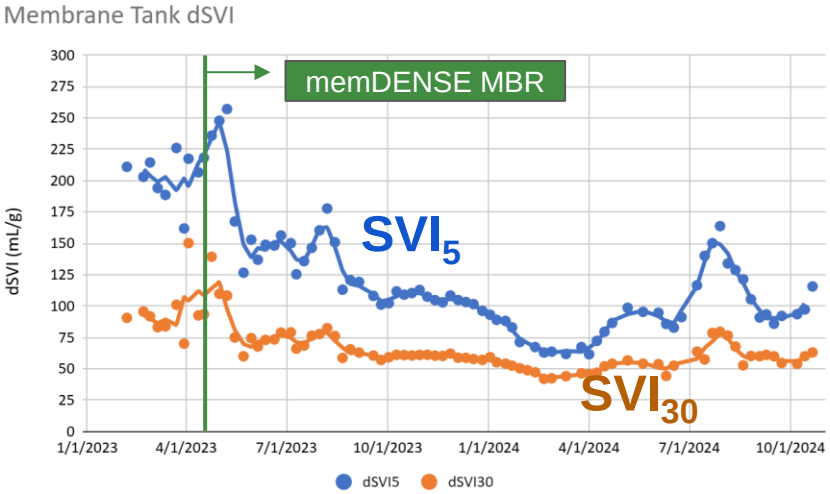
Improved sludge filterability

SVI_{30} stabilized **at 50 mL/g**



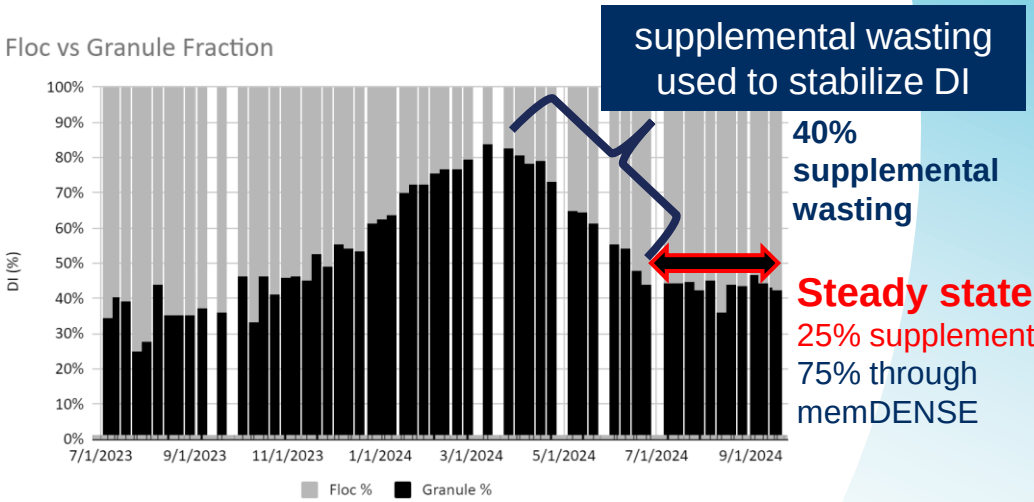
Settling Velocity Index (SVI):

- Speed of sludge settling over 5 and 30 minutes
- Indication of densification's effect on sludge
- Heavier, dense granules settle faster

DENSIFICATION INDEX

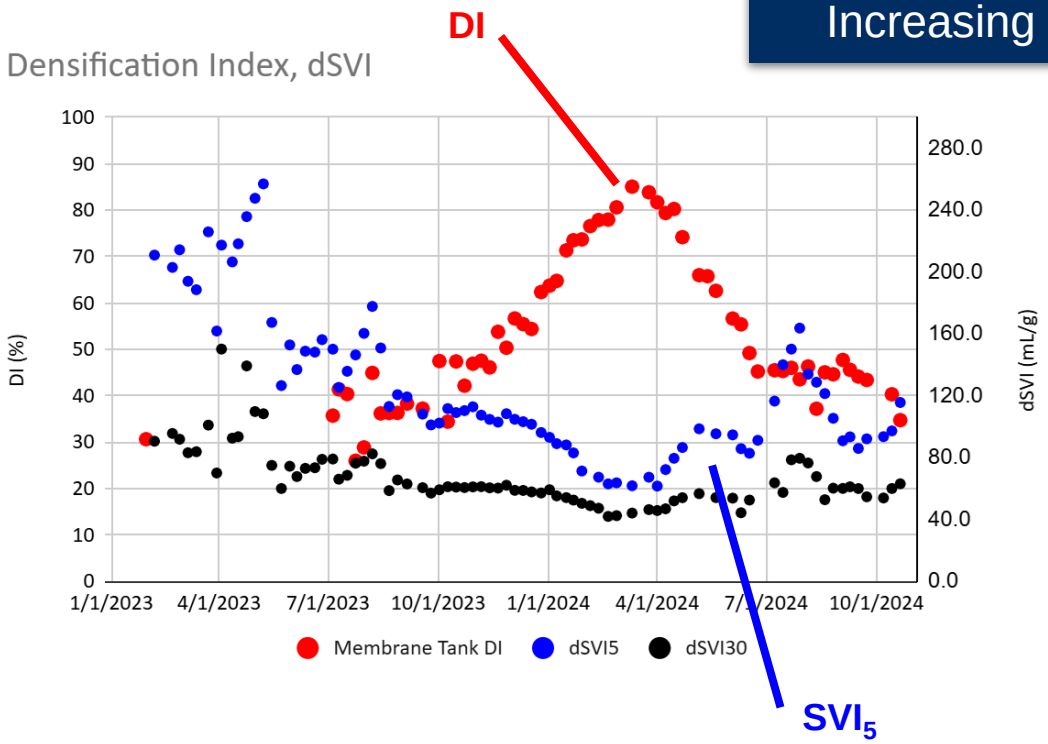
DI control

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



DI & SVI_5

Indicators of mixed liquor changes



Increasing DI leads to decreasing $SVI_{5,30}$

Controlling wasting for DI & SVI, achieves optimal filterability

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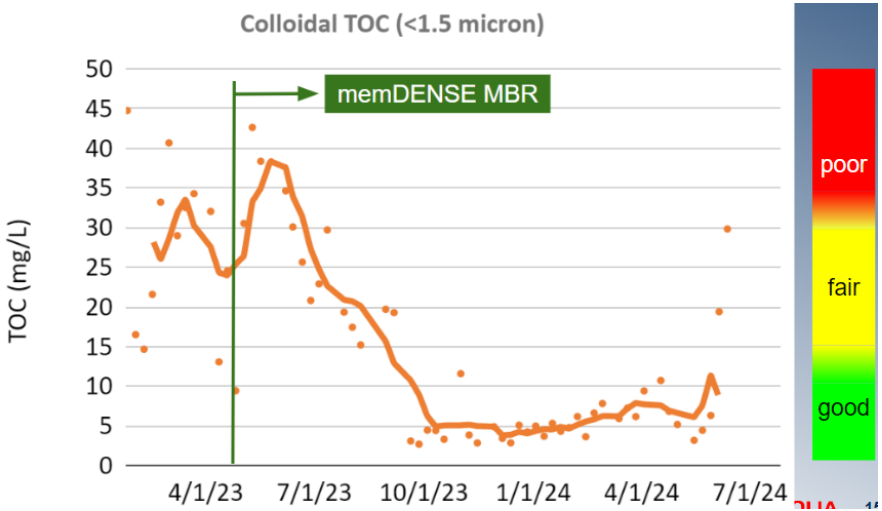
Removal of colloidal material (TOC)

TOC in mg/L



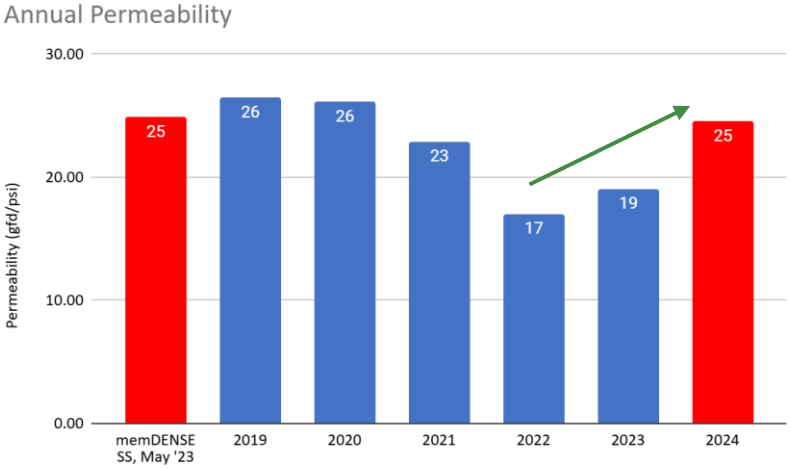
Total Organic Carbon (TOC):

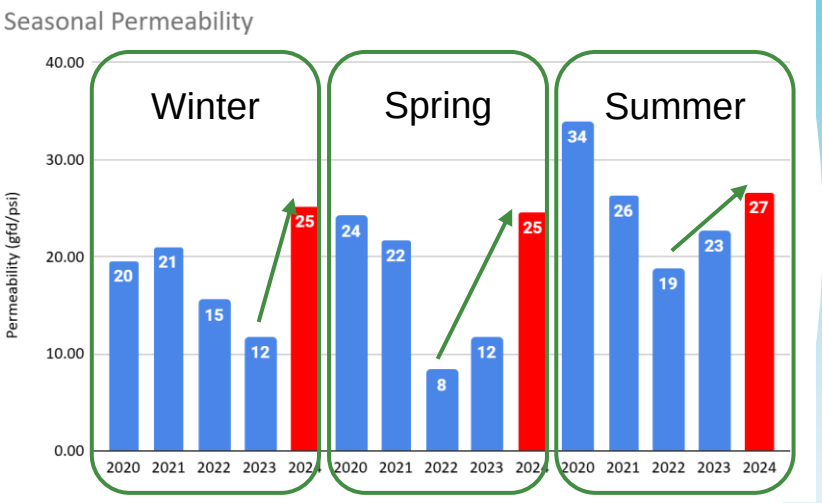
- Fractions smaller than 1.5µm linked to membrane fouling
- Fequires chemical cleaning to recover

With memDENSE:
↓83% colloidal TOC

memDENSE MBR

Improved TMP & permeability





Increased annual average permeability
- close to new membrane condition

Increased permeability every season
- with less variation between over the year

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OPERATIONS EXPERIENCE

VEOLIA

memDENSE MBR
Operations insights

- **Simple to operate system with very little operator input requirements**
  - Yearly/biyearly inspection of approx 30 min
- **Biological upset conditions detected quickly and easily in hydrocyclone overflow**
  - Detected while already being wasted from the system

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NEXT STEPS

DEMONSTRATING IMPROVEMENT IN OXYGEN TRANSFER EFFICIENCY

<u>Regular</u> off-gas campaign
with floating hood

in partnership with ***Pr. Diego Rosso***
DRH2O LLC

<u>Real time</u> off-gas measurement
with oxygen transfer monitoring column

in partnership with Graham McCarthy
Watergate Environmental Technologies

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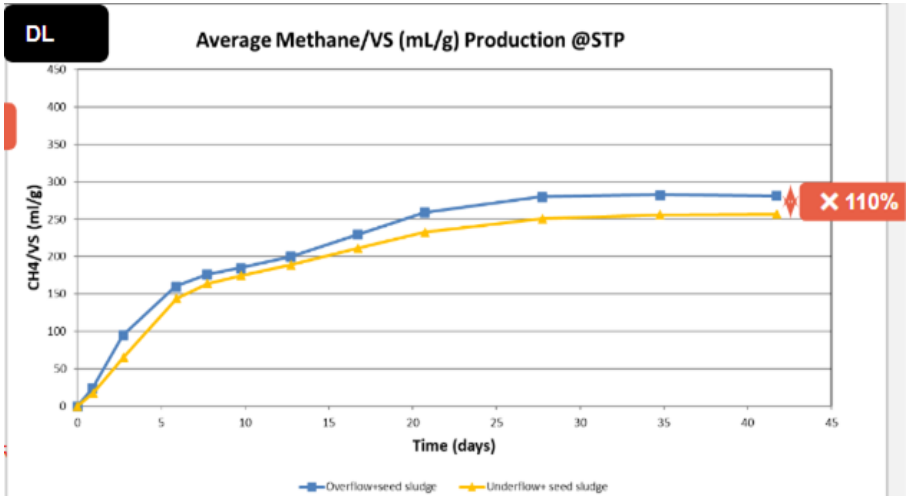
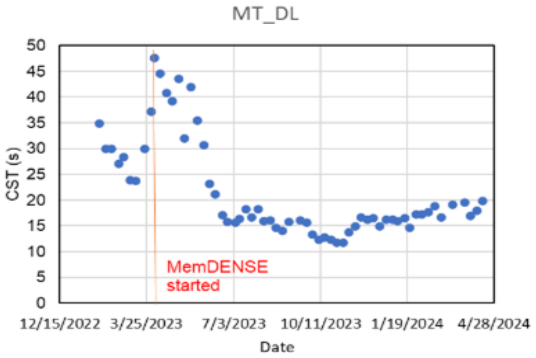
Sludge line performance improvement

- Improved dewaterability
- Increased Biochemical methane potential (BMP)
  - Potential for 20% increase





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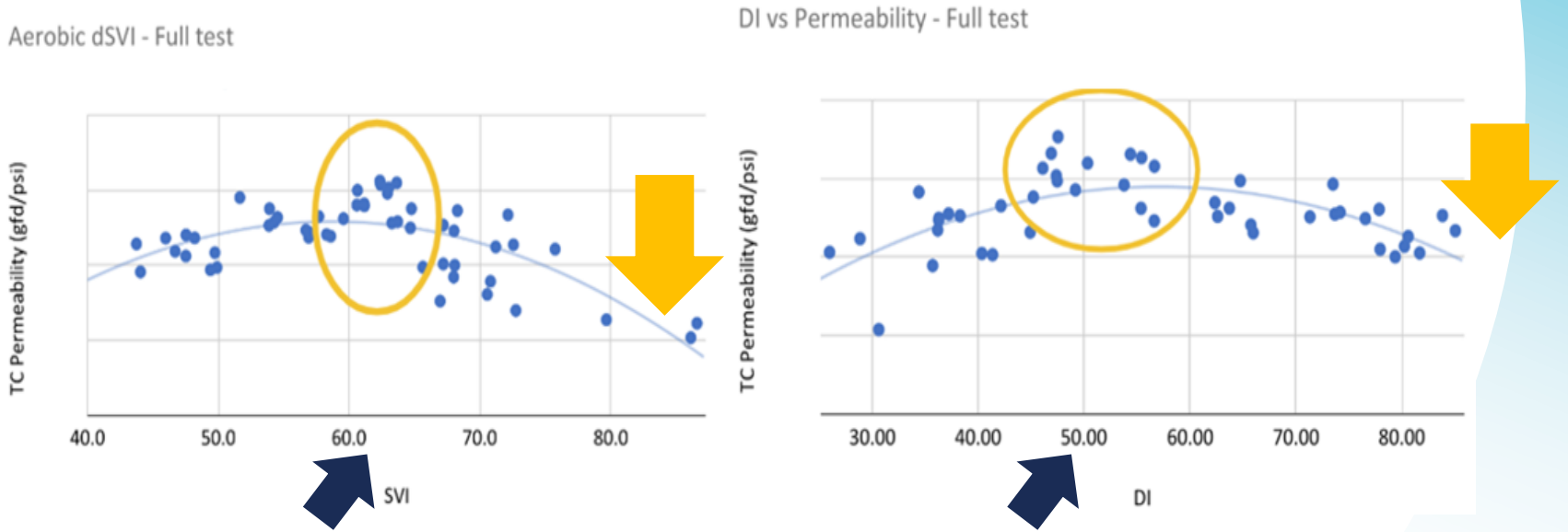
When is dense too dense?

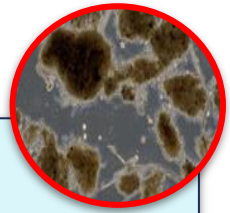
Climax of permeability observed **at 45-55%DI** **60-65 SVI_{30}**



memDENSE MBR

SUMMARY

memDENSE MBR
SUMMARY



BIOLOGICAL PERFORMANCE

- ✓ nuisance foam elimination
- ✓ increase resilience (biologically stable)
- ✓ better bioP
- ✓ potential for improved oxygen transfer
- ✓ potential for improved solids treatment

MEMBRANE PERFORMANCE

- ✓ reduced cleaning chemicals
- ✓ lower OPEX
- ✓ resilience
- ✓ potential for longer membrane life

memDENSE MBR = superior plant performance

ACKNOWLEDGEMENTS

City of Detroit Lakes Public Utility

- Rob Bredeson
- Heather Olson
- Erin Haverkamp
- Corey Will
- Drew Downhour

THANK YOU

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