AMTA/SCMA Joint Technology Transfer Workshop
Oklahoma City, OK – May 14-16, 2019

MBR "A to Z" – Fundamentals through Advanced Techniques in Utilizing Membrane Bioreactors

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Agenda

- Fundamentals of MBR Technology
- Advantages and Disadvantages of MBR
- Lessons Learned
- Current and Future Uses of MBR in Developing Reuse

Fundamentals of MBR Technology

- MBR separates solids and filters effluent in **one** step
- Why use MBR?
  - More efficient at solids separation than clarifiers
  - Bulking is no longer a concern!
  - Advanced membrane filtration is built-in, reuse water requirements can easily be met
    - Typical MBR effluent turbidity is 0.1-0.3 NTU
- How does MBR work?
  - Sludge builds up on the surface of the membrane. A pump draws a vacuum through the membrane (can also flow by gravity), drawing clean water through the membrane.

Fundamentals of MBR Technology

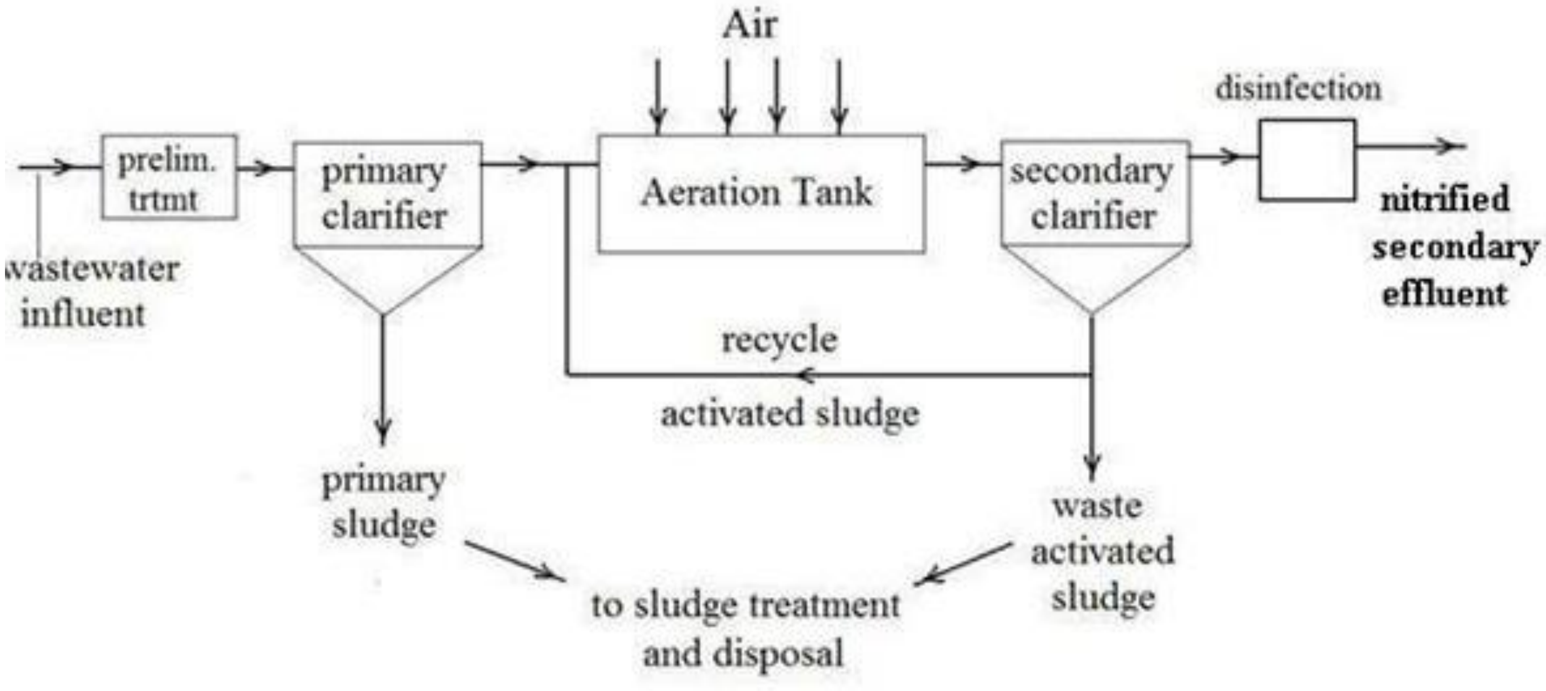
- History of MBR
  - Original MBR was a tertiary filtration system
    - Replaced conventional filtration only (similar to current MF/UF filtration systems in water treatment)
    - Operating flux was 20-30 gallons per square foot per day (gfd)
      - Water treatment membranes are designed for 50-70 gfd typically
    - Significant issues with membrane fouling
  - Current MBR design replaces clarification and filtration
    - Recommended operating flux is now 10-15 gfd to minimize fiber breakage
    - Membrane fouling substantially reduced

Fundamentals of MBR Technology

- How does MBR impact solids handling in wastewater processes?
  - Conventional Solids Handling
    - Secondary Clarification, RAS/WAS Pumping, Solids thickening, solids dewatering and disposal
    - Sludge in aeration basin – 2,000 – 4,000 mg/L MLSS
  - Membrane System Solids Handling
    - MBR, Waste solids from MBR basin, solids dewatering and disposal
    - Sludge in aeration basin – 4,000 – 10,000 mg/L MLSS
    - Sludge in MBR basin – 6,000 – 12,000 mg/L MLSS
      - **Some MBR systems have been operated at up to 20,000 mg/L !**

Fundamentals of MBR Technology

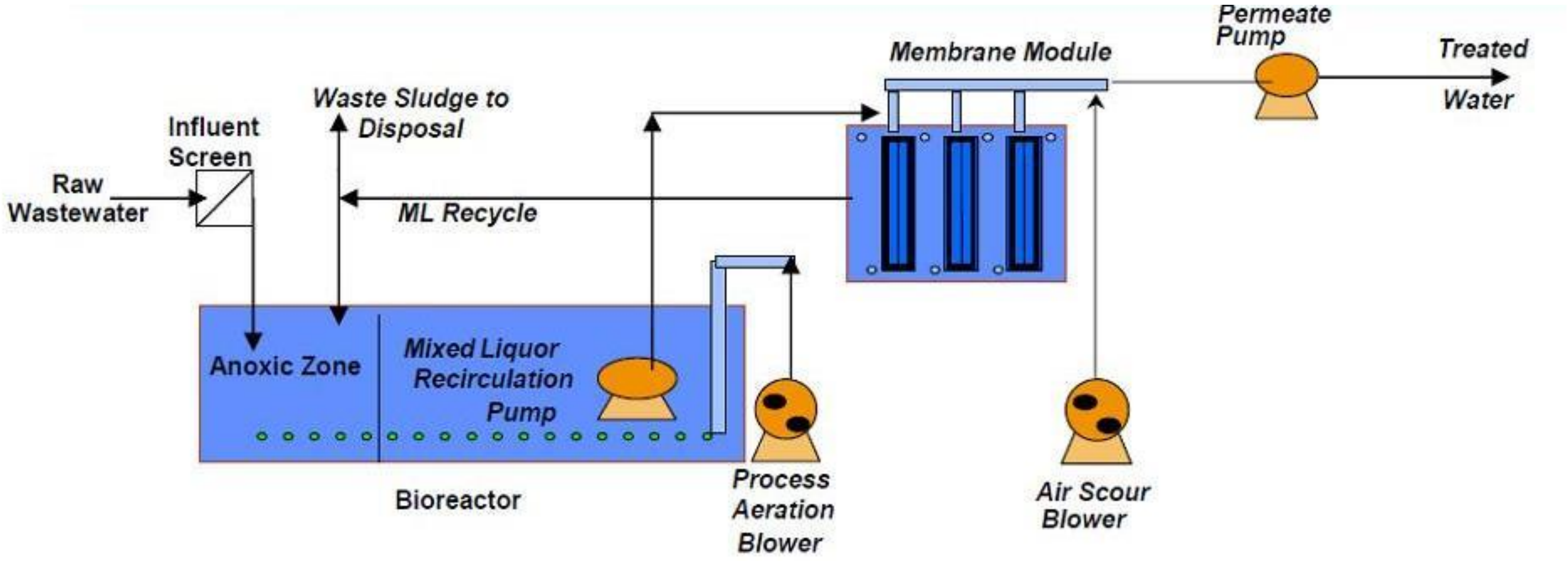
- Typical Conventional Treatment Process Flow Diagram



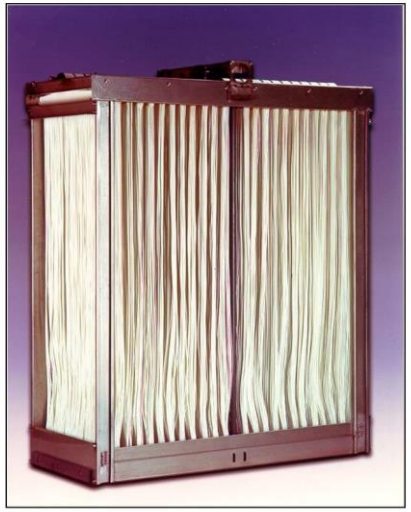
Activated Sludge Wastewater Treatment Flow Diagram

Fundamentals of MBR Technology

- Typical Current MBR Treatment Process Flow Diagram



Fundamentals of MBR Technology



Fundamentals of MBR Technology

Equipment Manufacturer	Membrane Manufacturer	Membrane			Global Experience		
		Type	Pore Size (um)	Material	No.	Largest MGD	Longest Years
Suez	Suez	Hollow Fiber	0.04	PVDF	460+	57.6	23
Kubota	Kubota	Flat Sheet	0.4	CPE	5,600+	42.7	24
Ovivo	Microdyne	Flat Sheet	0.1	PVDF	53	10.0	6
Evoqua	Memcor	Hollow Fiber	0.1	PVDF	138	28.5	17
Kruger	Toray	Flat Sheet	0.08	PVDF	8	1.0	11
Koch	Koch	Hollow Fiber	0.04	PVDF	8	3.4	9
H2O	Multiple Options	Flat Sheet or Hollow Fiber	0.04-0.1	Mult.	29	4.6	13
FibraCast	FibraCast	Fiber-Plate	0.04	PVDF	50+	8.4	4
Meiden	Meiden	Flat Sheet	0.04-0.1	Ceramic	70+	10.0	6

Advantages and Disadvantages of MBR

- **Advantages**
  - Superior effluent water quality as compared to conventional technologies
  - Can provide necessary water quality for advanced technology polishing (RO/NF/FO)
  - Significant increase in MLSS allows for minimal footprint, which can allow expansion of landlocked facilities that cannot expand with conventional technologies
  - High level of automation allows for operators to “grow” into new technology – a PhD is not required!

Advantages and Disadvantages of MBR

- **Disadvantages**
  - Effective pretreatment is more critical to MBR than conventional technologies
  - MBR membrane replacement is required at a higher frequency than major equipment replacement
  - Preventative maintenance mirrors efforts typically required for membrane filters in drinking water treatment – training above typical wastewater operator training is necessary
  - Poor preventative maintenance can drastically reduce membrane life, which can cost a utility significant $$
  - Poor design can drastically increase capital cost, O&M cost, and shorten membrane life – MBR is not a “plug and play” technology

Lessons Learned

- Lessons Learned over 20 Years of MBR Use in the United States
  - Some state agencies allow up to 3 mm fine screening – limit to 2 mm or smaller
  - Some MBR manufacturers say grit removal is optional – plan for grit removal
  - Some MBR manufacturers say no cleaning is required – develop a plan for cleaning membrane cassettes, either in the MBR tank or in an exterior tank
  - Most state agencies allow for a design flux of up to 15 gfd – plan for a more conservative flux, especially if this is your first MBR plant!
  - Last but not least…no MBR system is perfect, do your homework!

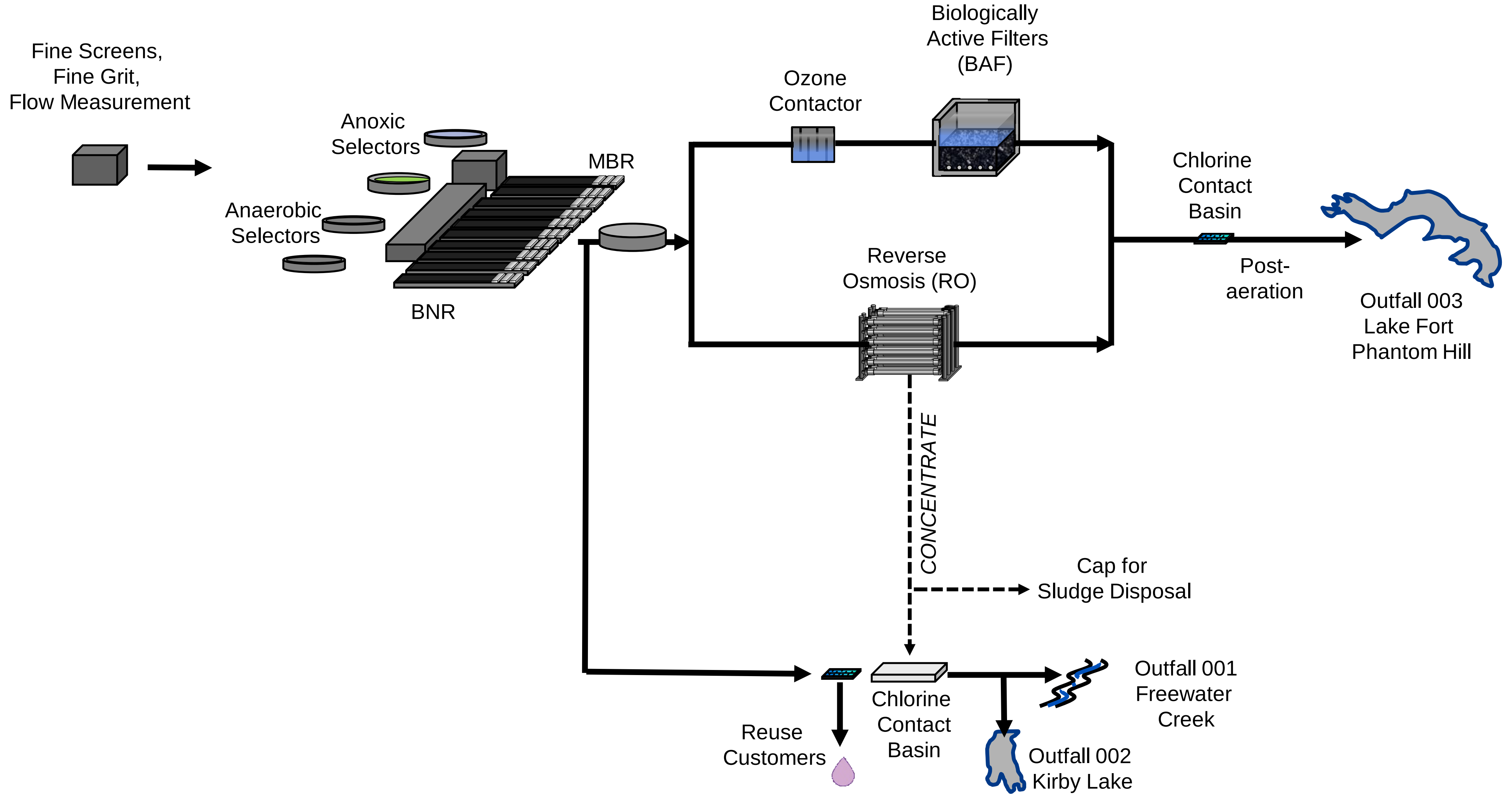
Current and Future Uses of MBR in Developing Reuse

- Current Uses of MBR in Developing Reuse
  - Multiple facilities worldwide using MBR for non-potable reuse
    - MBR typically provides effluent turbidity < 0.1 NTU with bacteria levels usually at < 1 CFU / 100 ml – suitable for human contact
  - One facility currently utilizing MBR for potable reuse (with more to follow!)
    - Abilene, TX USA

Current and Future Uses of MBR in Developing Reuse

- Current Uses of MBR in Developing Reuse
  - Abilene, TX USA facility – Indirect Potable Reuse (IPR) Project
    - 22 MGD BNR process
    - 12 MGD hollow fiber MBR (soon to be expanded)
    - 5.0 MGD three-stage RO (85% recovery)
    - 4.0 MGD Ozone / BAF
    - 7 MGD design, 9 MGD maximum potable reuse augmentation of nearby raw water reservoir for Abilene
    - 4-6 MGD non-potable reuse (NPR) supply for NPR customers in Abilene – reduces daily potable water demand by 4-6 MGD

Current and Future Uses of MBR in Developing Reuse



Current and Future Uses of MBR in Developing Reuse

- Current Uses of MBR in Developing Reuse – Abilene IPR Results

Parameter	Goal	Actual Performance
Annual Average Flow Rate to Lake Fort Phantom Hill	7 MGD	6-7 MGD
MBR Turbidity	< 0.3 NTU	0.05-0.10 NTU
Total Phosphorus	0.5 mg/L	0.03 mg/L
TDS	375 mg/L	325 mg/L
Chloride (as Cl^-)	100 mg/L	80 mg/L
Sulfate (as SO_4^{2-})	95 mg/L	70 mg/L
Pathogen Removal/Inactivation[b]		
Cryptosporidium parvum	4-log	4-log+
Giardia lamblia	4-log	4-log+
Viruses	0.5-log	0.5-log+
Contaminants of Emerging Concern (CECs)	50 - 90% Reduction	80% Reduction

Current and Future Uses of MBR in Developing Reuse

- Future Uses of MBR in Developing Reuse
  - Multiple pilot testing studies worldwide are now being planned or conducted with the goal of implementing MBR full-scale for potable reuse
    - Examples of Critical Testing Goals:
      - Identify what types of MBR are suitable for providing necessary feed water quality to advanced polishing technologies, like RO
        - Hollow fiber is proven, but what about flat sheet, fiber-plate, ceramics?
        - To minimize colloidal fouling, RO needs a feed water silt density index (SDI) value of less than 5, preferably less than 3 (Title 22 approval is not the same!)
      - If an MBR system cannot provide consistent SDI values, can other polishing technologies be used – ED, EDR, EDI, Ozone/BAF?

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Questions?

Thank you for your time!

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