Level | Pressure | Flow | Temperature | Liquid Analysis | Registration | Systems Components | Services | Solutions

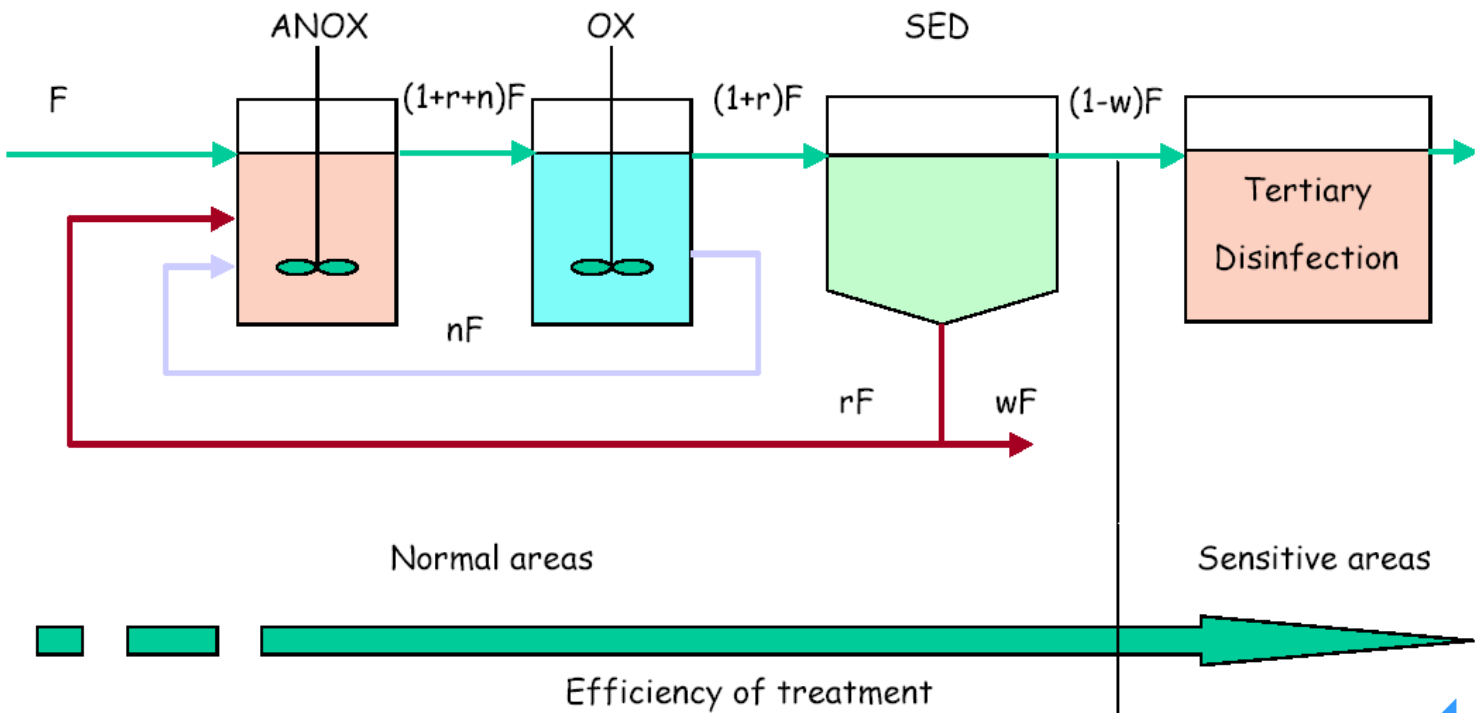
MBR in wastewater treatment

An introduction

Endress+Hauser

People for Process Automation

Conventional activated sludge process (ASP)



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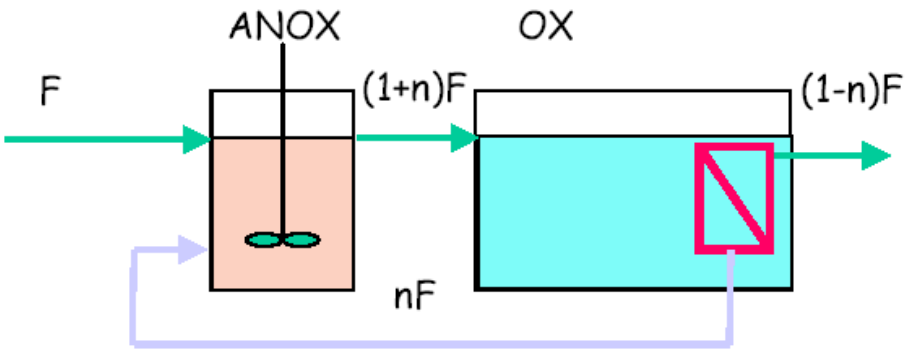
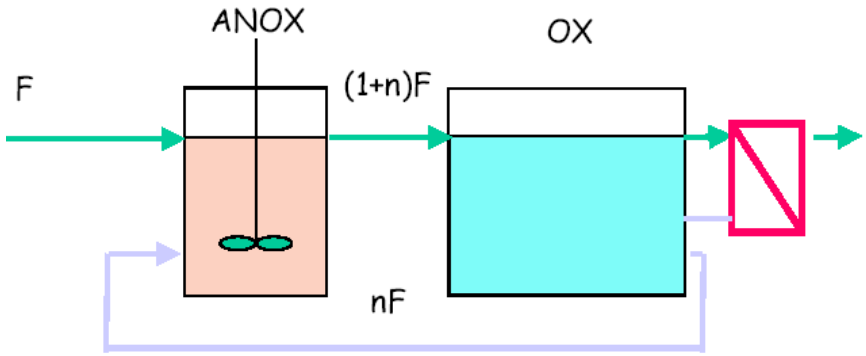
Membrane Bioreactor process (MBR)



- Submerged MBR
  - > capital cost
  - > aeration cost
  - < pumping cost
  - < cleaning
  - < operation cost



- Side stream MBR
  - < flow variation

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Pro membrane bioreactor

- Small footprint required
  - No secondary clarifier
  - Higher sludge concentrations possible
- Removal of micro pollutants
  - Reuse opportunities
  - Less disinfectant necessary
- Safe solids separation
  - High sludge age guarantees nitrification also under non-optimum conditions
  - High sludge age leads to low sludge production
  - High effluent quality

Con membrane bioreactor

- Enhanced pretreatment required
  - Protection of membranes against coarse solids
- Low “peak to average ratio” required
  - Cost of membrane equipment is proportional to the peak hydraulic rate
- Energy consumption
  - Due to higher viscosity lower oxygen transfer rates can be achieved -> higher energy demand
  - “Cross flow” aeration is needed for fouling control
- Membrane fouling/ cake formation
  - Chemical cleaning necessary
  - Hydraulically cleaning necessary

Comparison ASP versus MBR

	MBR	ASP
Footprint	☺	☹
Removal of micro pollutants	☺	☹
Effluent quality	☺	☹
Sensitive solids separation	☺	☹
standard pre-treatment	☹	☺
Sensitive to ratio dry-wet weather	☹	☺
Energy consumption	☹	☺

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Drivers and Barriers for MBR

Drivers

- Water reuse demand
- High property prices
- High effluent quality targets
- Reduced buffer zones required in developed areas
- Reduced price for membranes

Barriers

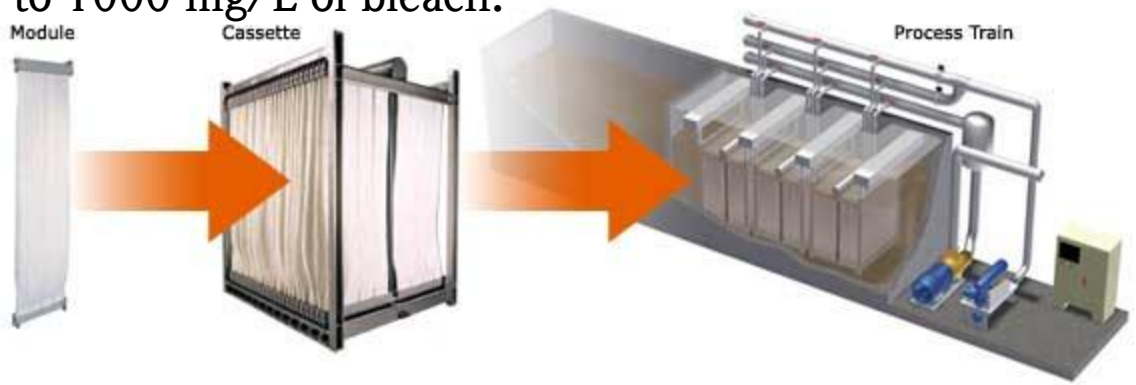
- Mixed channel sewer system/ influence of wet weather infiltration
- Wastewater characteristics e.g. high phosphate concentrations in the inlet
- Many existing wwtp, which can not be upgraded to MBR
- Tendency to centralized wwtp or large scale wwtp (may change with experience)

Key players

- US and Canada:
  - Zenon Environmental (CA)
  - Kubota (through its licensees) (JP)
  - Ionics/Mitsubishi Rayon
  - U.S. Filter (USA)
  - Aqua-Aerobics/Pall Corporation
  - Norit X-flow
- Europe:
  - Zenon (CA)
  - Wehrle Werk (D)
  - Huber (D)
  - Aquator (UK)
  - Kubota (JP)
  - Norit X-Flow (NL)
  - VA Tech (A)
  - Ondeo (FR)
  - Veolia Environnement (FR)

Zenon principle

- submerged membrane
- hollow fibers
- pore size 0.1 micron (0.035 micron effective)
- backpulse system is used to force flow back through the fibers every 10-15 minutes to prevent plugging.
- individual membrane chambers are provided to allow in situ cleaning of the membrane banks. Membranes are taken out of service, the chambers drained and the membranes are soaked for 24-48 hours in 200 to 1000 mg/L of bleach.



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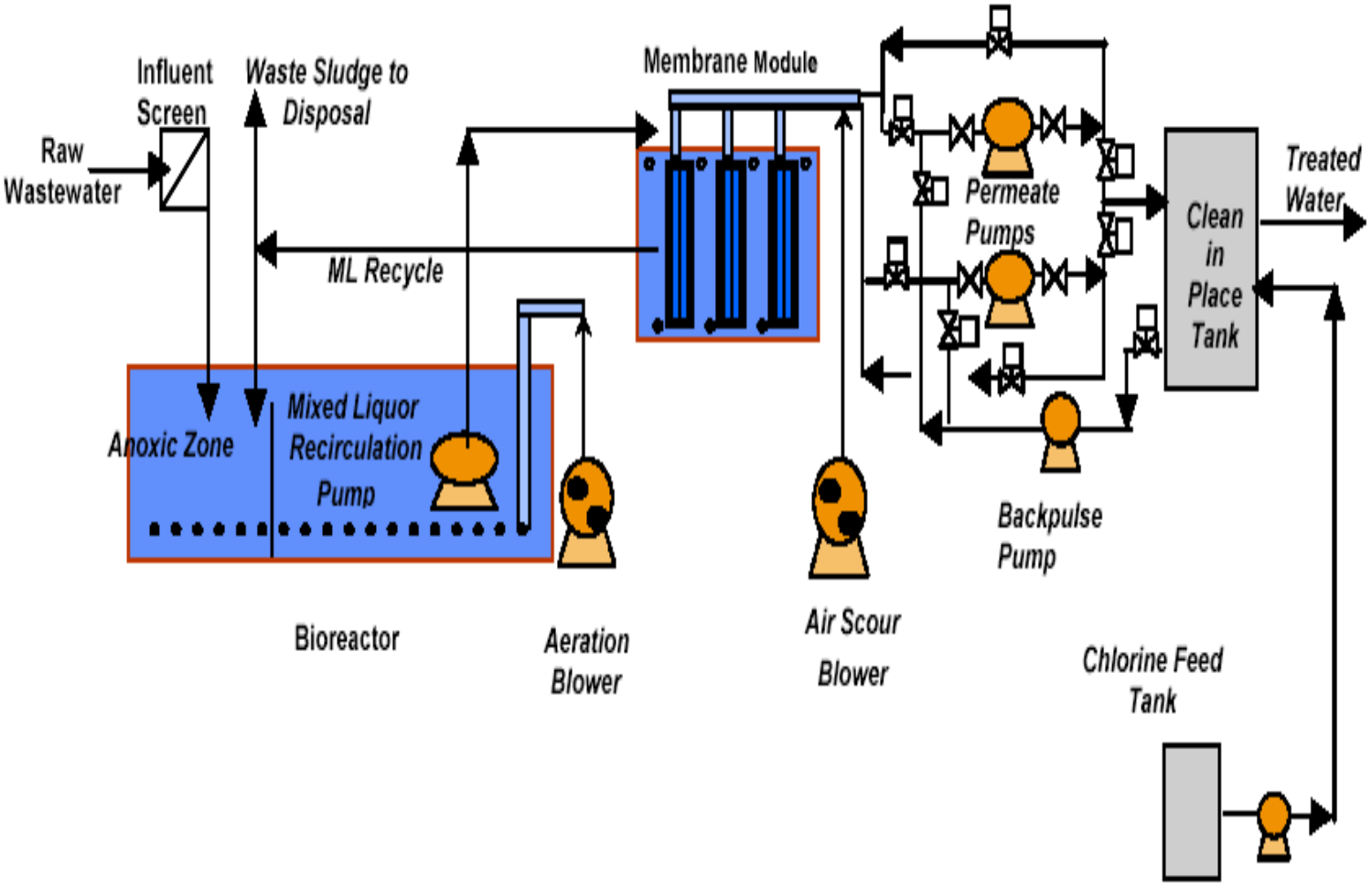
Zenon Zeeweed Schematic



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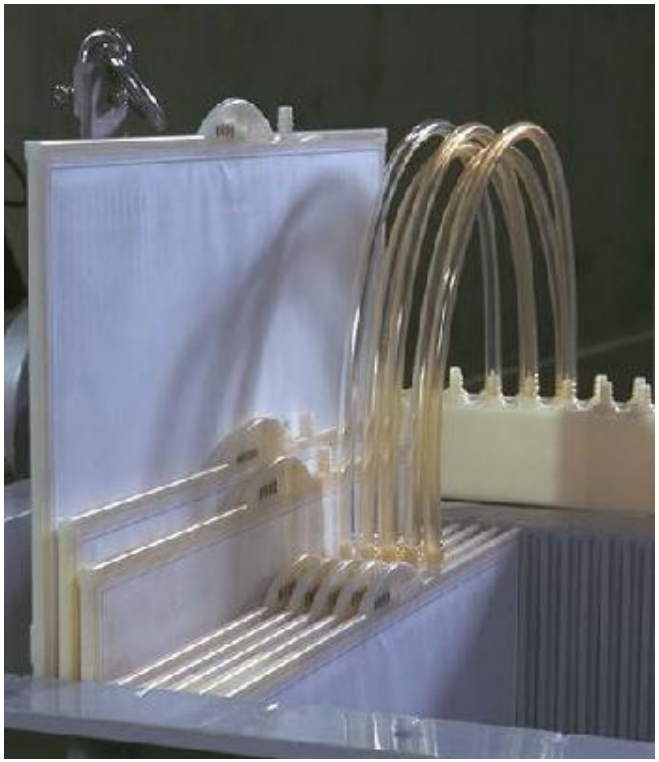
Kubota principle

- submerged membrane
- Plate membranes
- pore size 0.4 micron (0.1 micron effective).
- No back-pulse system
- cleaning cycle can be done in the mixed liquor WITHOUT draining the tank. A dilute solution of bleach is allowed to flow by gravity back through the permeate lines. The solution soaks in the membranes for 1-2 hours, and then the plant is brought back on-line.



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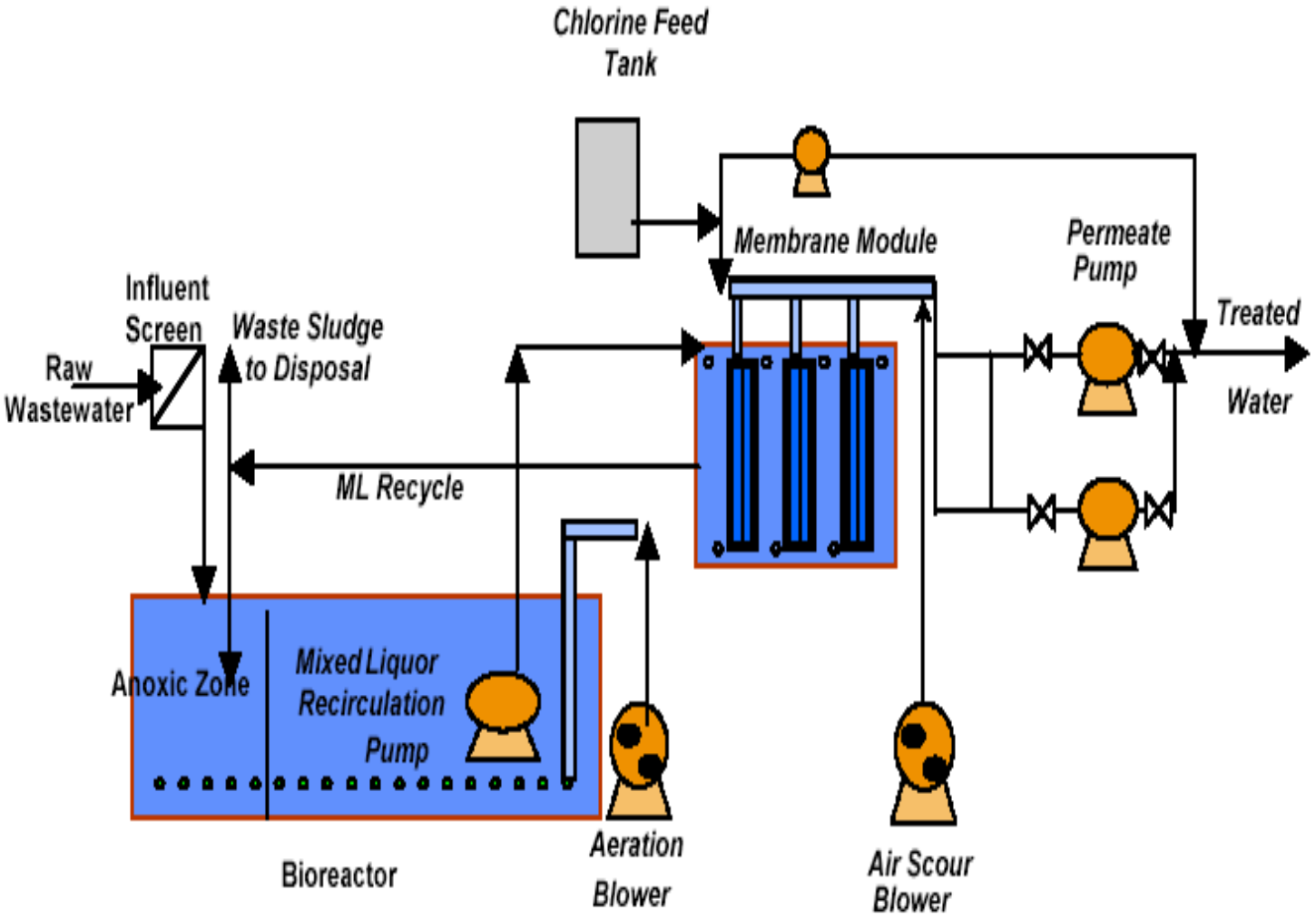
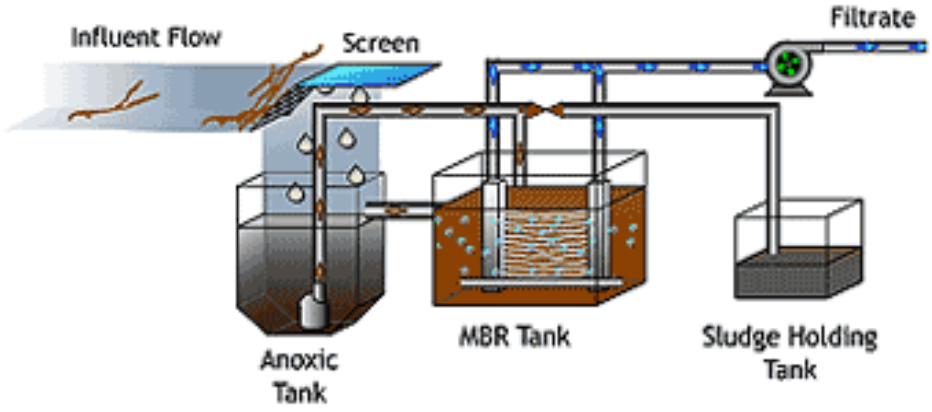
Kubota Schematic



Ionics MBR

The 0.4 µm microfilters are submerged and placed into an aeration basin. A vacuum is applied downstream of the membranes to allow for the solid/liquid separation process to occur. The membranes eliminate the need for a secondary clarifier because they act as an absolute barrier. Air is introduced into the system to scour the membranes and drive the biological treatment



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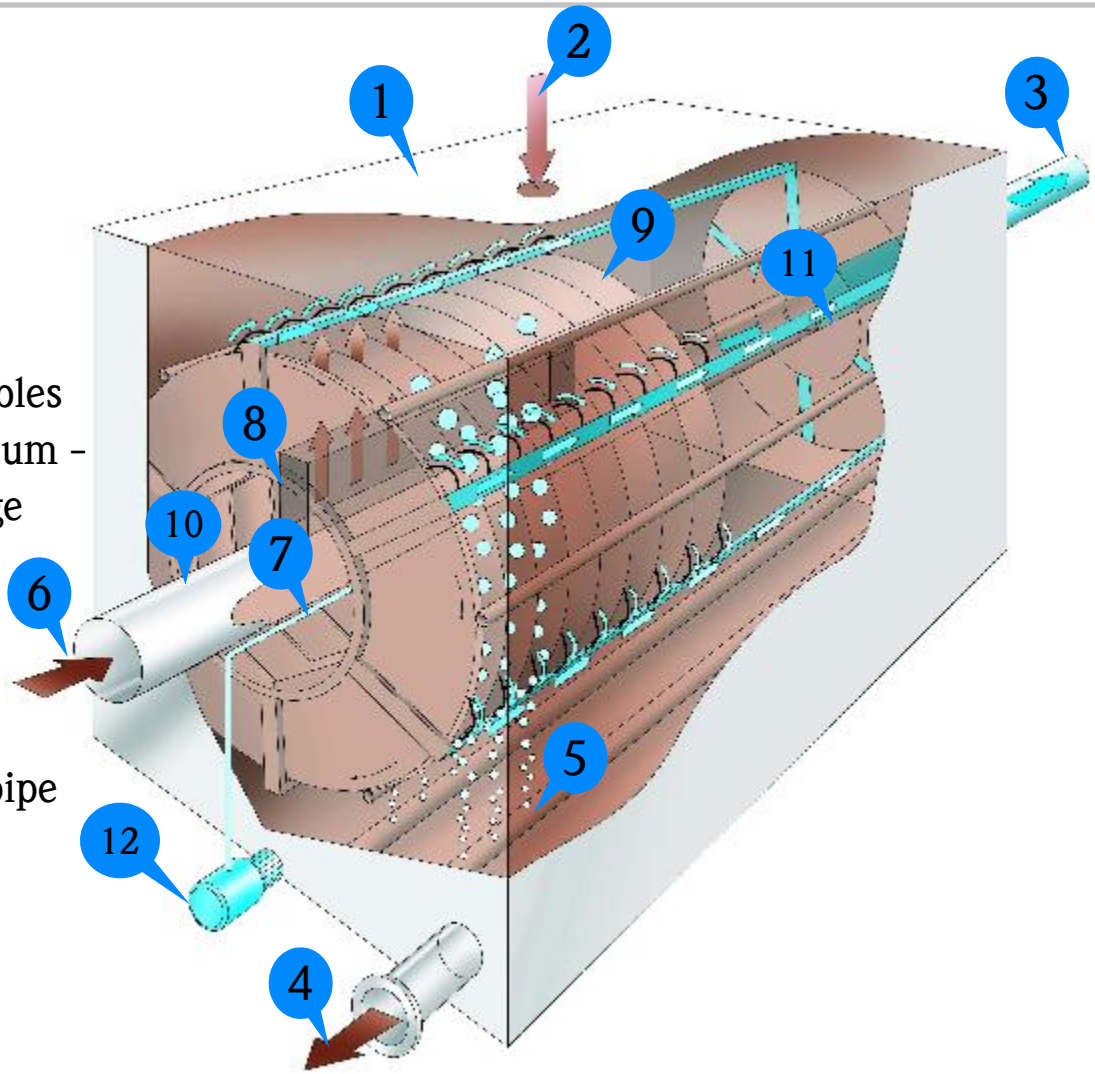
Huber MBR

1. reactor tank
2. wastewater inlet
3. permeate discharge
4. sludge discharge
5. aeration with fine bubbles
6. inlet for scouring medium – activated sludge
7. scouring air inlet
8. jet flushing
9. membranes
10. rotating hollow shaft
11. permeate collection pipe
12. scouring blower



The largest MBR Plant

ZENON Environmental Inc. announced it has been selected to supply King County in the State of Washington with the world's largest membrane bioreactor.

The ZeeWeed MBR (membrane bioreactor) will treat an average day flow of approximately 144,000 cubic meters of municipal sewage or 38 million gallons per day (mgd) with peak flows up to 204,000 cubic metres or 54 mgd, serving over 100,000 households.

Design of the green-field plant is currently underway with construction expected to begin in 2006 and completion scheduled for 2010 for the Brightwater plant.

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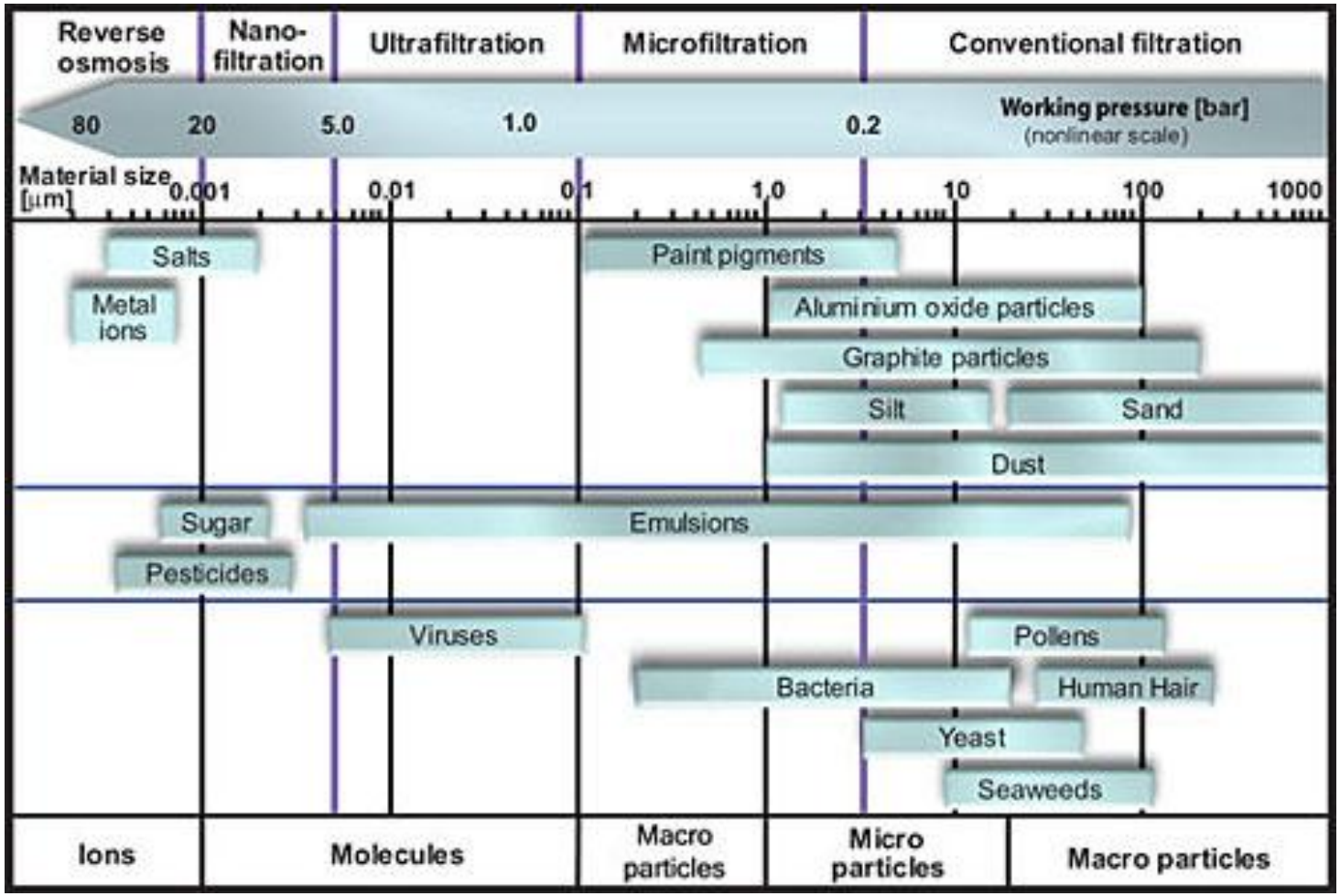
Filtration



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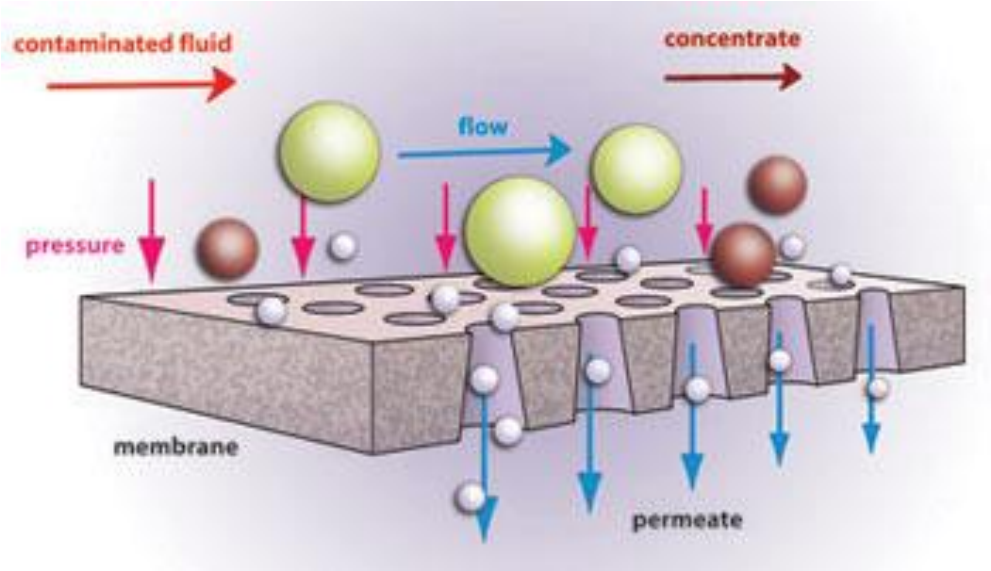
Cross flow filtration



Besides proper selection of membrane material and pore size efficiency of cross flow filtration depends on proper adjustment of

- Flow
- Pressure

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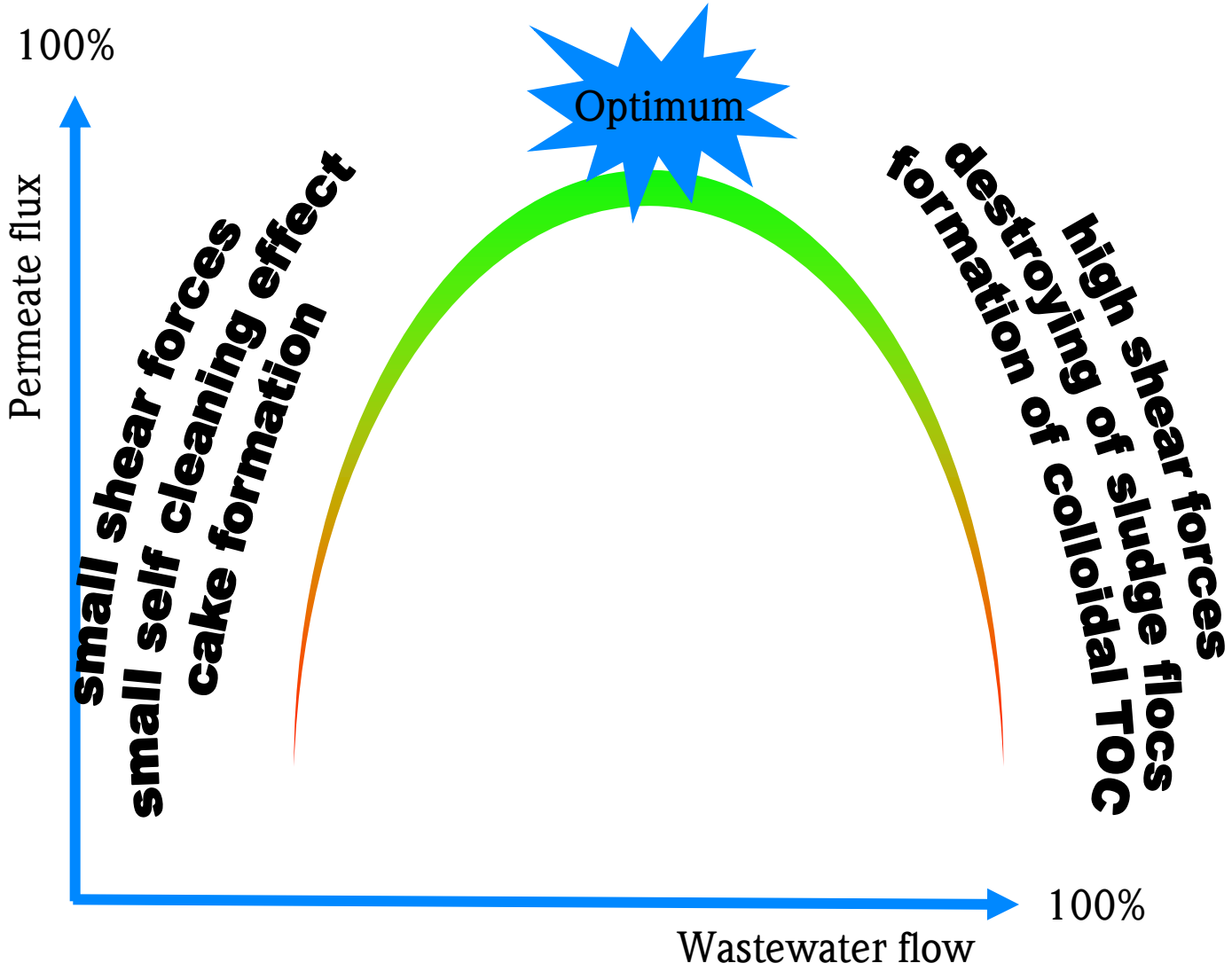
Wastewater flow vs permeante flux



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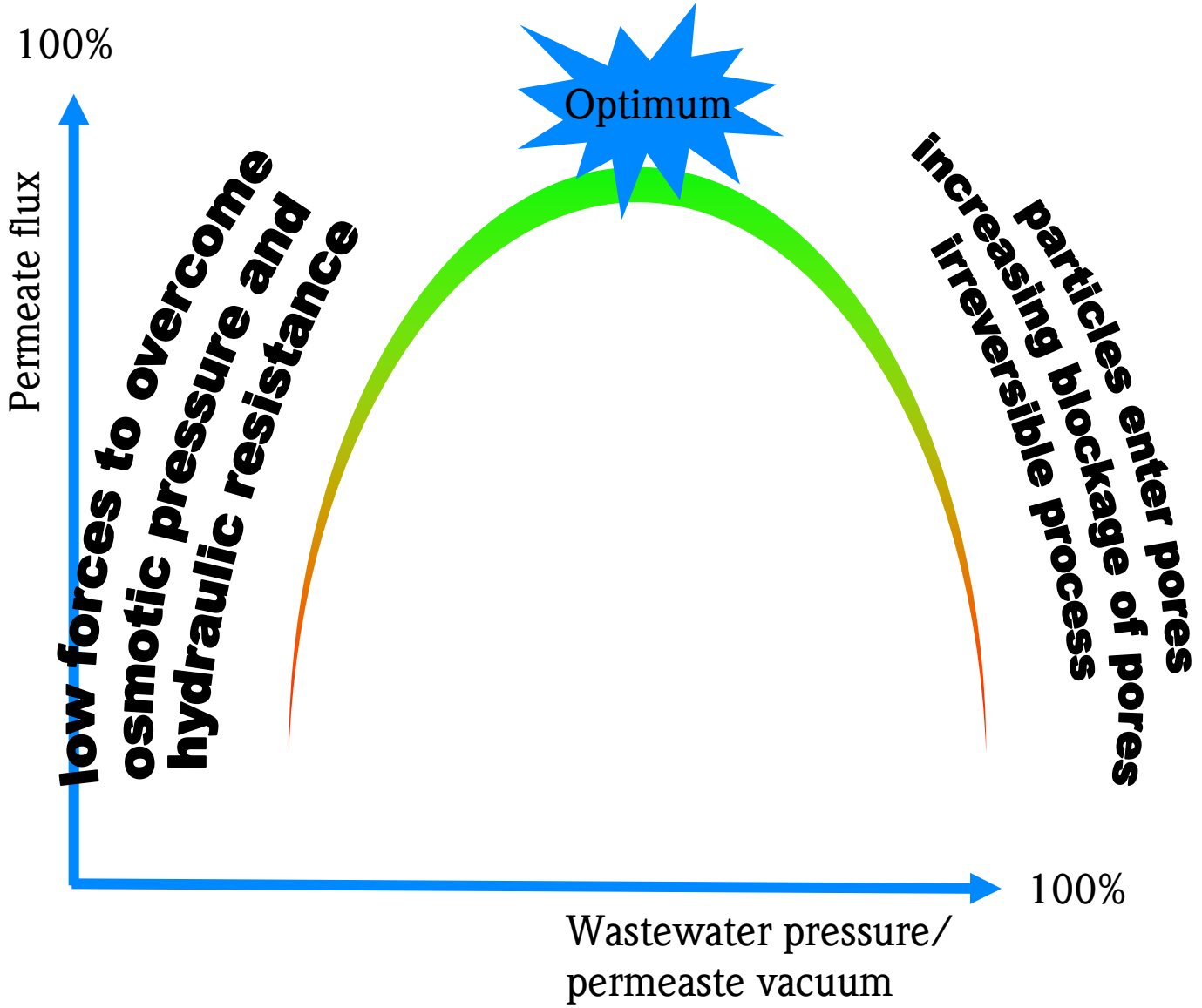
Wastewater pressure vs permeante flux



General operation of MBR

- Control
  - Membrane is operated at defined flux setpoint
  - Cleaning is triggered by differential pressure loss
- Typical online measurements
  - - Level controls preferably Radar or Ultra shall installed in Balancing tank and Bioreactor
  - - Float level switch for all transfer pumps (duty/duty/standby)
    - pH for Primary Feed and Bioreactor
    - DO for Bioreactor
    - Redox for Primary treatment
    - Pressure gauges for Membrane inlet and outlet
    - Flowmeters for MBR Feed and Permeate (According to the plant throughput UF membrane plants are in operation or stand by)
    The data should be available on-line via a data logger

Typical on-line measurement

- Level controls preferably Radar or US installed in Balancing tank and Bioreactor
- Float level switch for all transfer pumps (duty/duty/standby)
- pH for Primary Feed and Bioreactor
- DO for Bioreactor
- ORP for Primary treatment
- Pressure gauges for Membrane inlet and outlet
- Flowmeters for MBR Feed and Permeate (According to the plant throughput UF membrane plants are in operation or stand by)

Typical laboratory measurement

- MBR Feed: all listed parameters for discharge compliance as COD, BOD, NH4-N, NO3-N, PO4-P, MLSS, fats, heavy metals etc...
- Bioreactor: MLSS, MLVSS, SVI
- MBR Permeate: as in the Feed

Samples are usually taken at the outlet of the balancing, outlet Primary, from the Bioreactor and the Permeate

The typical set-points and control strategy depend of the effluent and of the ETP process

Plant Performance Conventional vs. MBR Upgrade*

Influent Conditions

Flow	116	m^3/day
BOD	19.9	kg/day
TSS	12.3	kg/day
TN	5.0	kg/day

Bio-System Parameters

	Conventional Plant		MBR Upgrade	
MLSS	2,115	mg/l	13,565	mg/l
DO	3.8	mg/l	6.8	mg/l
WAS	2.8	m^3/day	1.03	m^3/day
	4,236	mg/l	11,368	mg/l
	12.3	kg/day	11.8	kg/day

Effluent Quality

BOD	25	mg/l	0.7	mg/l
TSS	30	mg/l	2.5	mg/l
	3.6	kg/day	0.27	kg/day
Ammonia	6	mg/l	2*	mg/l
Max Daily Total Coliform	4,217**	#/100 ml	41	#/100 ml
Geo. Mean Fecal Coliform	372**	#/100 ml	4	#/100 ml

*The effluent ammonia level is typically less than 1.0 mg/l. Jan 01 experienced a prolonged period of non-nitrification, which has skewed the overall average for these few months of data.

** After ultraviolet disinfection

*David A. Gaouette Wastewater Treatment Facility, USA