Membrane bioreactors (MBRs) for wastewater treatment

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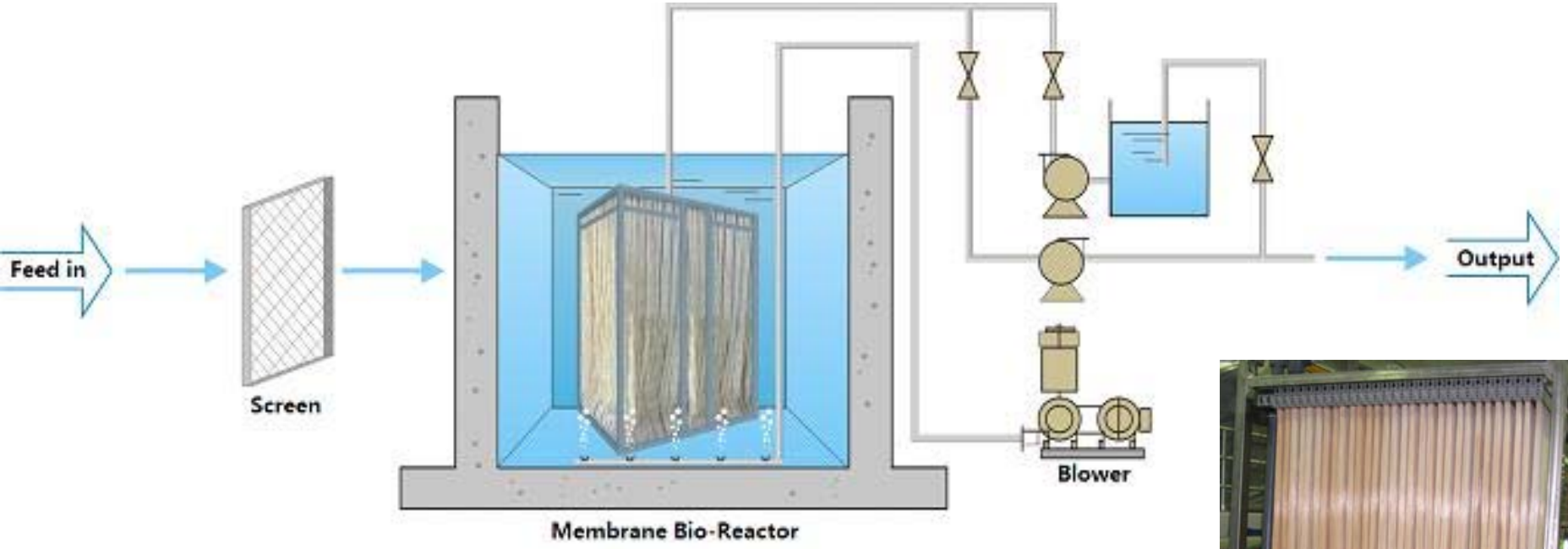
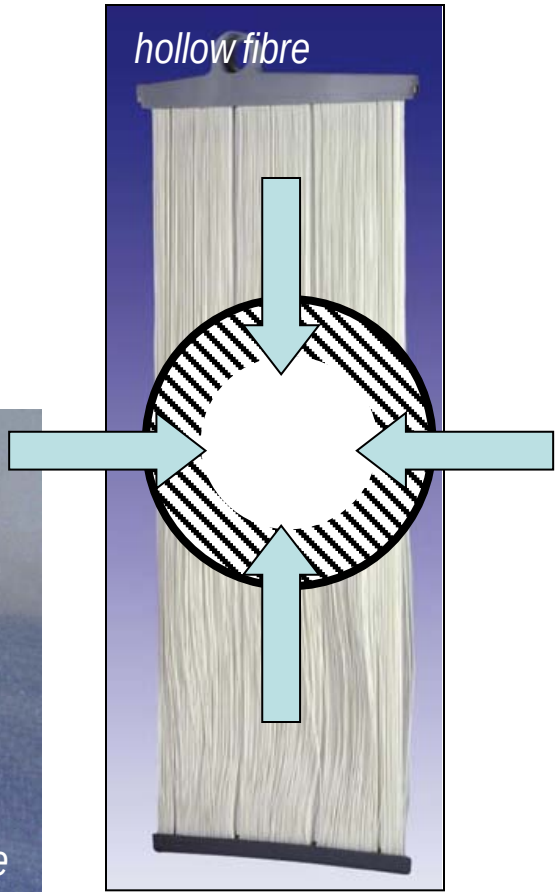
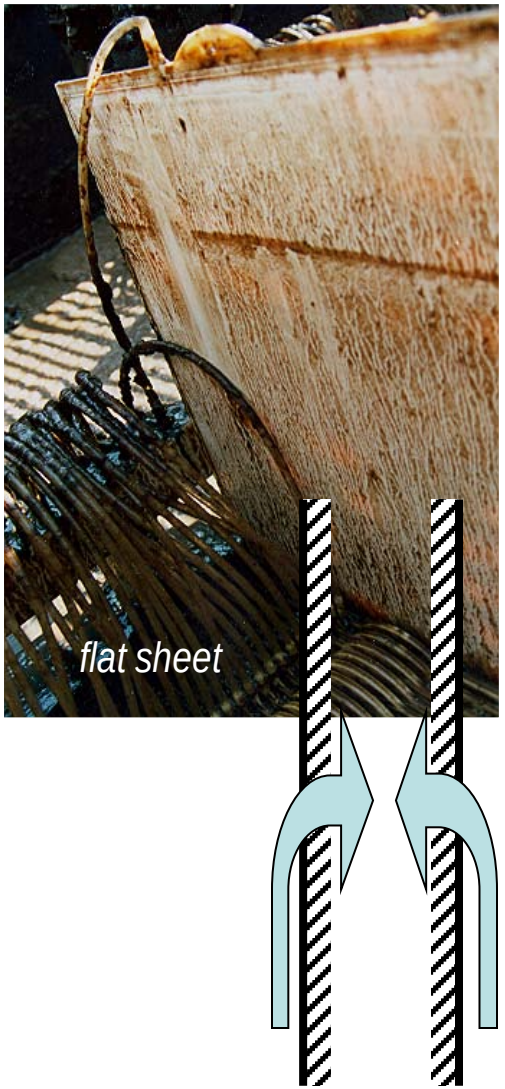
What is it?



Membrane configurations

- Three types:
- flat sheet (FS)
- hollow fibre (HF)
- multitube (MT)



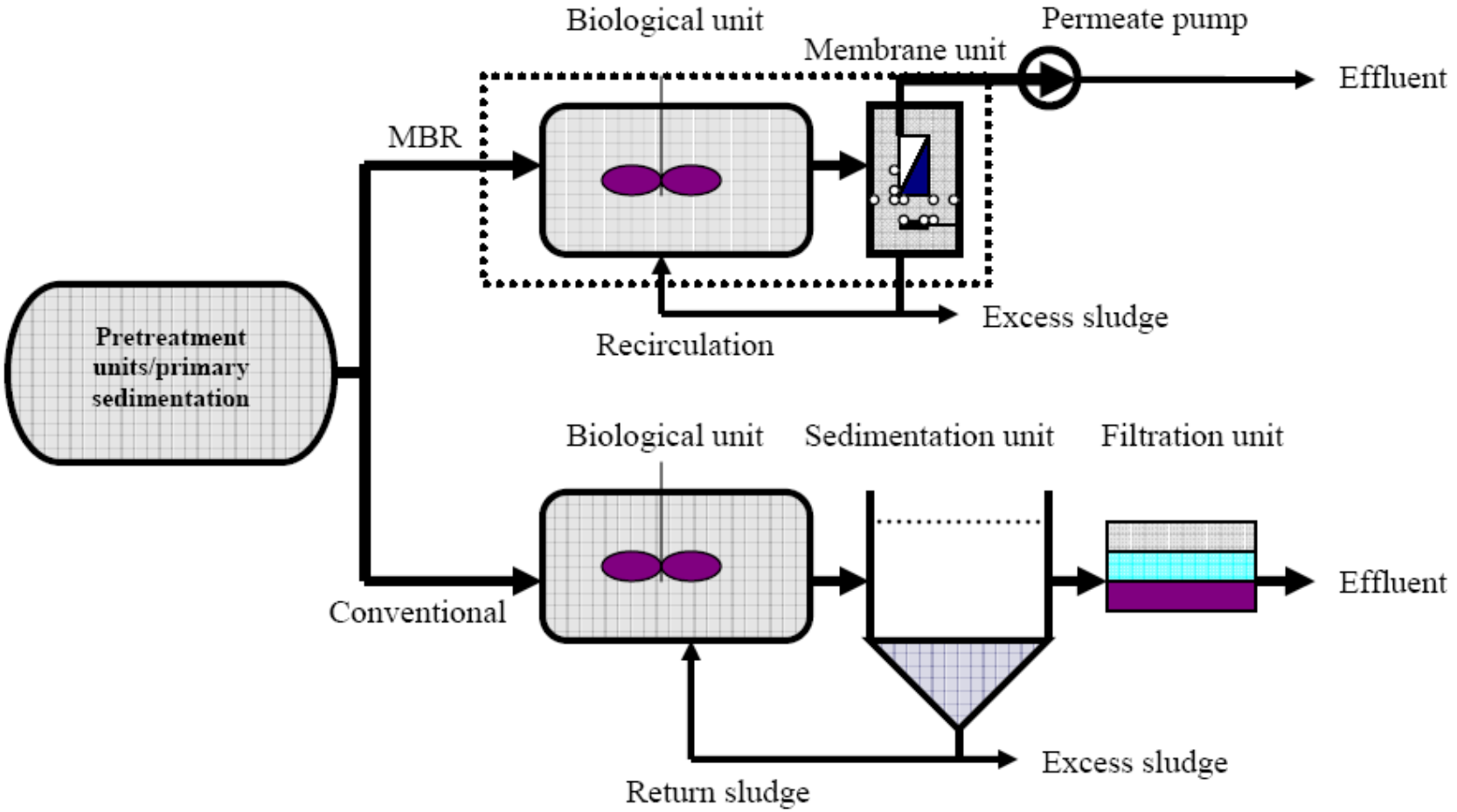


What is a MBR in wastewater treatment?

- A MBR is a process variation on the conventional activated sludge (CAS) process
  - Suspended Growth System
  - Clarification (Biosolids Separation) and Biomass Recycle

- *Membranes* instead of secondary clarifiers (and granular media filtration) to separate the MLSS from the secondary effluent

MBR vs. CAS

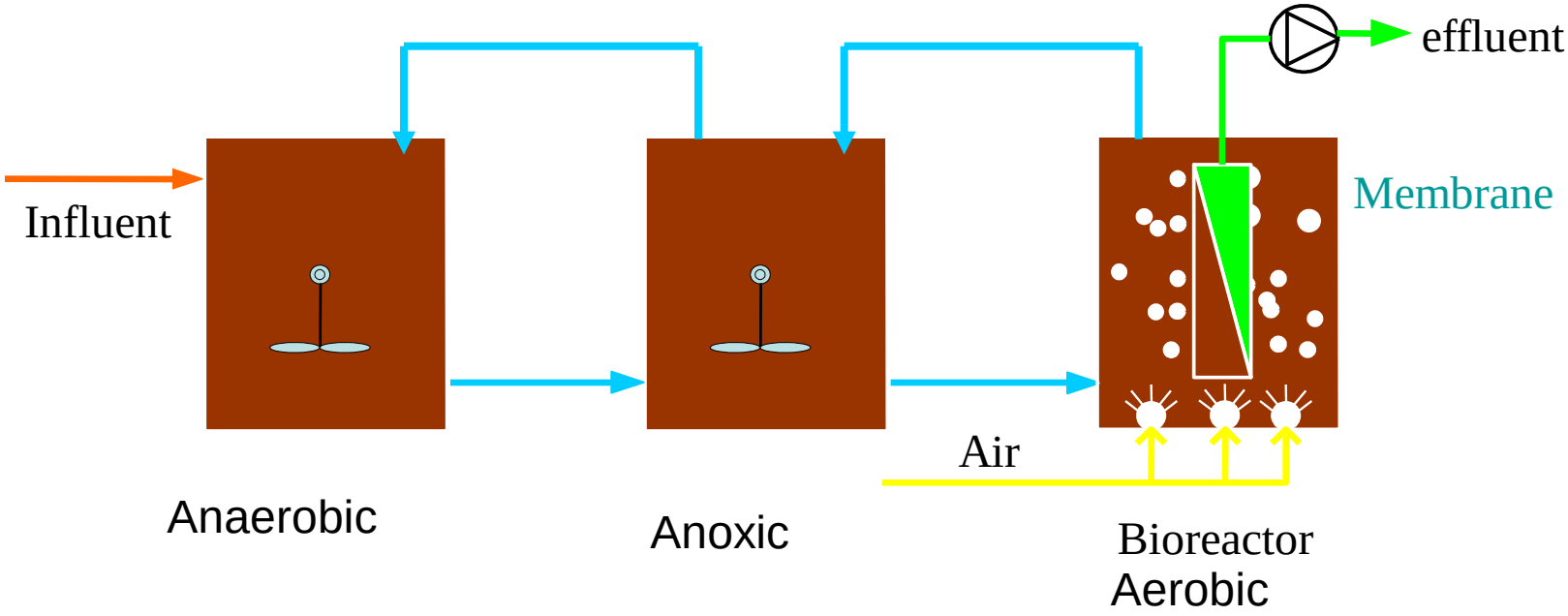

Biological unit
Permeate pump
Membrane unit
Effluent
MBR
Pretreatment units/primary sedimentation
Recirculation
Excess sludge
Biological unit
Sedimentation unit
Filtration unit
Conventional
Effluent
Return sludge
Excess sludge

MBR versus CAS process parameters

- MBR process operates over a considerably different range of parameters than the conventional activated sludge process
  - SRT 5 - 20 days for conventional system
    20 - 30 days for MBR (higher)
  - F/M 0.05 - 1.5 d^{-1} for conventional system
    < 0.1 d^{-1} for MBR (lower)
  - MLSS 2,000 mg/L for conventional process
    5,000 - 20,000 mg/L for MBR (higher)

- Generally, no primary clarification with MBR; practice may change with larger MBRs

MBR process for organic matter, N, P removal



- An aerobic compartment for COD degradation & nitrification;
- An anoxic compartment for denitrification;
- An anaerobic compartment for phosphorus removal.

Advantages MBR

- Small footprint
- No settlement problems
- No further polishing required for disinfection/clarification
- No equalisation of hydraulic and organic loadings required

Disadvantages

- Membrane surface fouling
- Membrane channel clogging
- Process complexity
- High capital cost
- High running costs

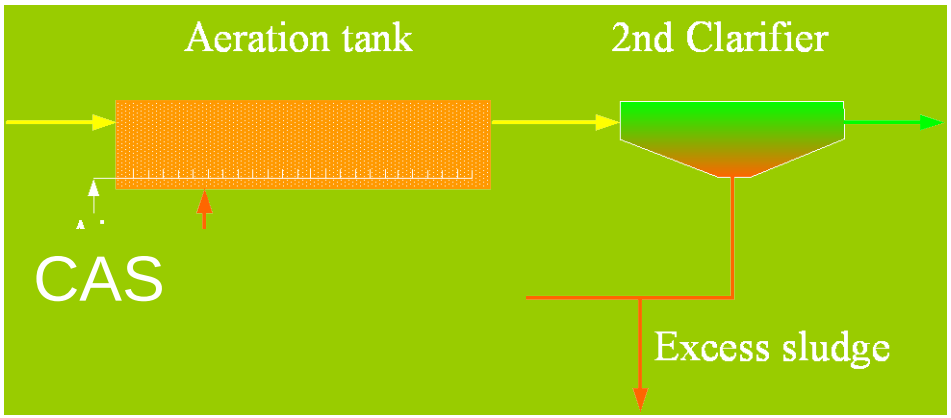
MBR applications

- Municipal wastewater:
  - Retrofitting/expansion of existing plant
    - Placement of submerged membrane modules in aeration basin
    - Parallel expansion alongside conventional WWTP
  - Wastewater reuse (helps justify costs)
  - Strict effluent regulations

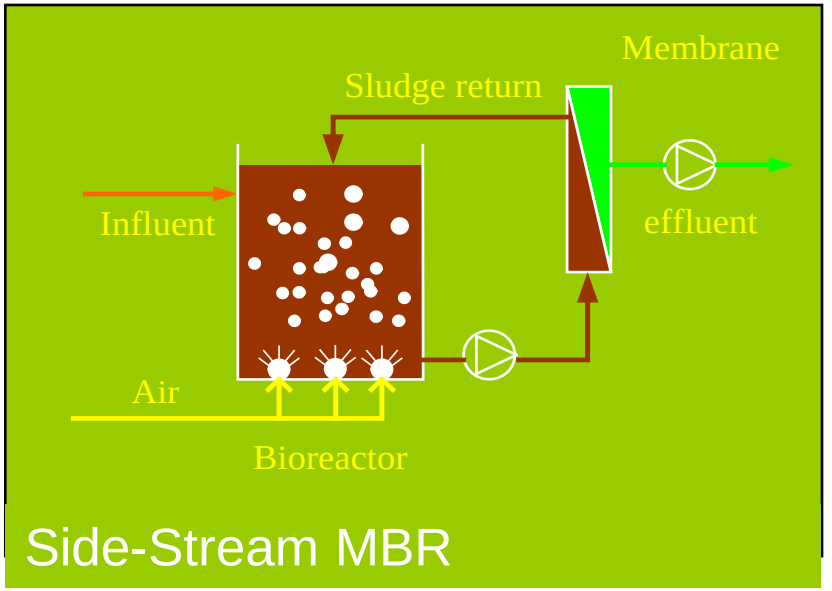
- Removal of emerging trace organic compounds
  - Pharmaceutically Active Compounds
  - Endocrine Disrupting Compounds
  - Other recalcitrant

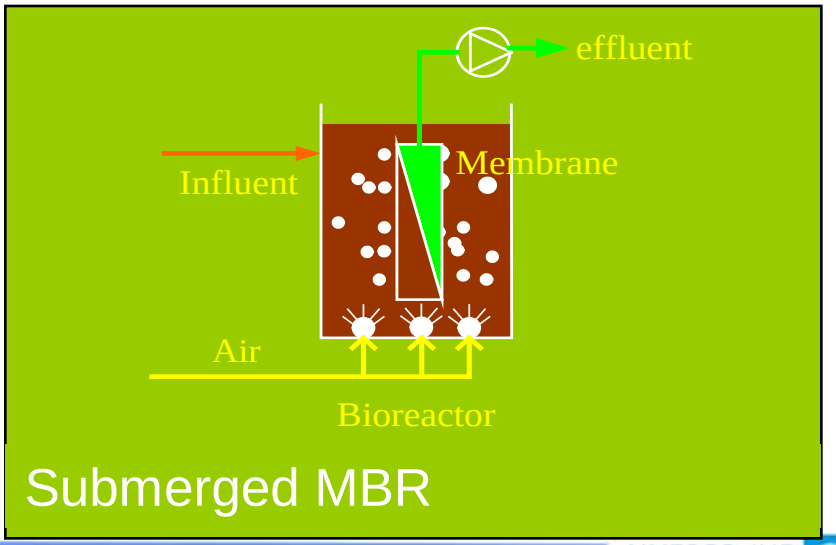
MBR process operations

CAS



MBR





History

Relatively new technology, rapid expansion:

- Sidestream MBR configuration commercialised in 1970's, niche applications, little market penetration
- First submerged MBR installed in 1990
- Exponential growth in installed capacity over last 15 years

MBR Process configurations

- Submerged
- More recent development
- Membrane placed in bioreactor
- Higher aeration cost
- Lower liquid pumping costs
- Lower flux
- Less frequent cleaning required
- Lower operating costs
- Higher capital costs

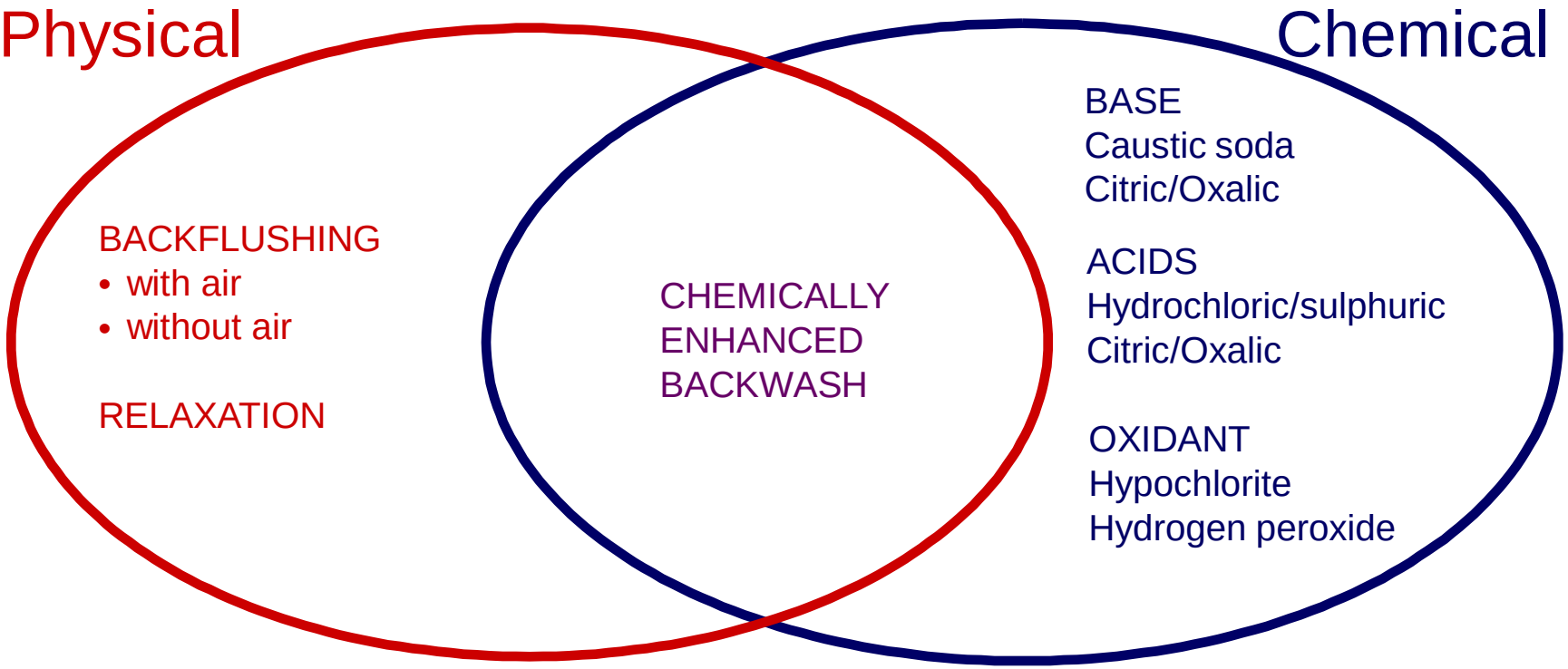
- Sidestream
- Longest history
- Membrane placed externally
- Lower aeration costs
- Higher liquid pumping costs;
- Higher flux
- More frequent cleaning require
- Higher operating costs
- Lower capital costs

Membrane fouling

Three different ways of defining fouling:

- Practically: reversible, irreversible or irrecoverable
- Mechanistically: surface coating, pore plugging
- Material type: chemical nature, particle size, origin

Membrane cleaning



MBR design

- Obtaining appropriate balance between operational flux, aeration and cleaning, which means:
  - maximising impact of aeration
  - facilitating cleaning with minimal downtime and chemicals consumption
  - providing a high membrane area at a low cost

- Most important of these is aeration efficiency