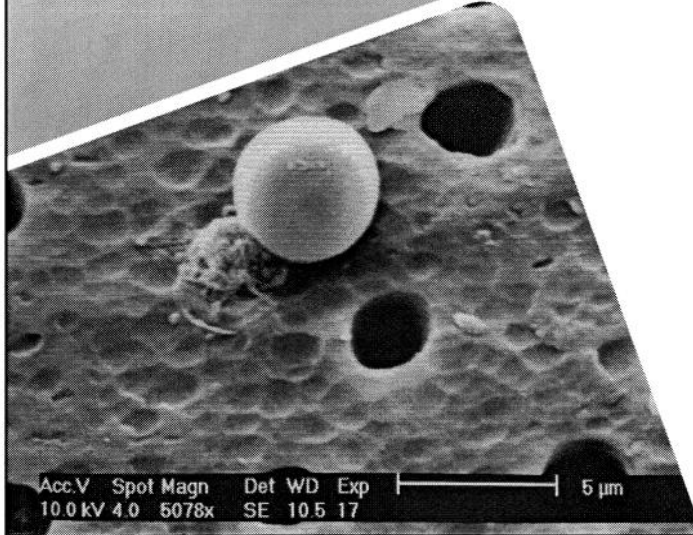
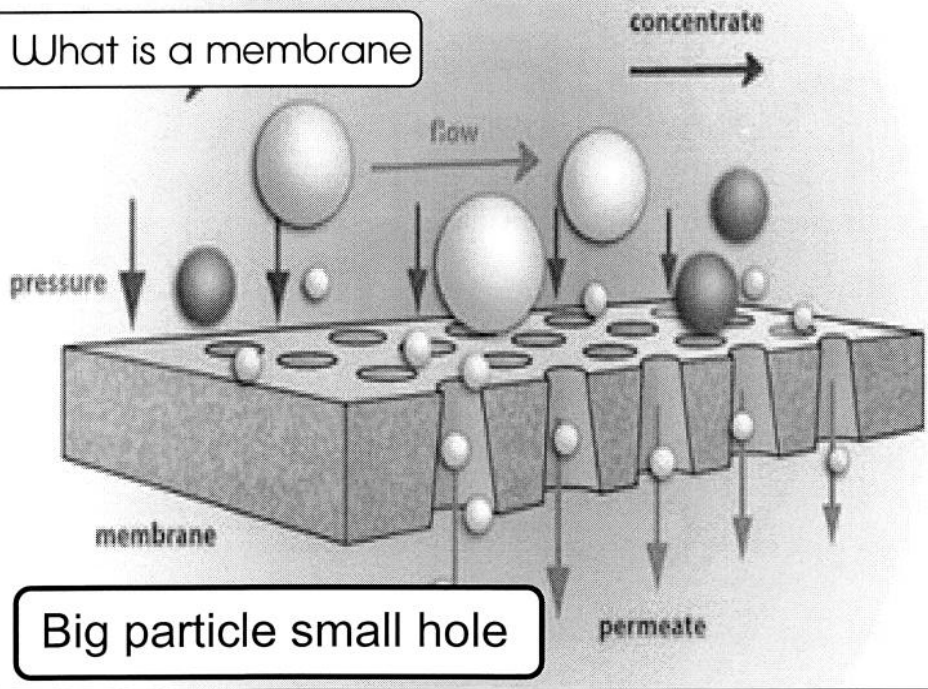


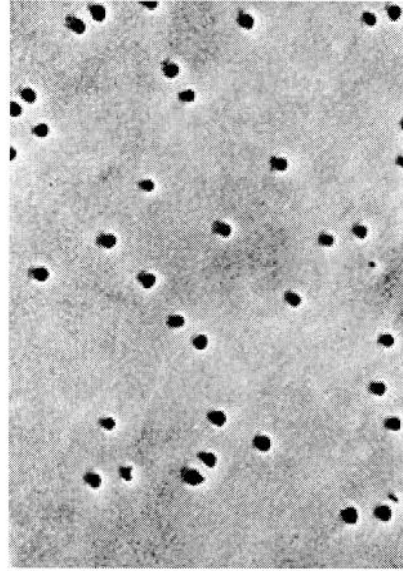
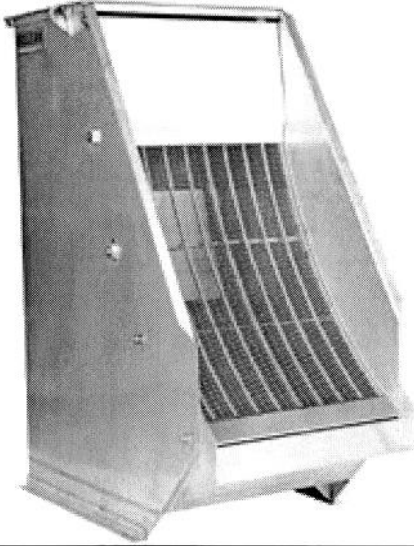
Membrane processes



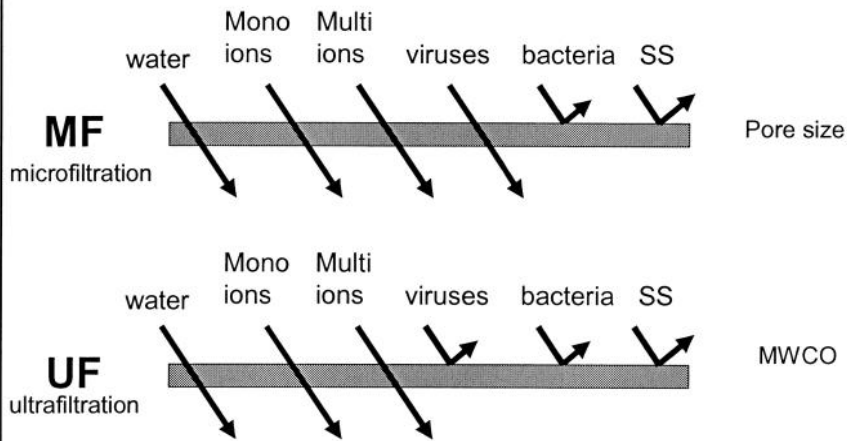
What is a membrane



So a membrane is really just a very fine screen..

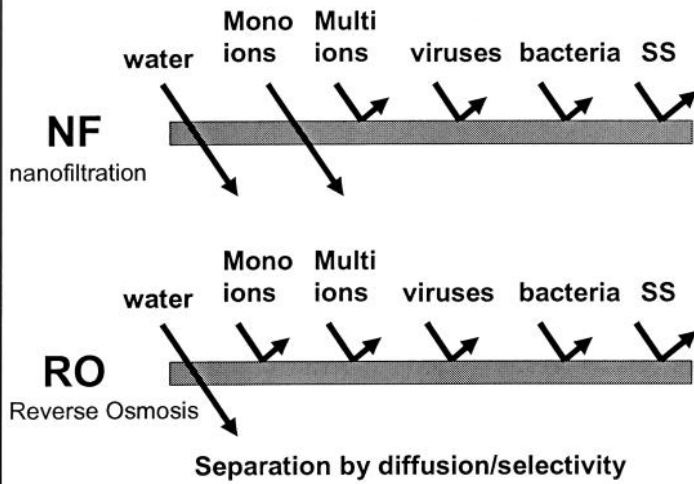


So what can porous membranes remove

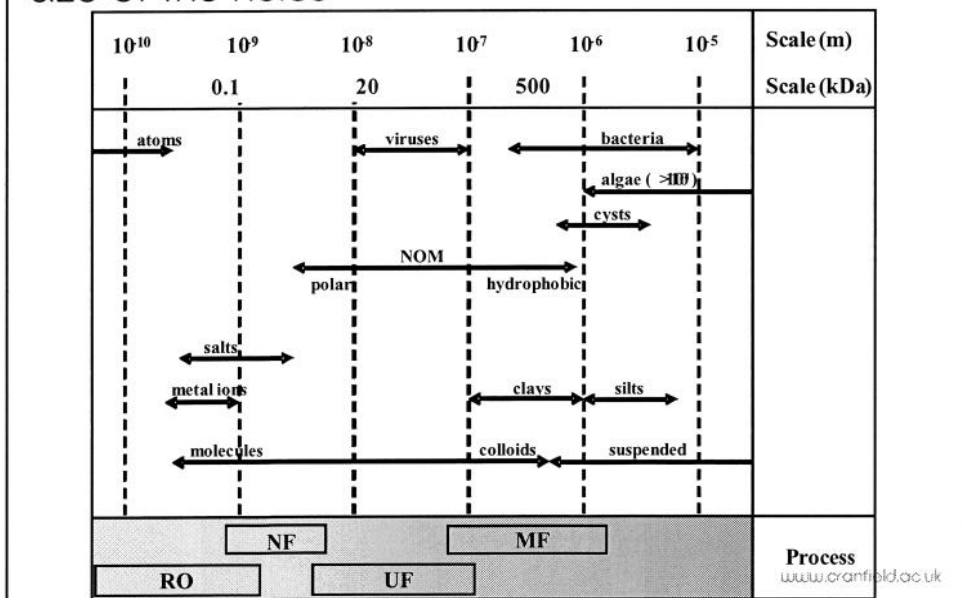


Separation by size exclusion (removes things bigger than pore size)

So what can dense membranes remove



Membranes are classified by the size of the holes



So what can they NOT remove

**No commercial successful
membrane exists to remove
uncharged inorganic
molecules such as hydrogen
sulphide and small
uncharged organics**

Pros and cons

Viewed as expensive

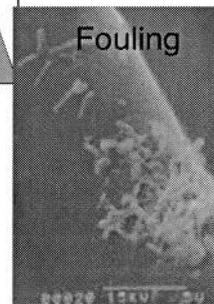
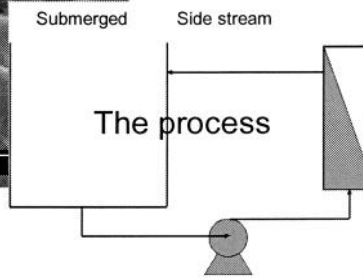
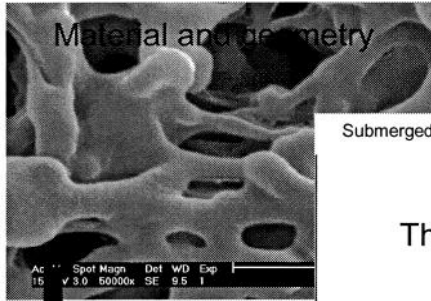
High maintenance

Absolute barrier

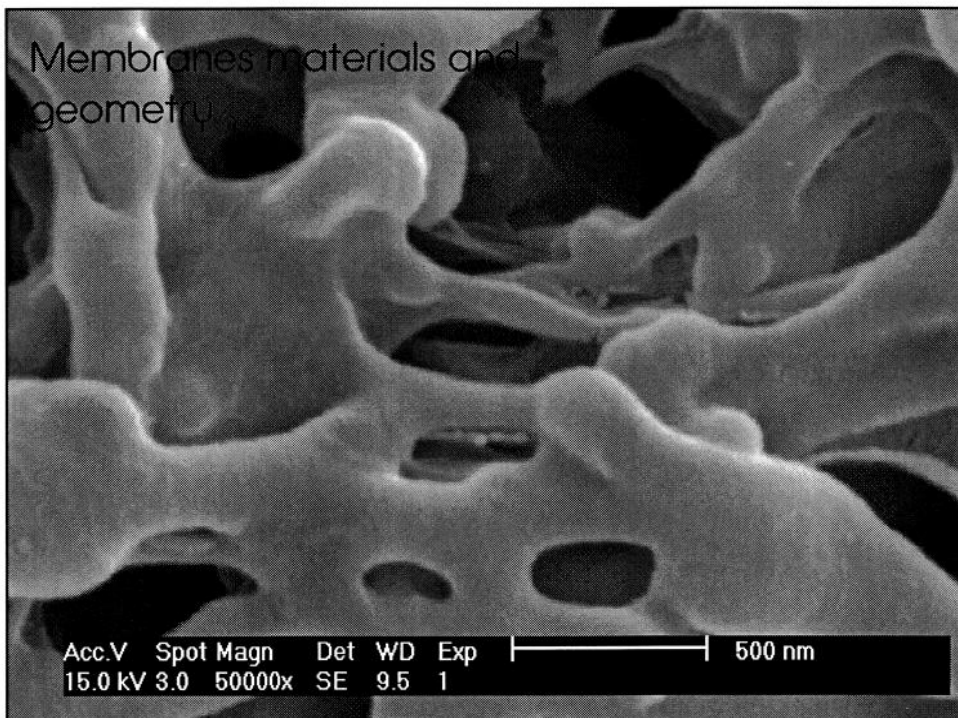
Modular

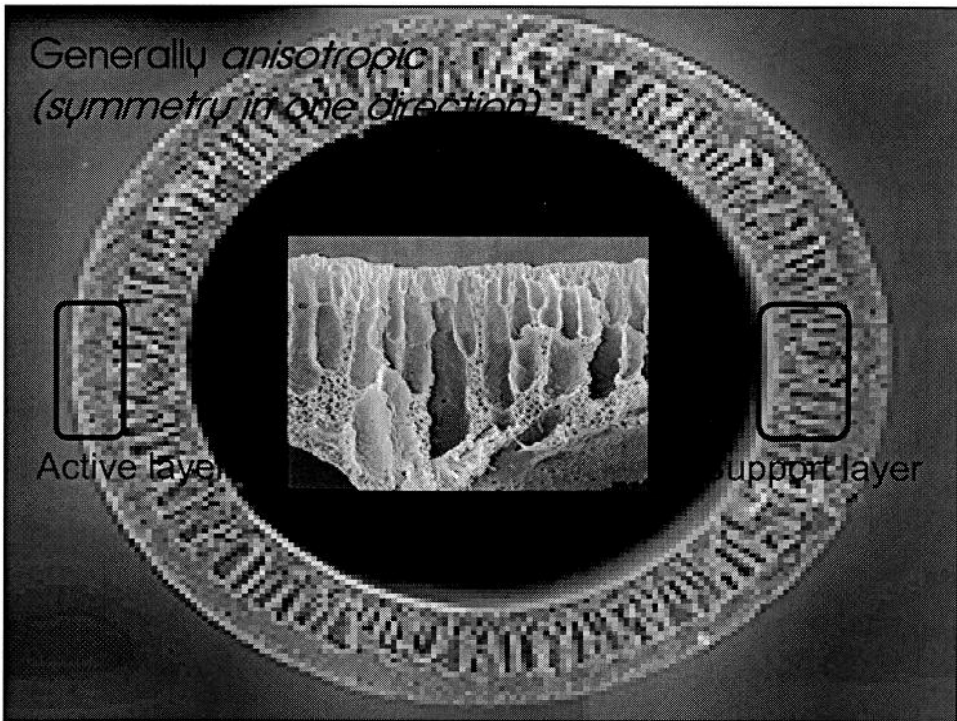
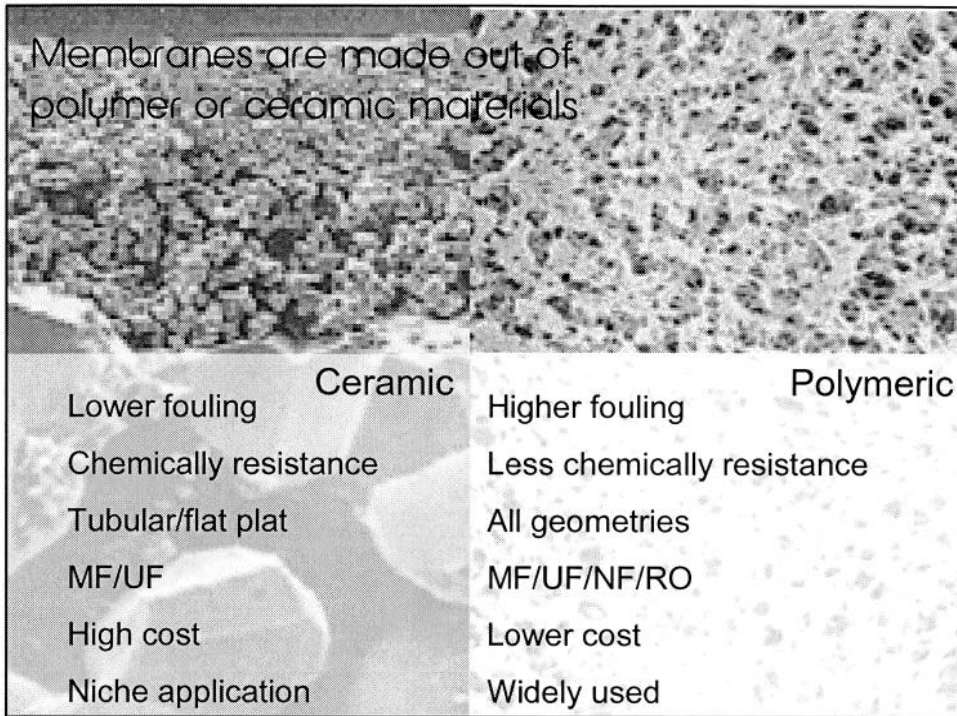
Excellent water quality

Membranes are defines in three ways

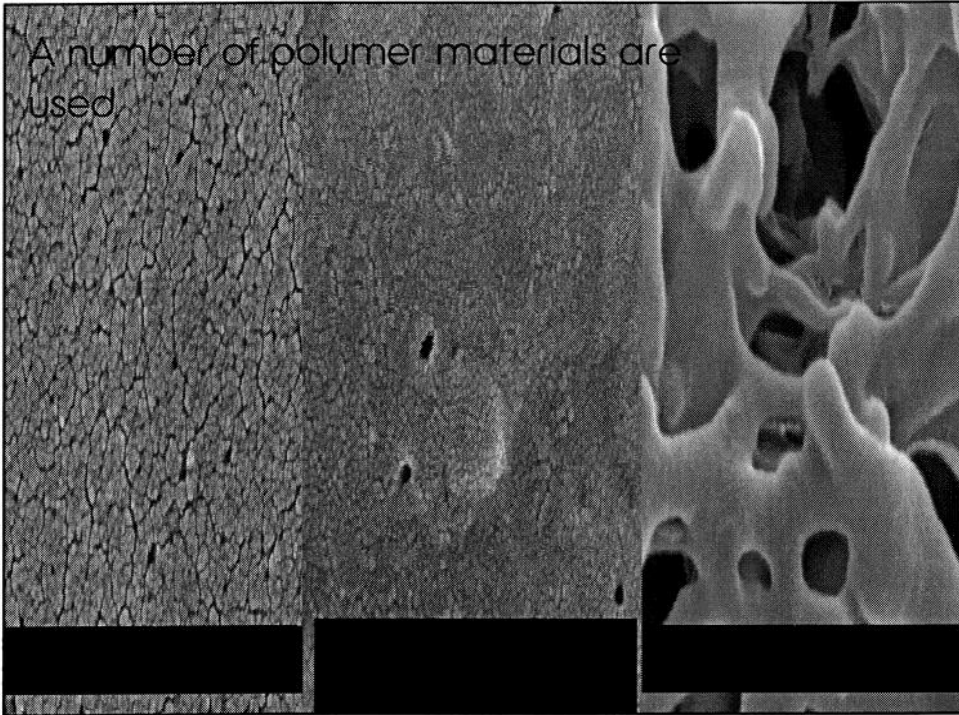


Membranes materials and geometry



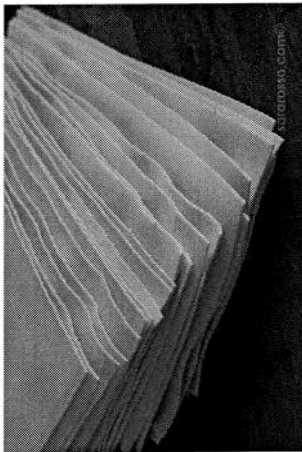


A number of polymer materials are used

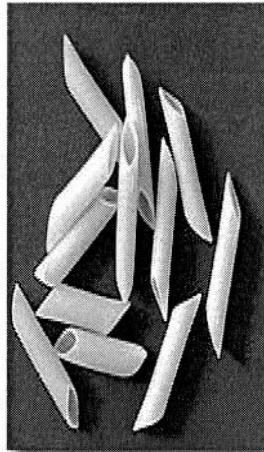


Membrane configuration: the pasta connection

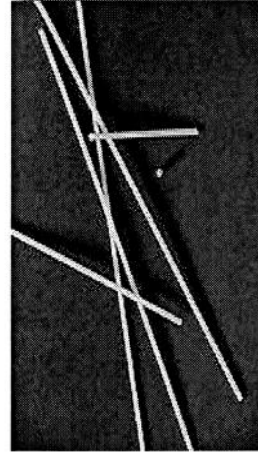
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Flat sheet (Lasagna)

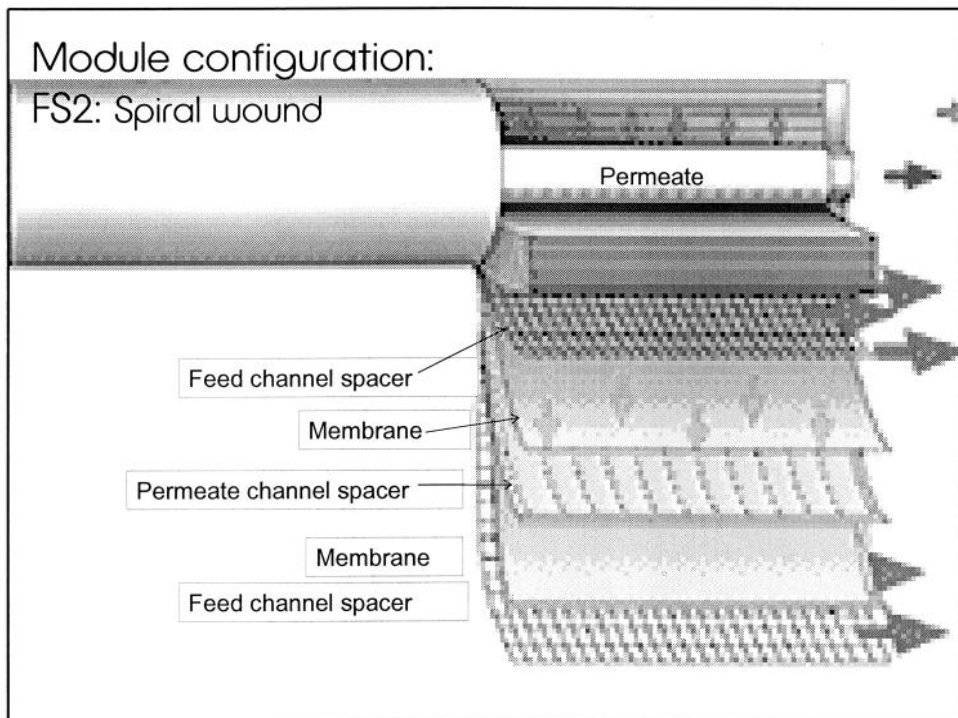
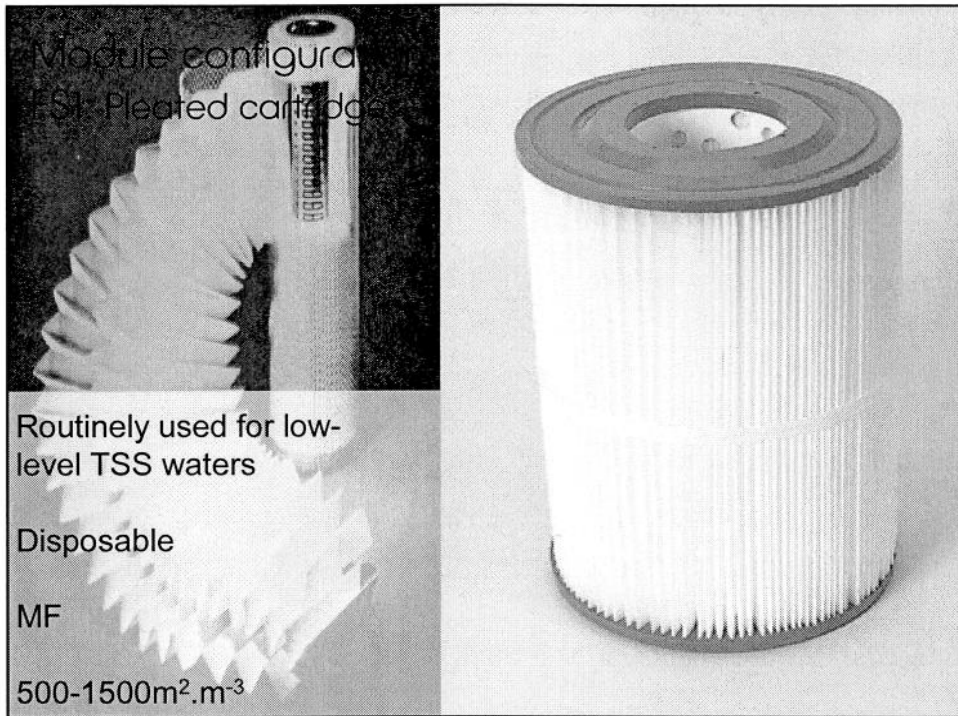


Tubular (Penne)

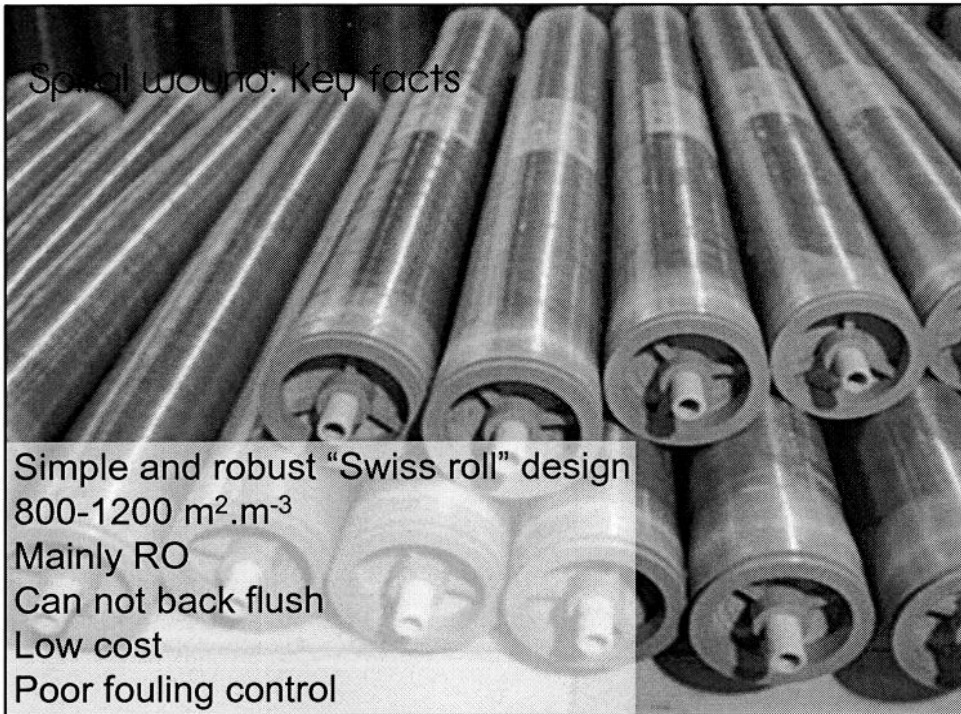


Hollow Fibre (Bucatini)

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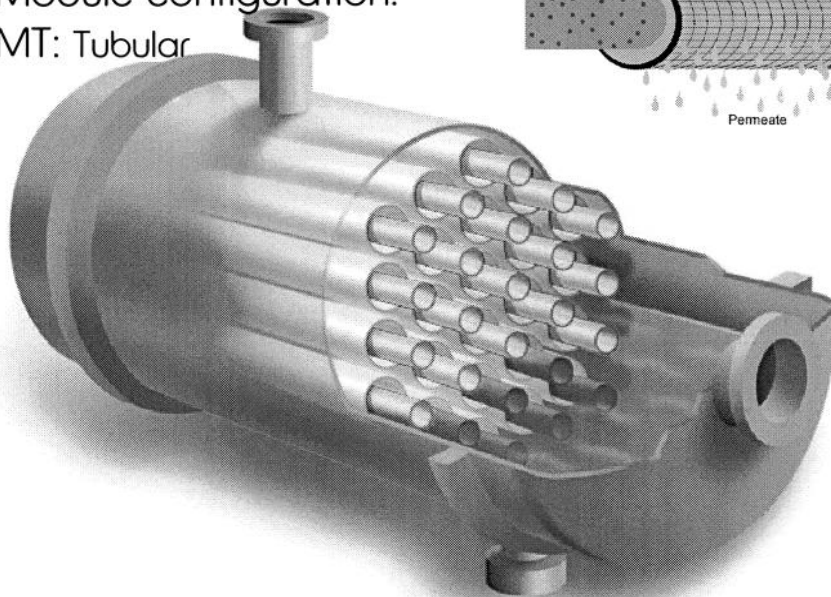
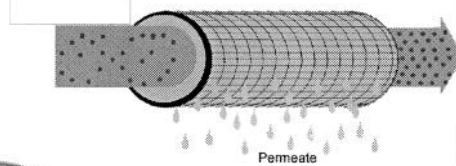
Spiral wound: Key facts



Simple and robust "Swiss roll" design
800-1200 m².m⁻³
Mainly RO
Can not back flush
Low cost
Poor fouling control

Module configuration:

MT: Tubular

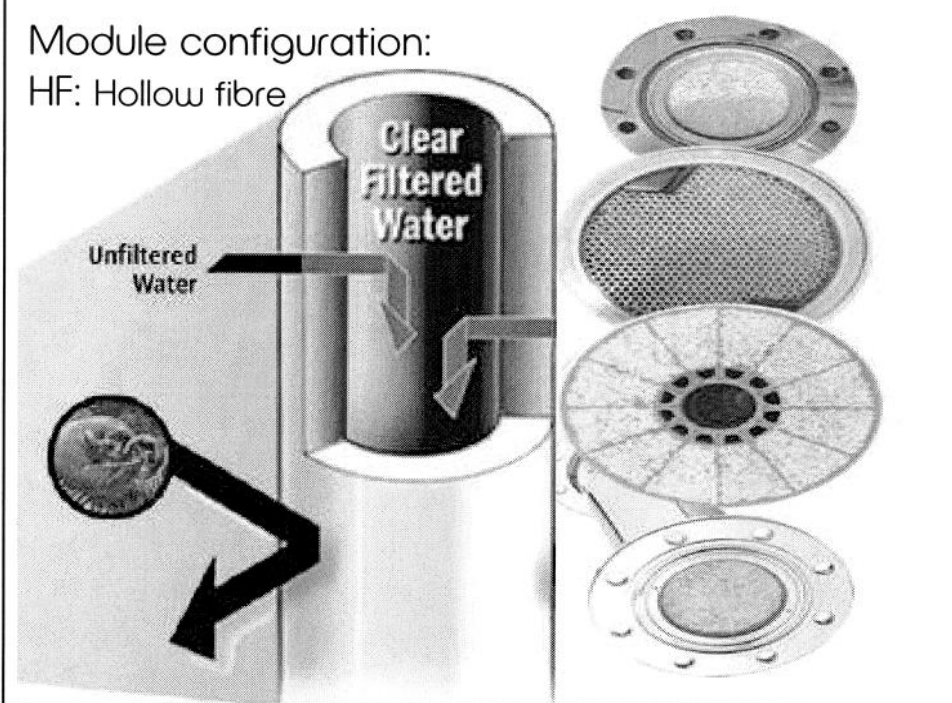


Tubular membranes: key facts

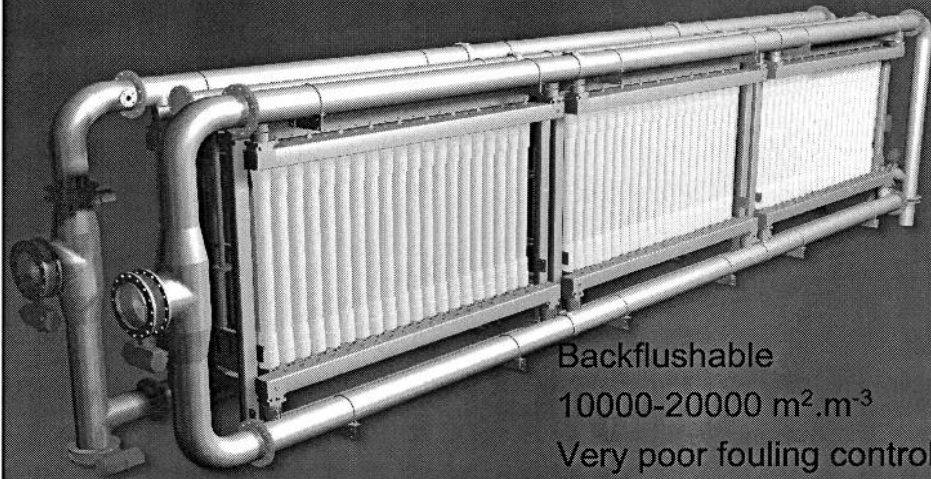
Single or multitubes
Ceramic and polymer
150-300 $\text{m}^2 \cdot \text{m}^{-3}$
Very good fouling control
UF, NF
Submerged or side stream

Module configuration:

HF: Hollow fibre



Hollow fibre: key facts



Backflushable

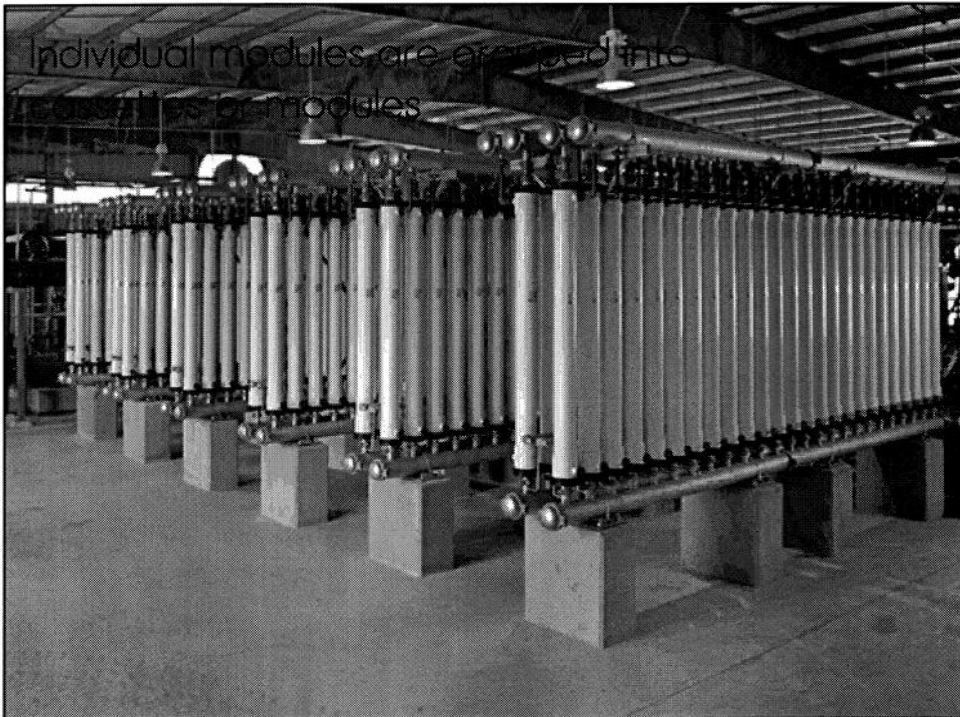
10000-20000 $\text{m}^2.\text{m}^{-3}$

Very poor fouling control

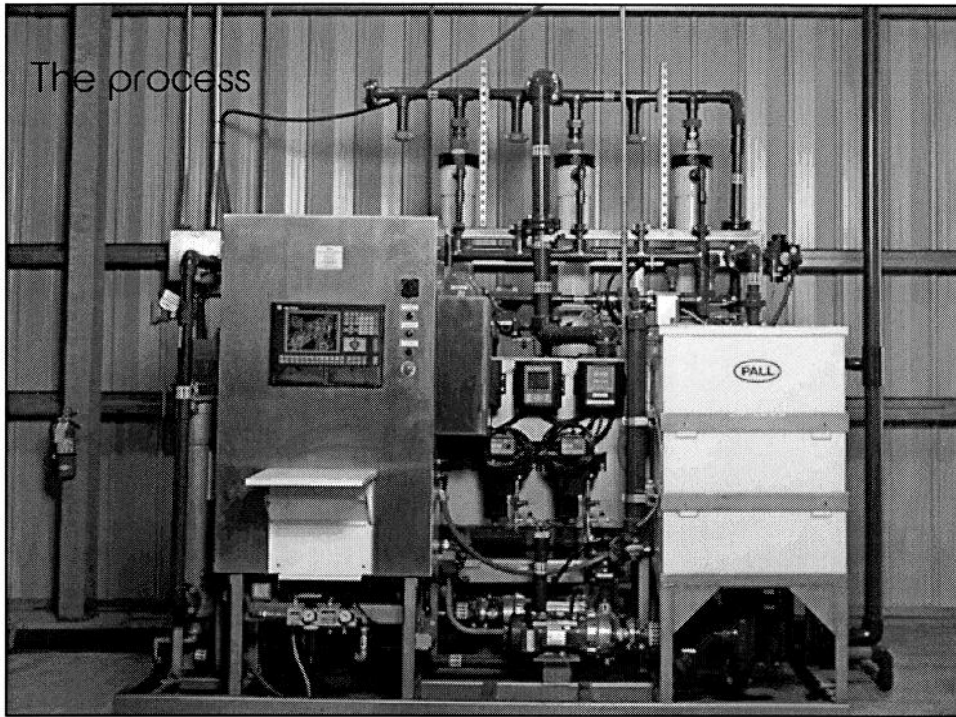
MF, UF, RO

Submerged / side stream

Individual modules are arranged into
rows of modules

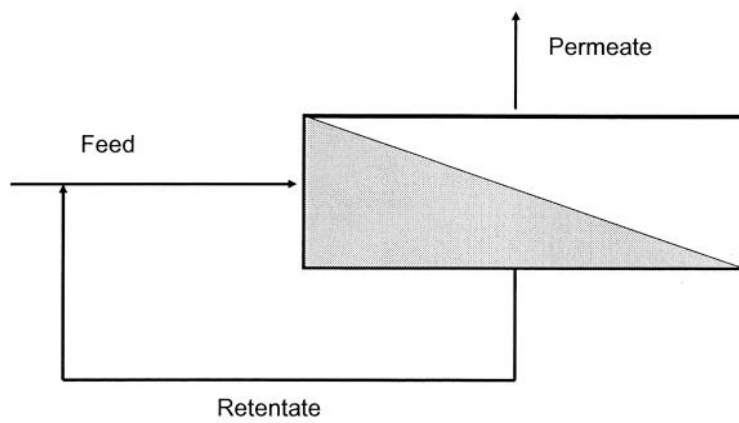


The process



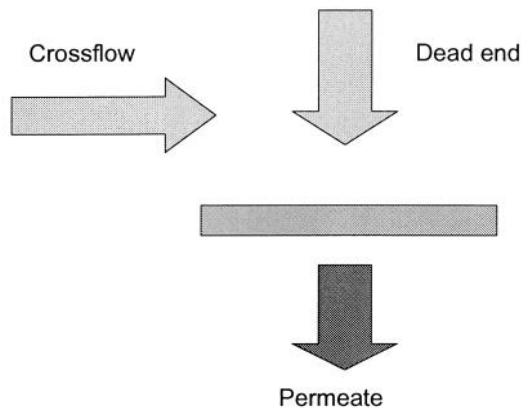
Definitions: flow streams

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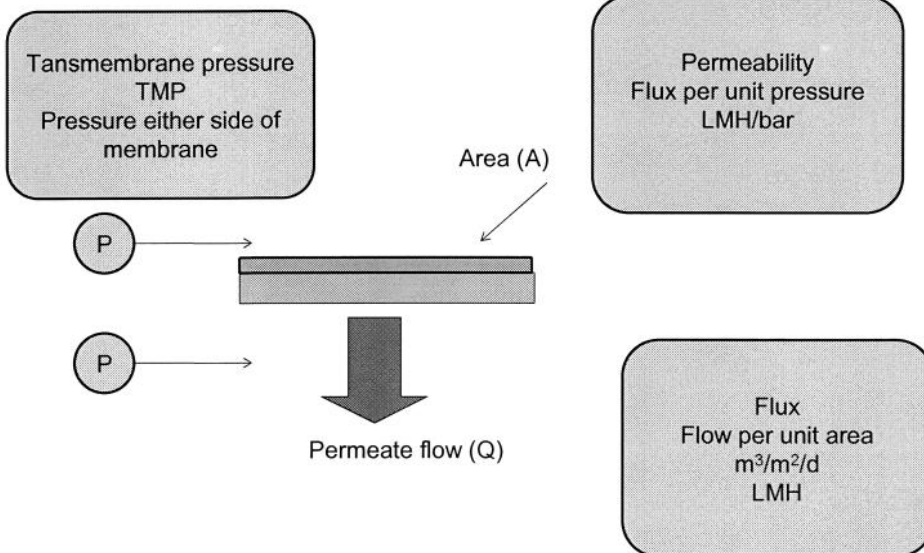


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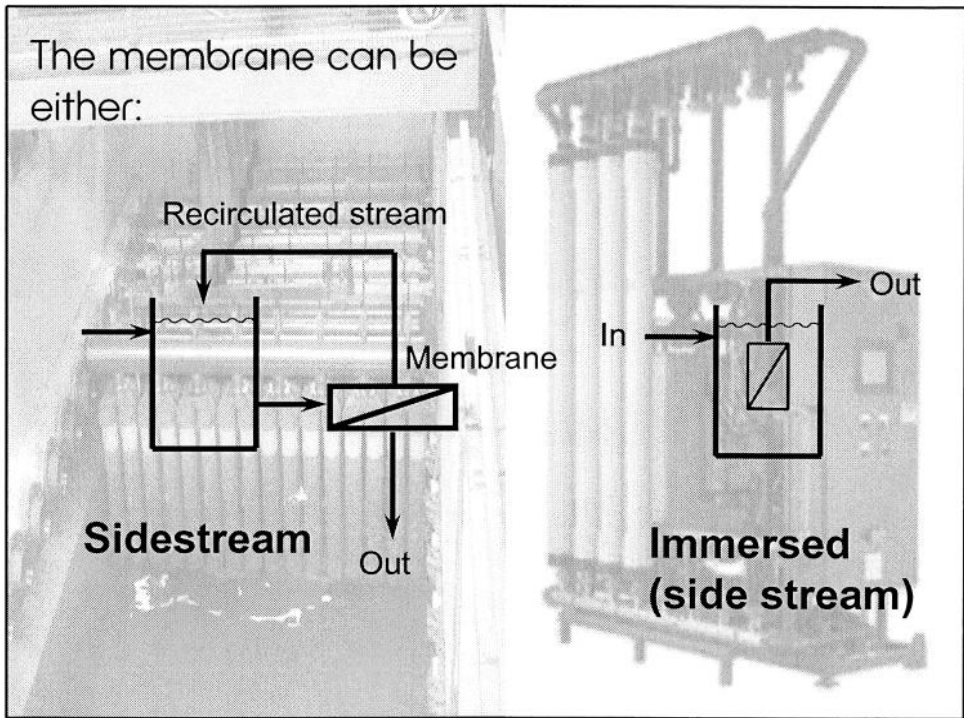
Definitions: flow direction



Definitions: flux and pressure

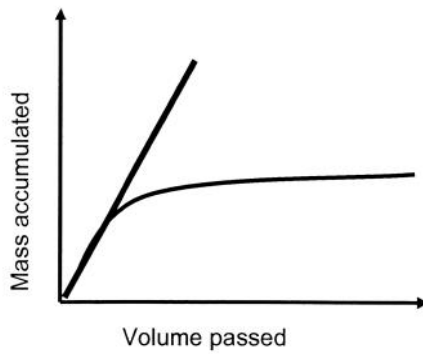
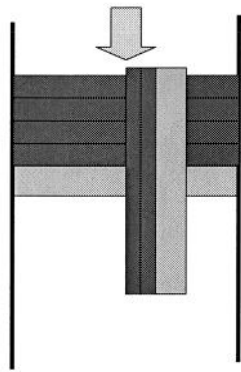


The membrane can be either:

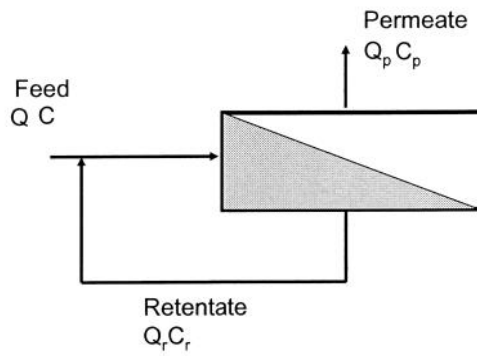


So what happens when you operate a membrane

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Definitions of performance

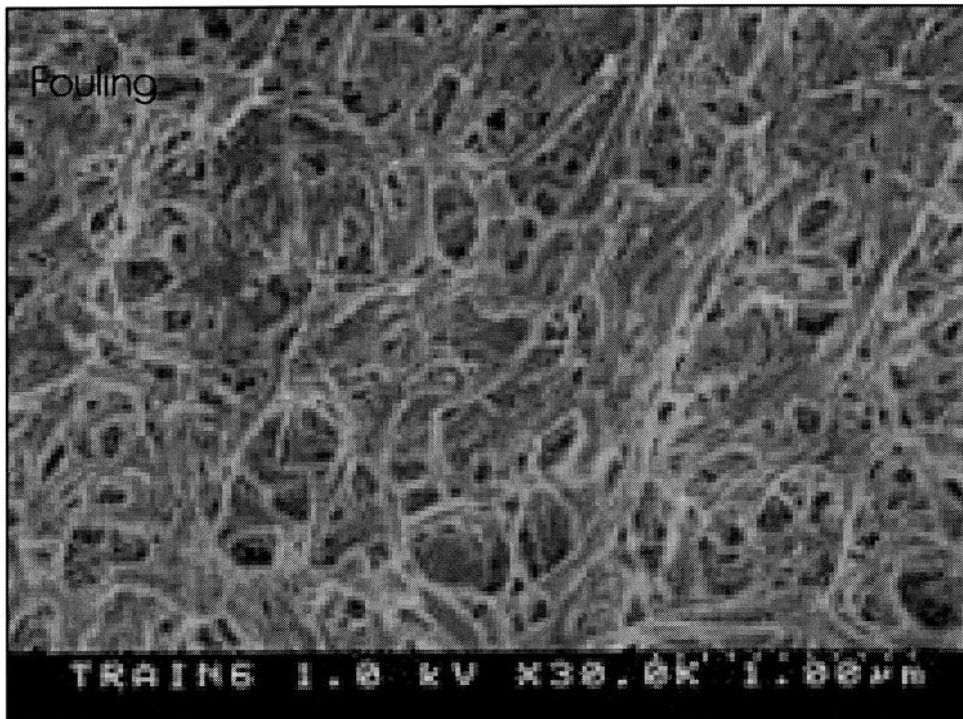


Conversion (recovery)

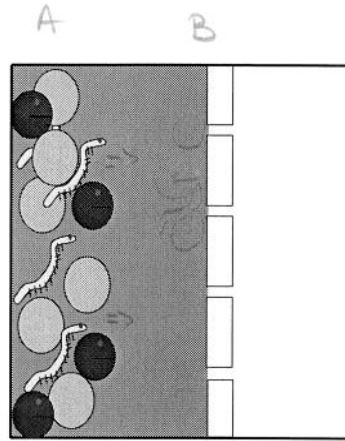
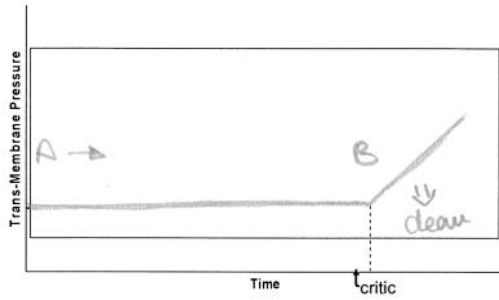
$$\Theta = \frac{Q_p}{Q}$$

Rejection

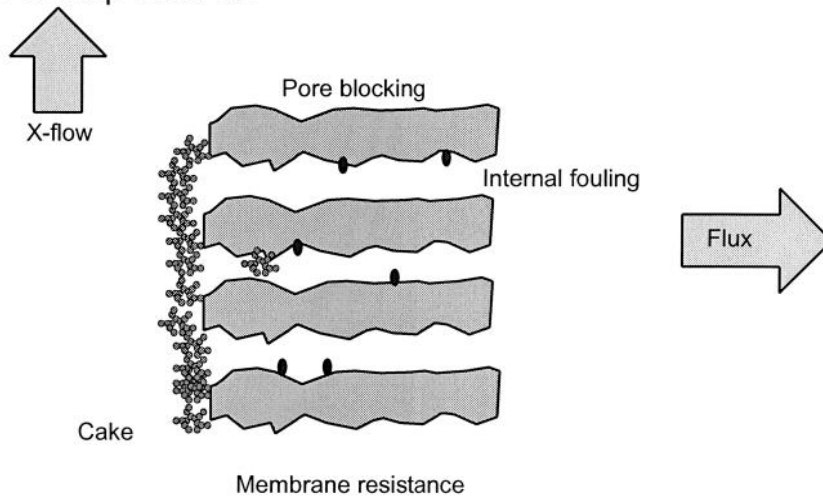
$$R = 1 - \frac{C_p}{C}$$

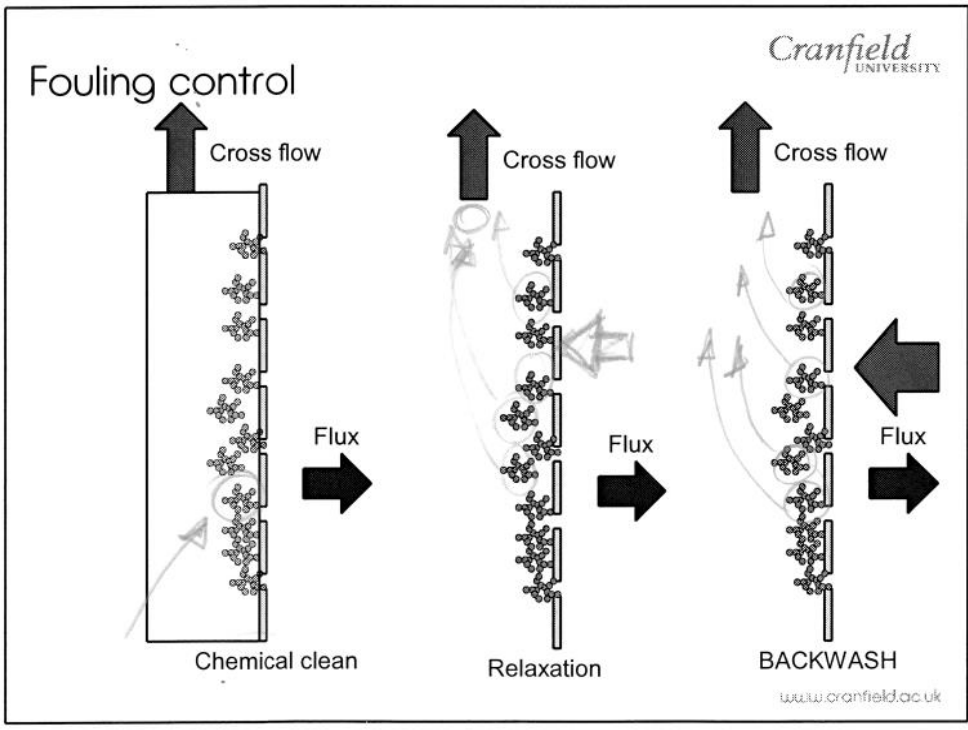
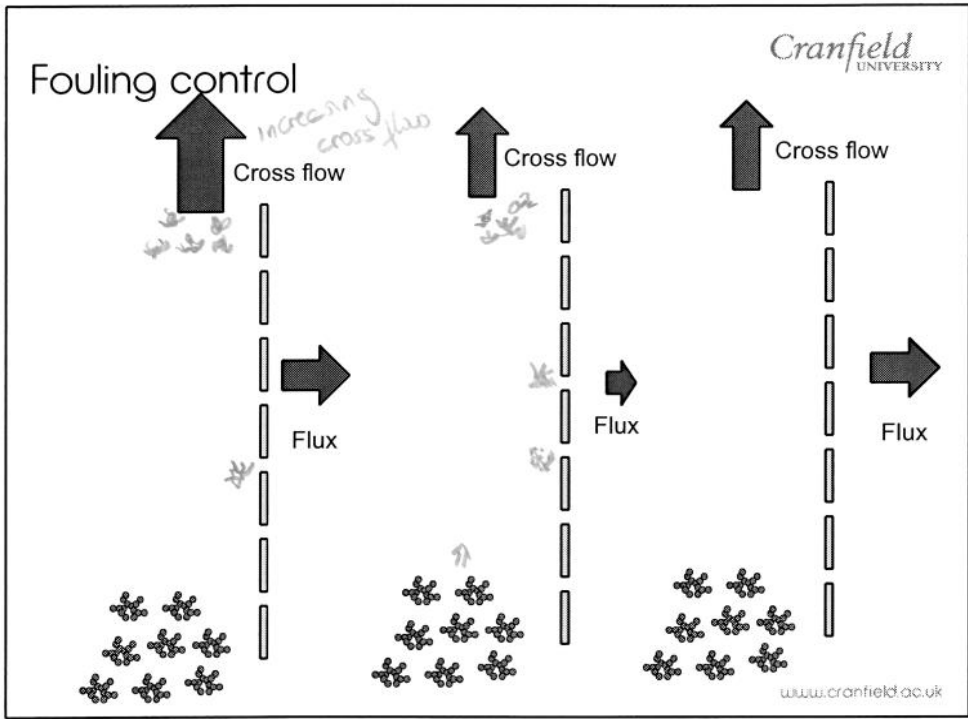


So what happens when you operate a membrane

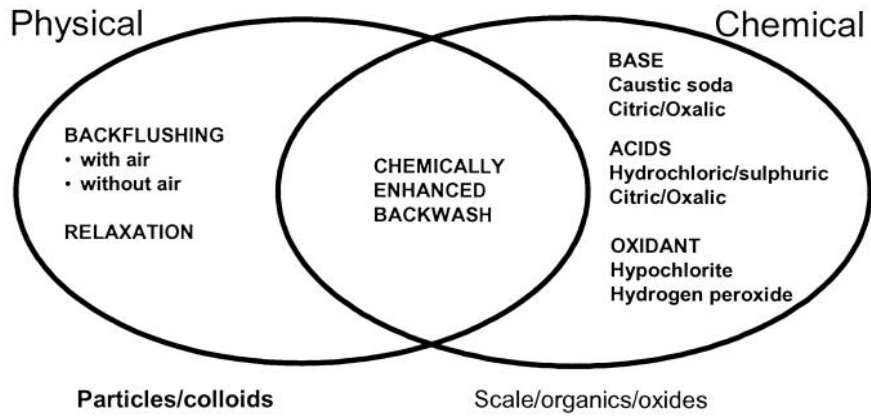


The pressure drop is generated by four components

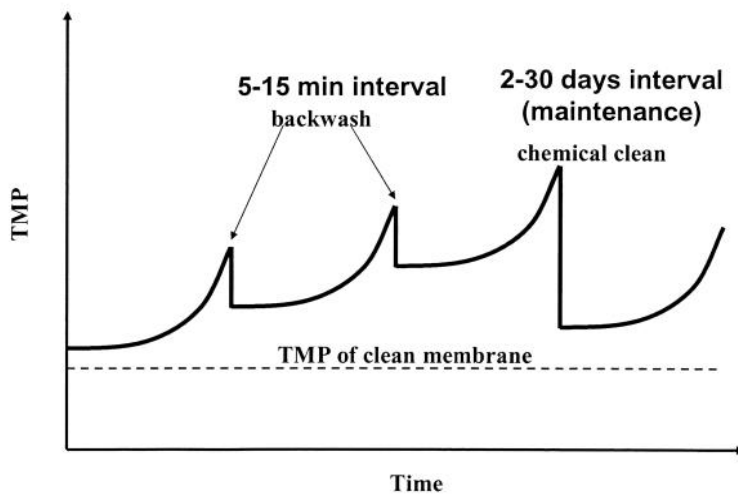


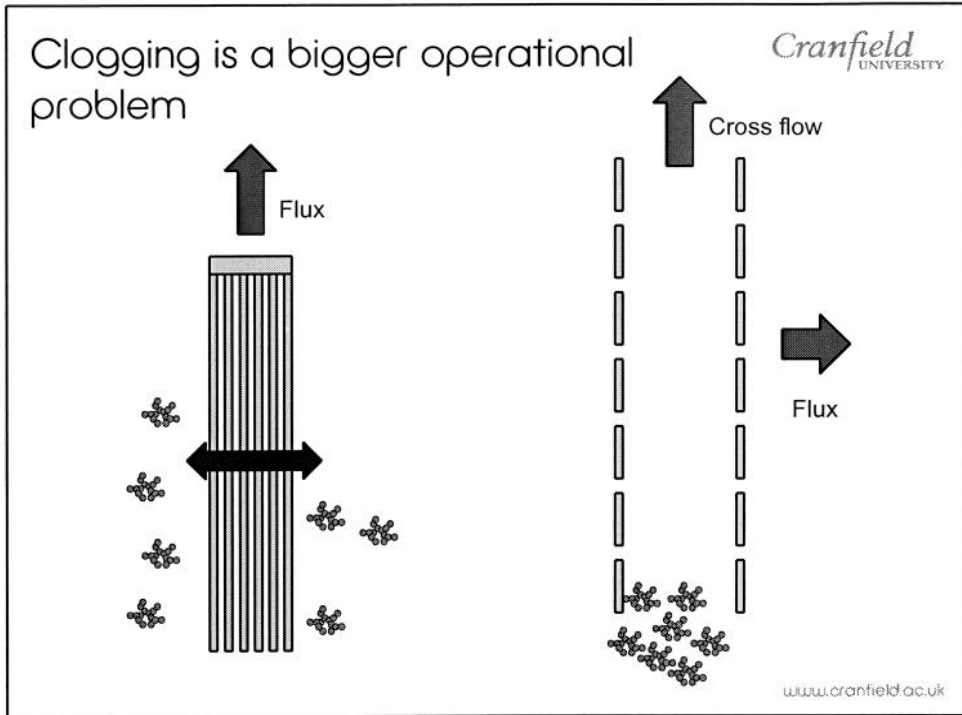


Cleaning methods



Impact of cleaning





Commercial systems (2006-2007)

Company	System	Material	Config ^{ion}	Capacity (1000 m ³ .d ⁻¹)
Memcor/USF	HF, MF	PP, PVDF	Side/sub	1400
Norit/X-flow	HF, UF	PES	Side	400
PALL	HF, MF	PVDF	Side	400
Zenon	HF, UF	PVDF	Sub	450
KOCH/FS	HF, UF	PS	Side	250
Other	HF, UF	CA, PES,	Side	86
Other	SW, T NF	CA, PES, CT	Side	23