Optimising MBR operation

The future of small scale plants

Roger BEN AIM

Emeritus Professor INSA Toulouse

benaim@insa-tlse.fr

Parameters of action in a MBR

- ***Biological parameters***: only one : SRT
- What strategy for design and control of unsteady state operation:
  - *Design for maximum organic load?*
  - *Installing some storage capacity?*
  - *Is an increase of SRT or a decrease of sludge concentration always profitable?*

- ***Hydraulic parameters***:

  1) aeration rate and aeration frequency.

  2) periodic backwashing or relaxation
- Variation of these parameters depending on the transmembrane pressure evolution.

UF or MF ?

- MF : theoretically more permeable .
- But more sensible to internal irreversible fouling
- Limited in Log Removal of bacteria and viruses

- UF : most UF membranes have a permeability of 150-200 l/h.M2 which corresponds to 30-40 l/h.M2 for 0.2 bar.
- Less sensible to internal fouling.
- Good removal of bacteria and viruses

Hydraulic parameters

- Influence of the aeration rate
- Bacwashing or relaxation?
- Influence of the frequency .

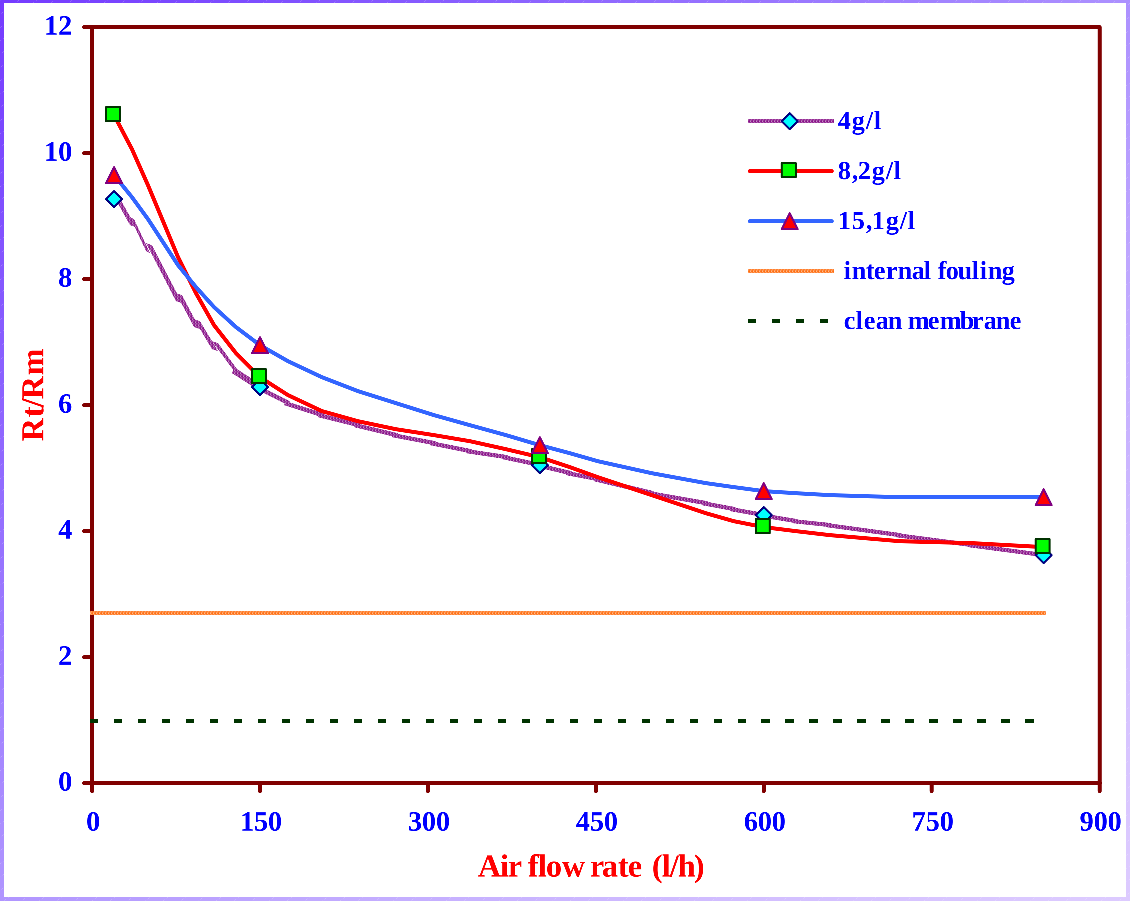


Figure 5. Effect of air flow rate on the Rt/Rm ratio at different activated sludge concentration.

500d ZeeWeed® Cassette

0.04 μm nominal pore size

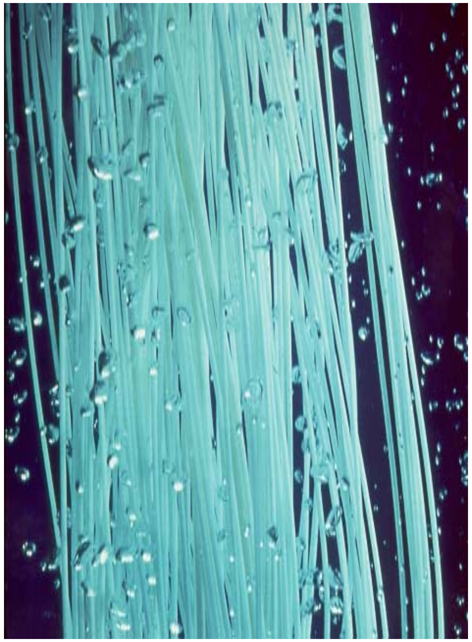
hollow fibres in array (pulled out above)

Arranged in stack

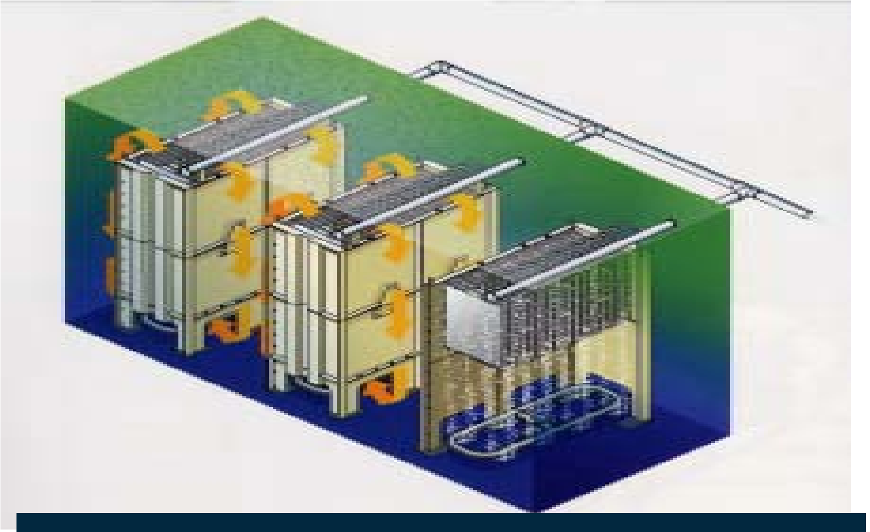
aerated from below


Permeate
Air


MVC-175W



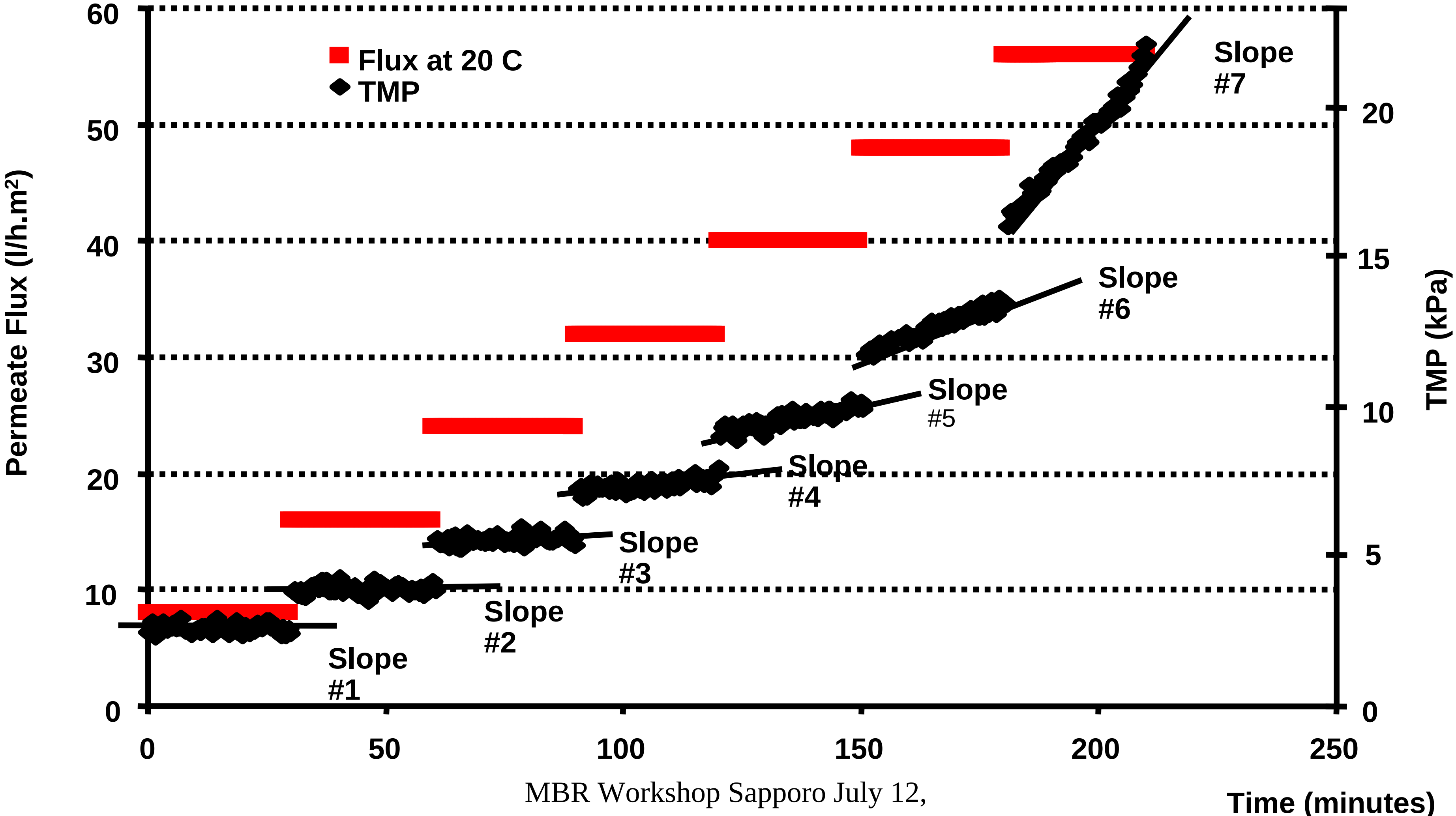
Kubota system layout



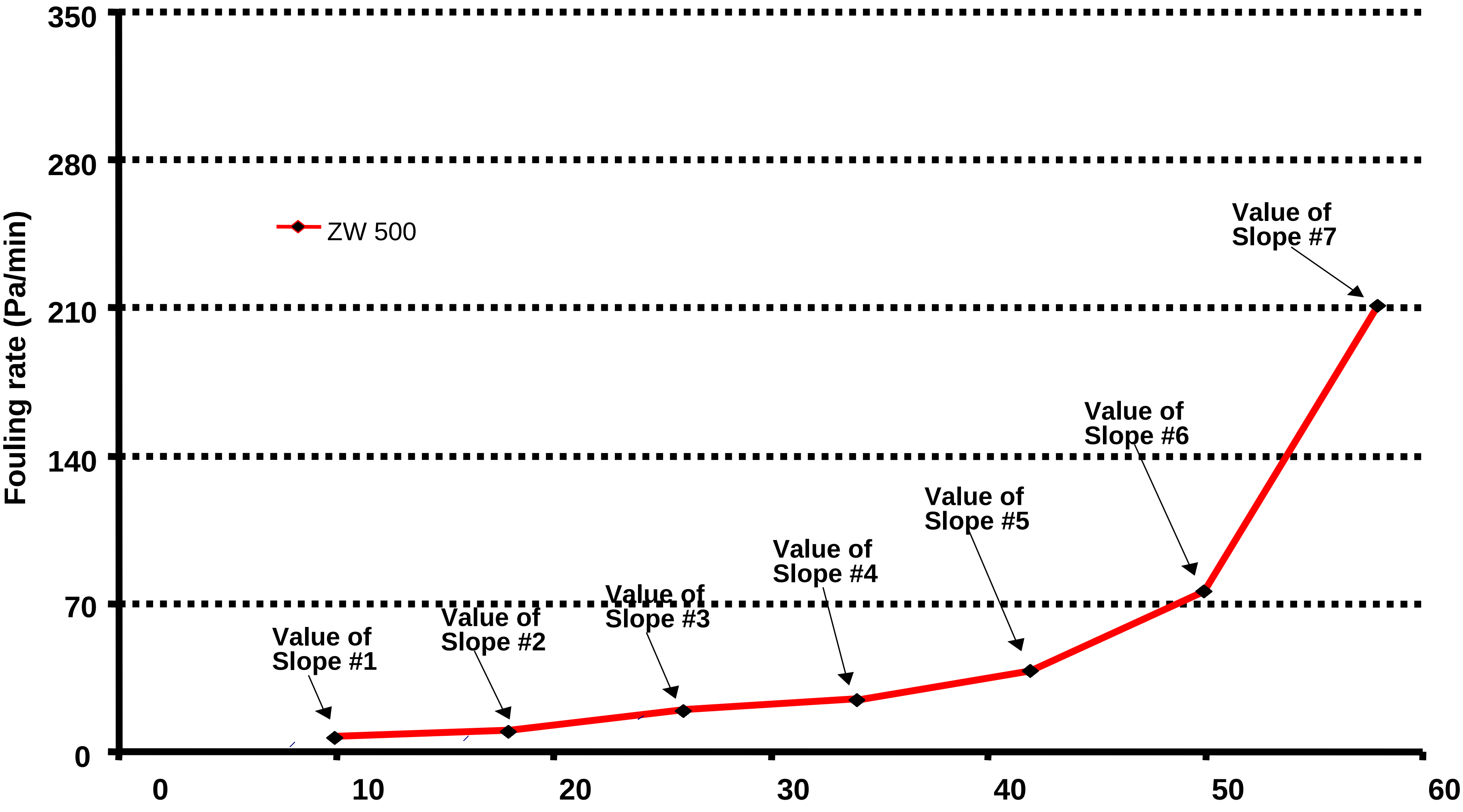
0.4 μm polyethylene flat sheets welded to backing plate

Situated above diffuser below which air is injected

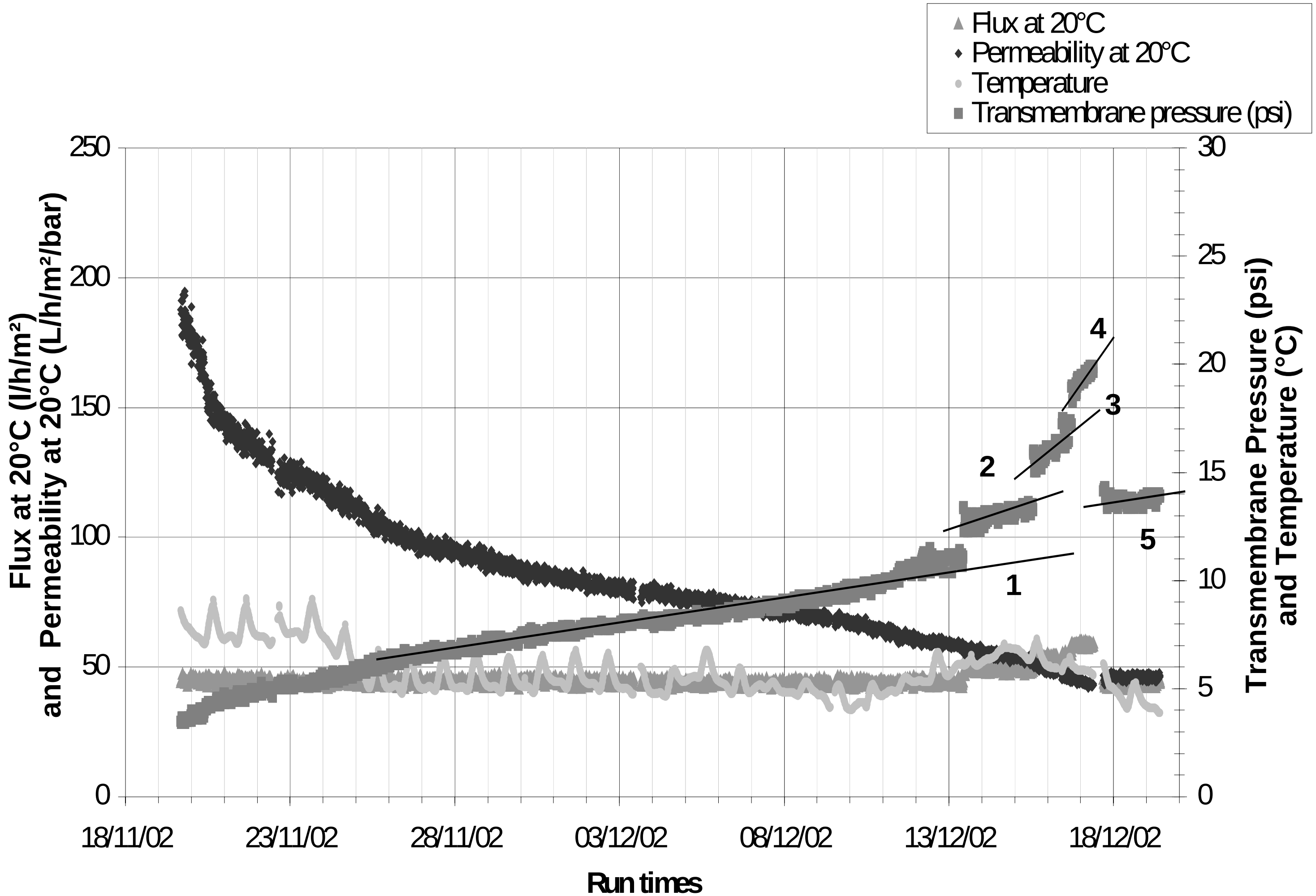
Fouling Curves



Fouling Rate Determination



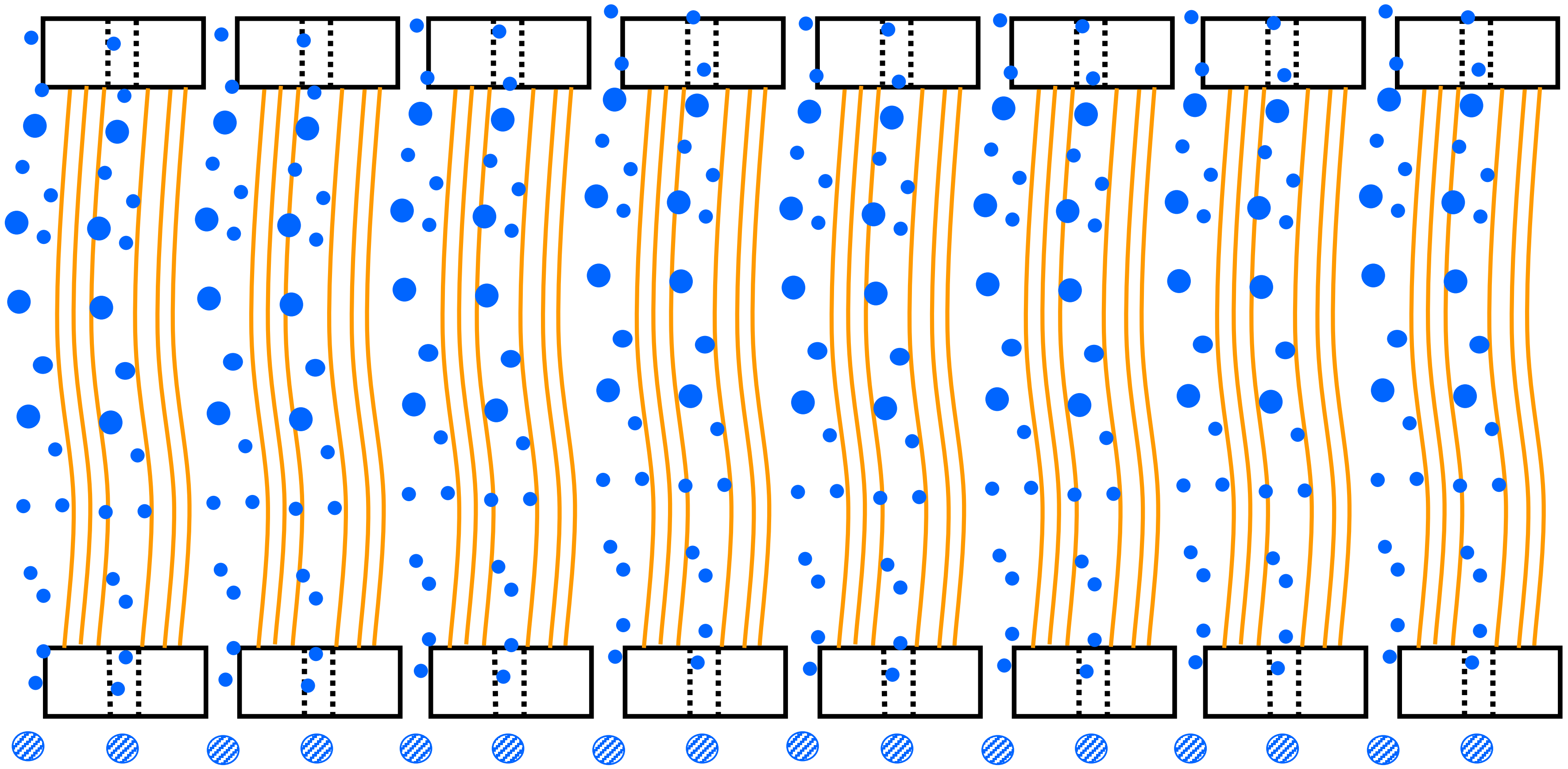
Example of the choice of the permeate flux



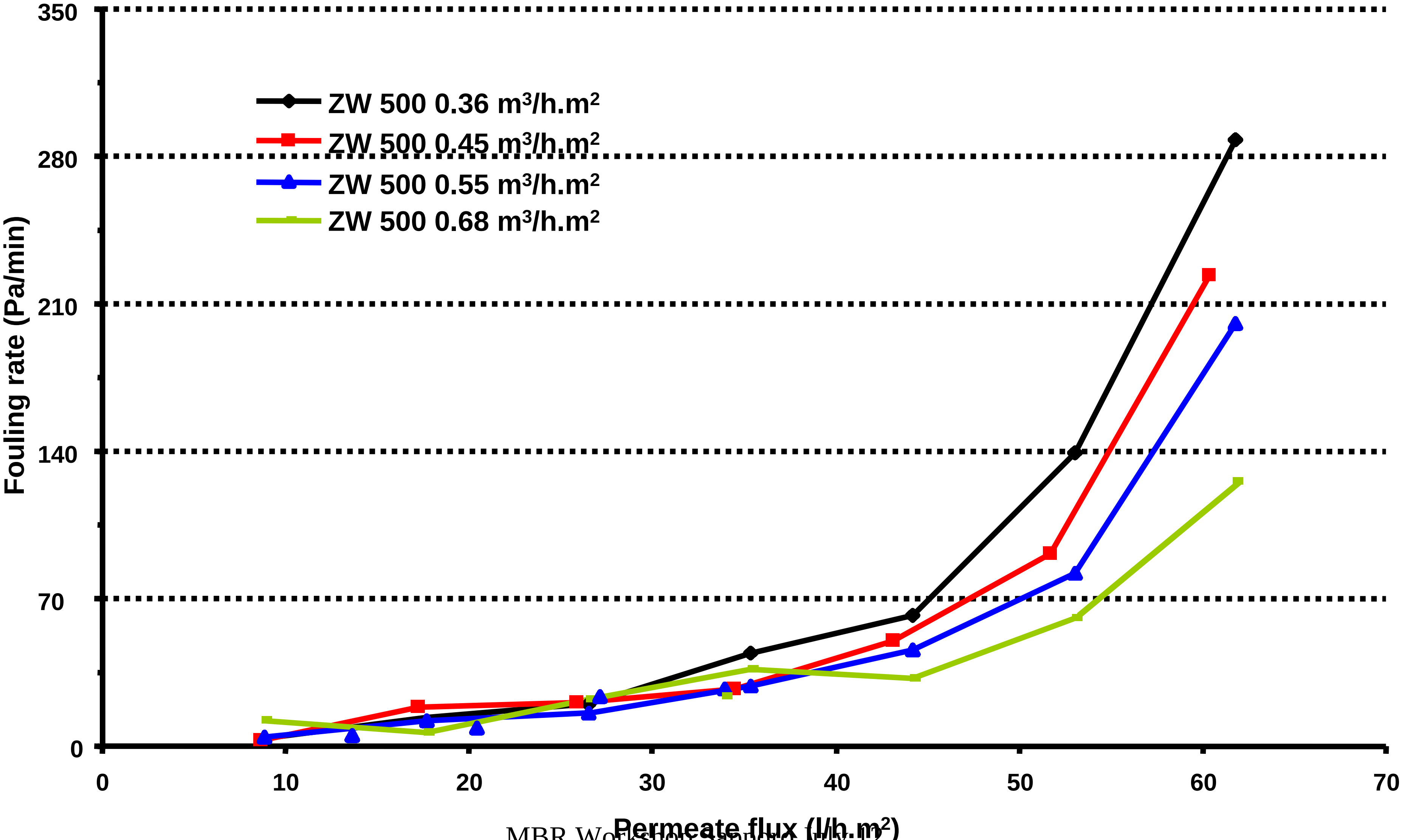
Influence of the conditions of aeration

The “cycling method”

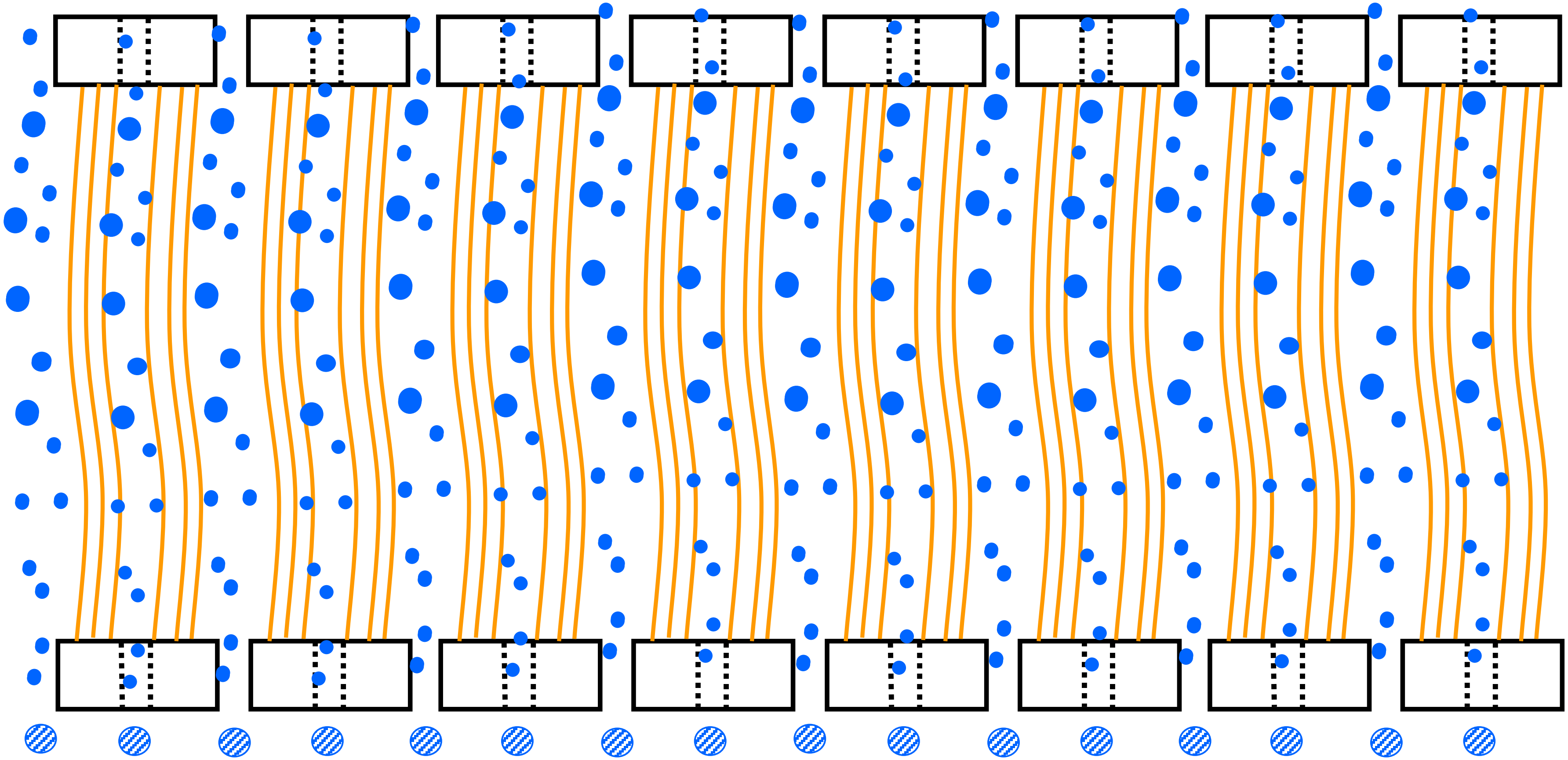
Continuous Aeration Configuration



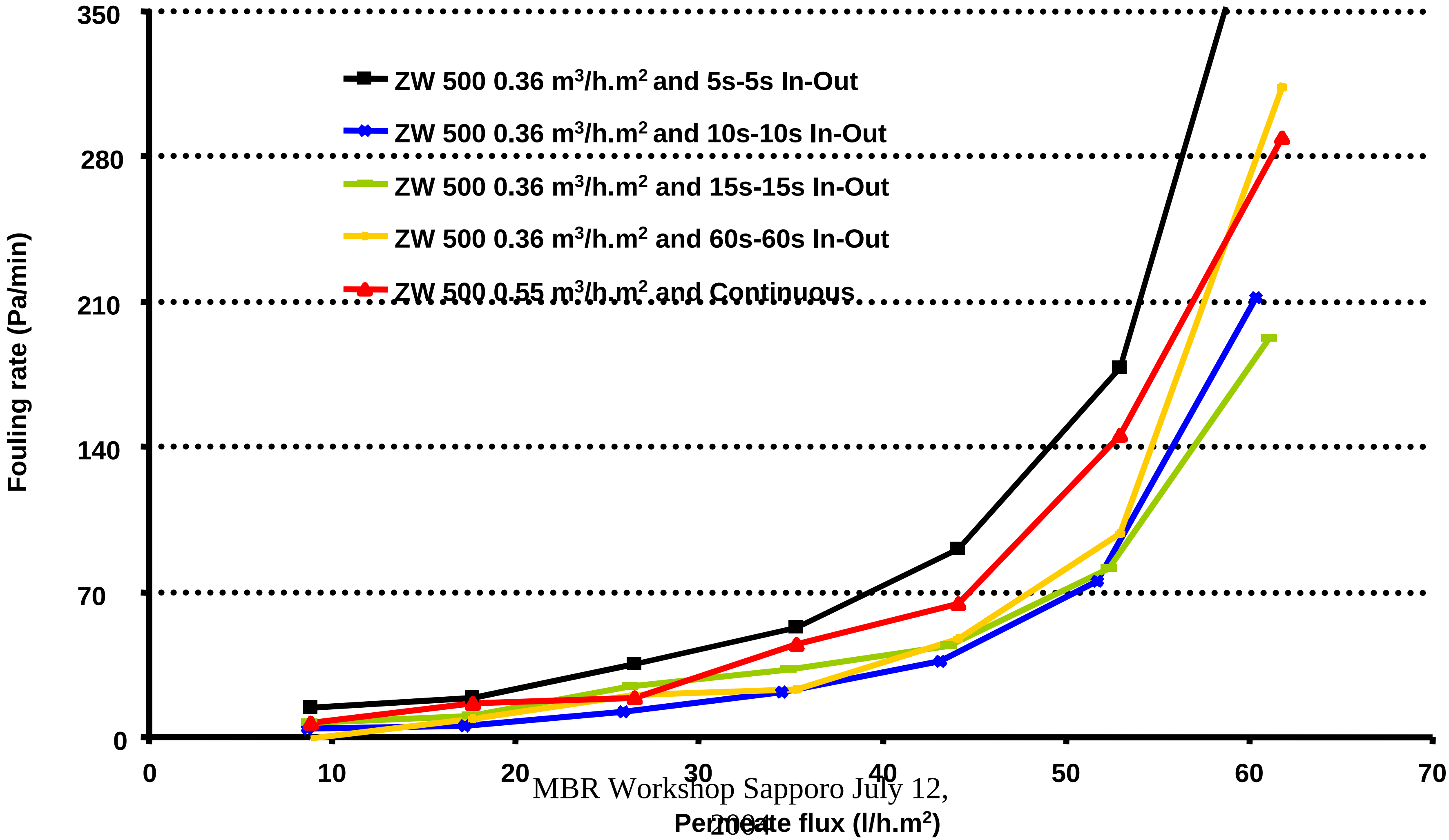
Evolution of the Fouling Rate with the Air Flow in Continuous Aeration



Air Cycling Configuration



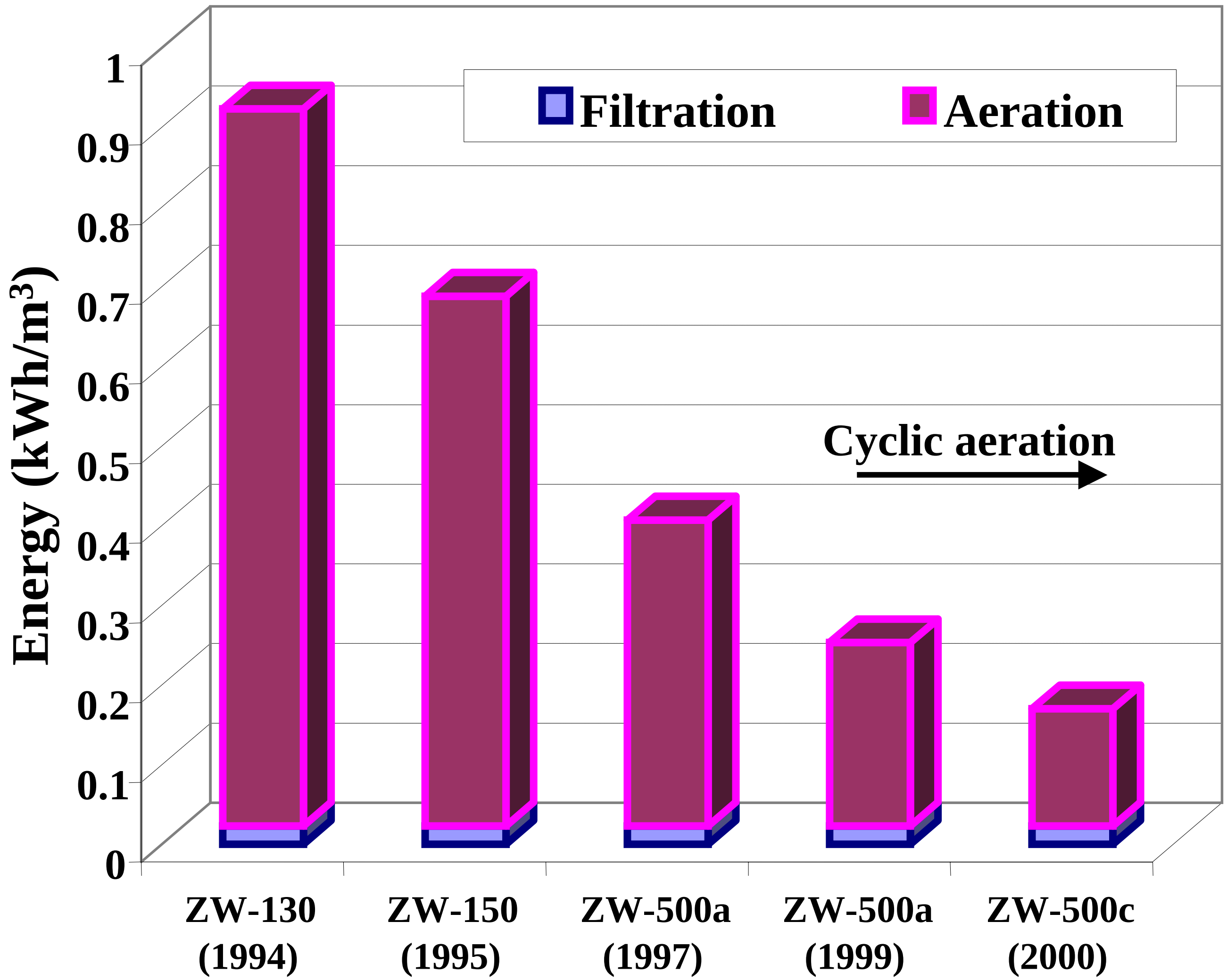
Evolution of the Fouling Rate with the Cycling Frequency



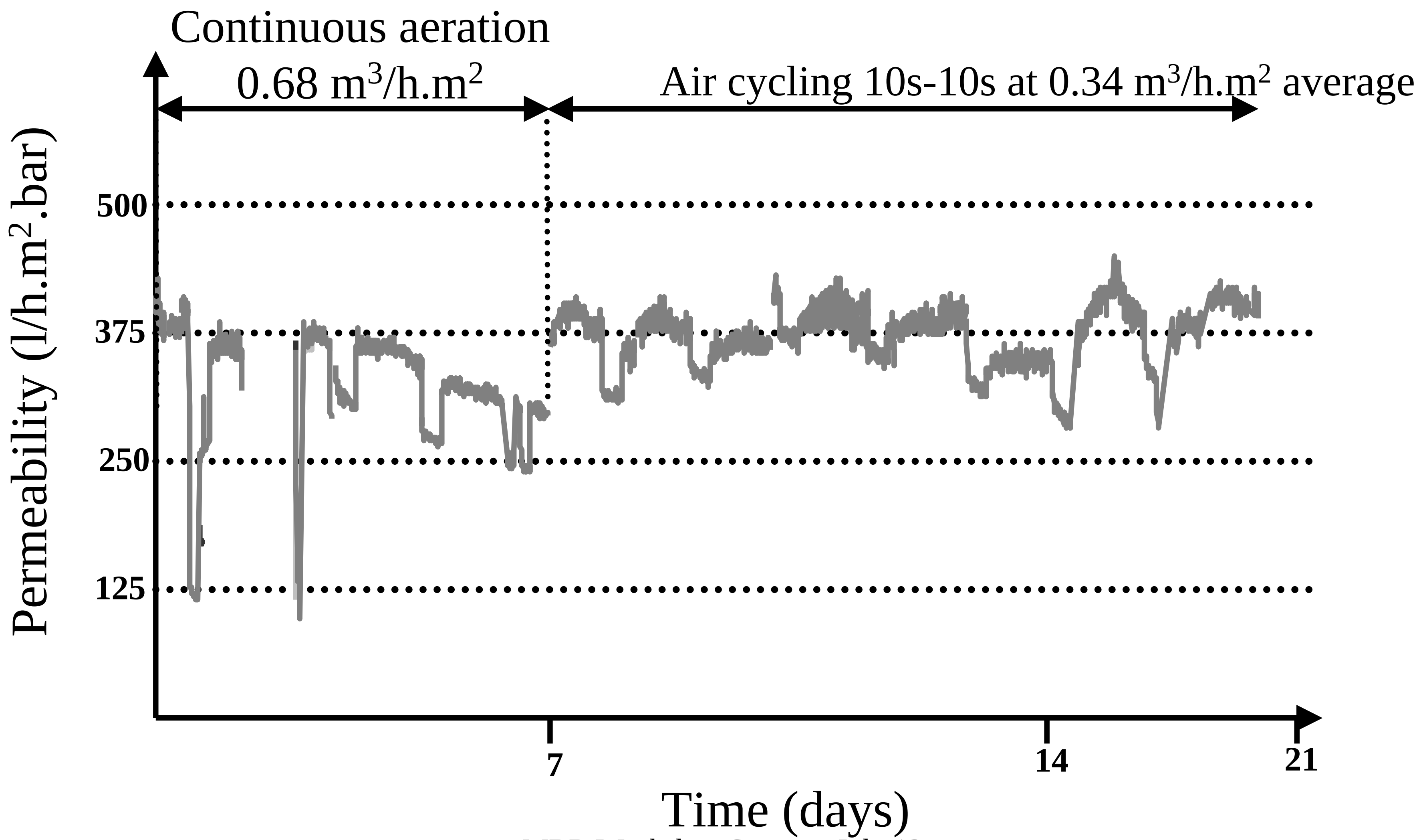
Advantages of Cyclic Aeration

- Unsteady State Generation
  - Higher local aeration intensity, bigger bubbles
  - Reduction of bubble by-pass between fiber bundles
  - Increased contact between fibers and bubbles
- Density Gradients
  - Lateral liquid flow through the fiber bundle
  - Increased fiber movement

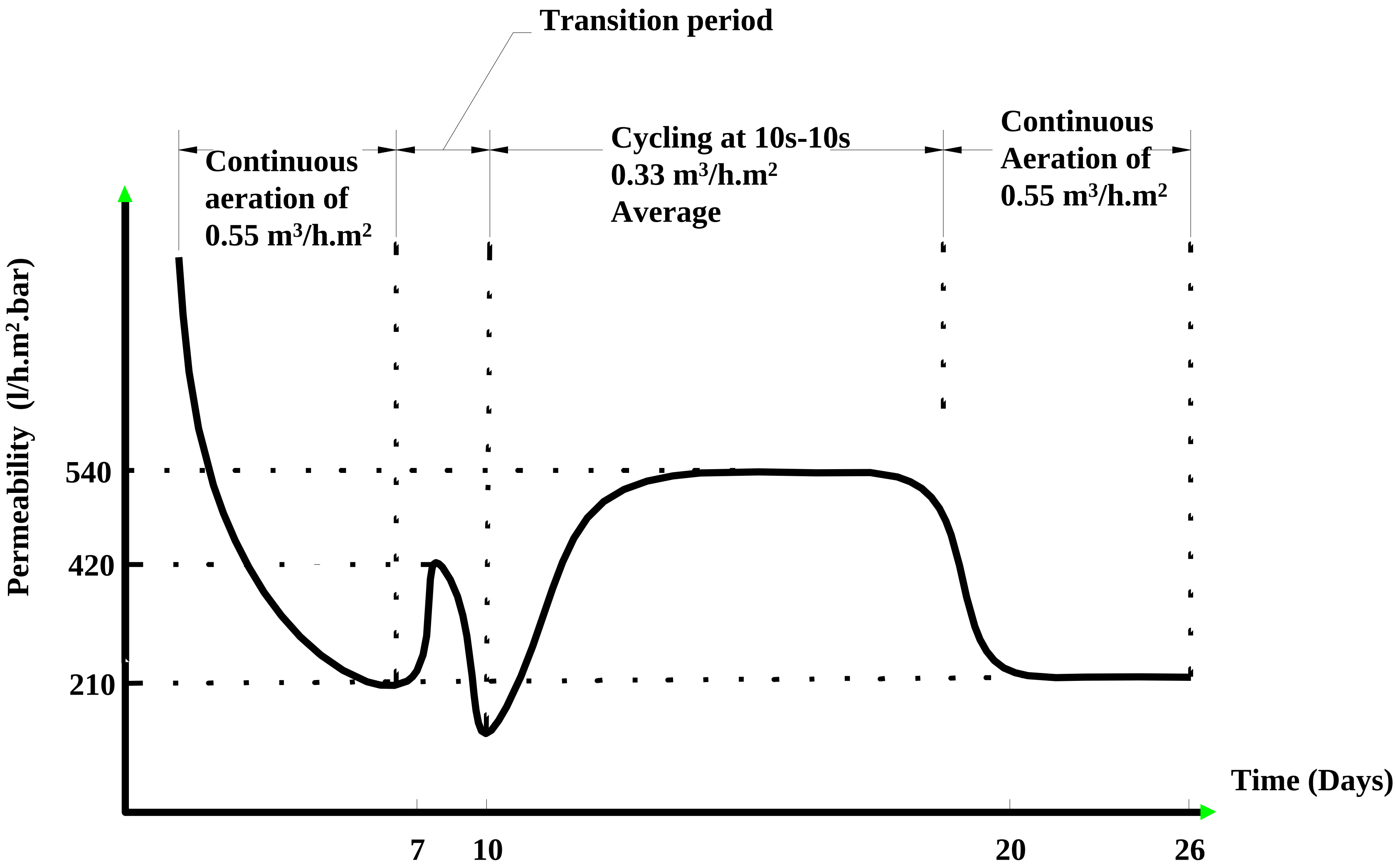
Wastewater: Energy Consumption



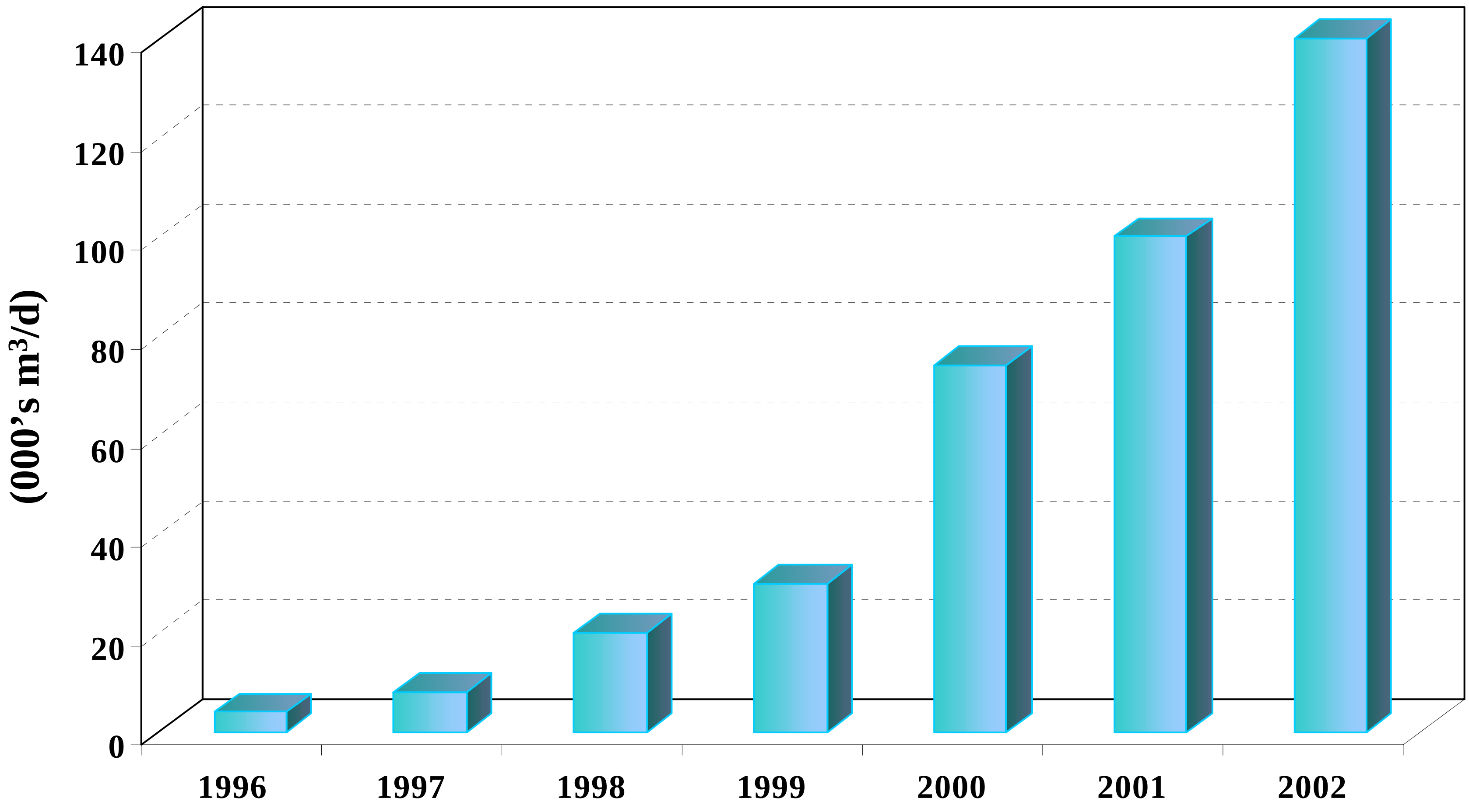
Influence of Cycling for the Treatment of Municipal Wastewater



Influence of Cycling for the Treatment of Surface Water



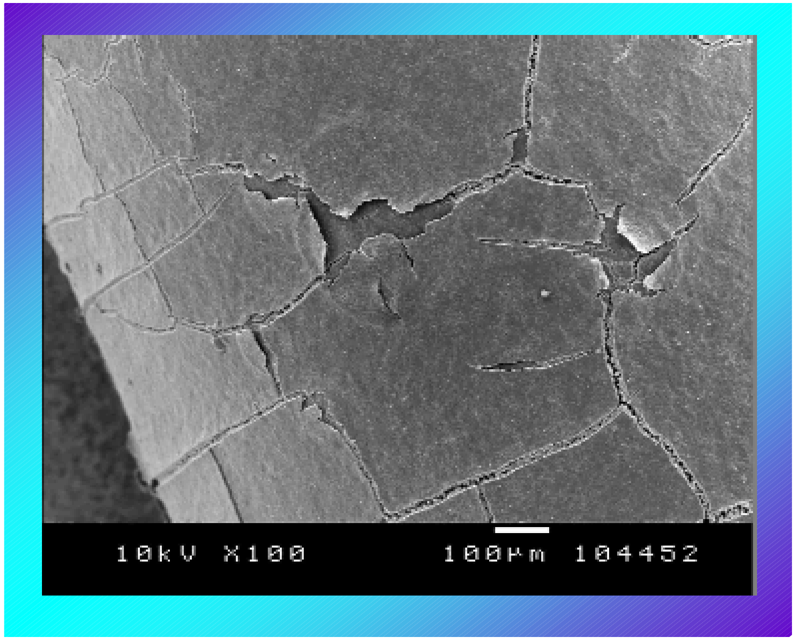
ZeeWeed® ZenoGem®
Installed Capacity in North America

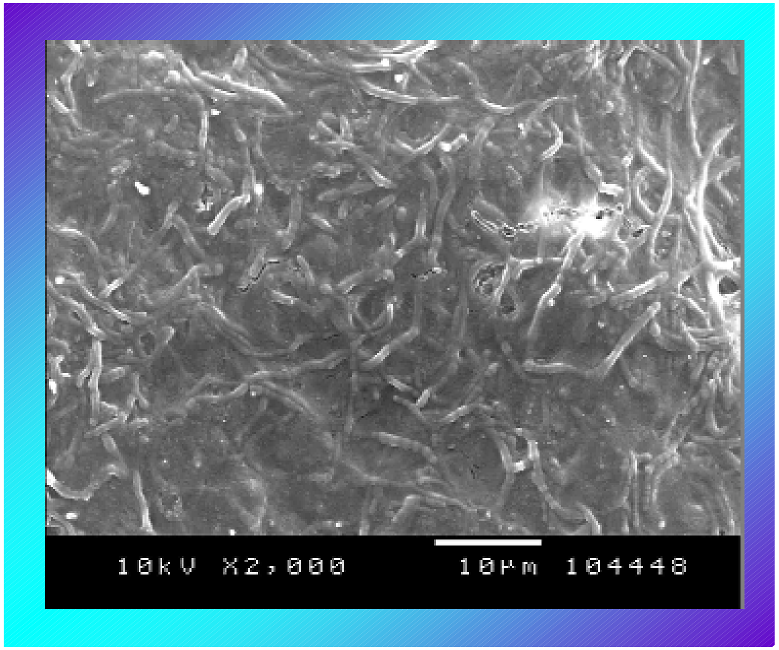


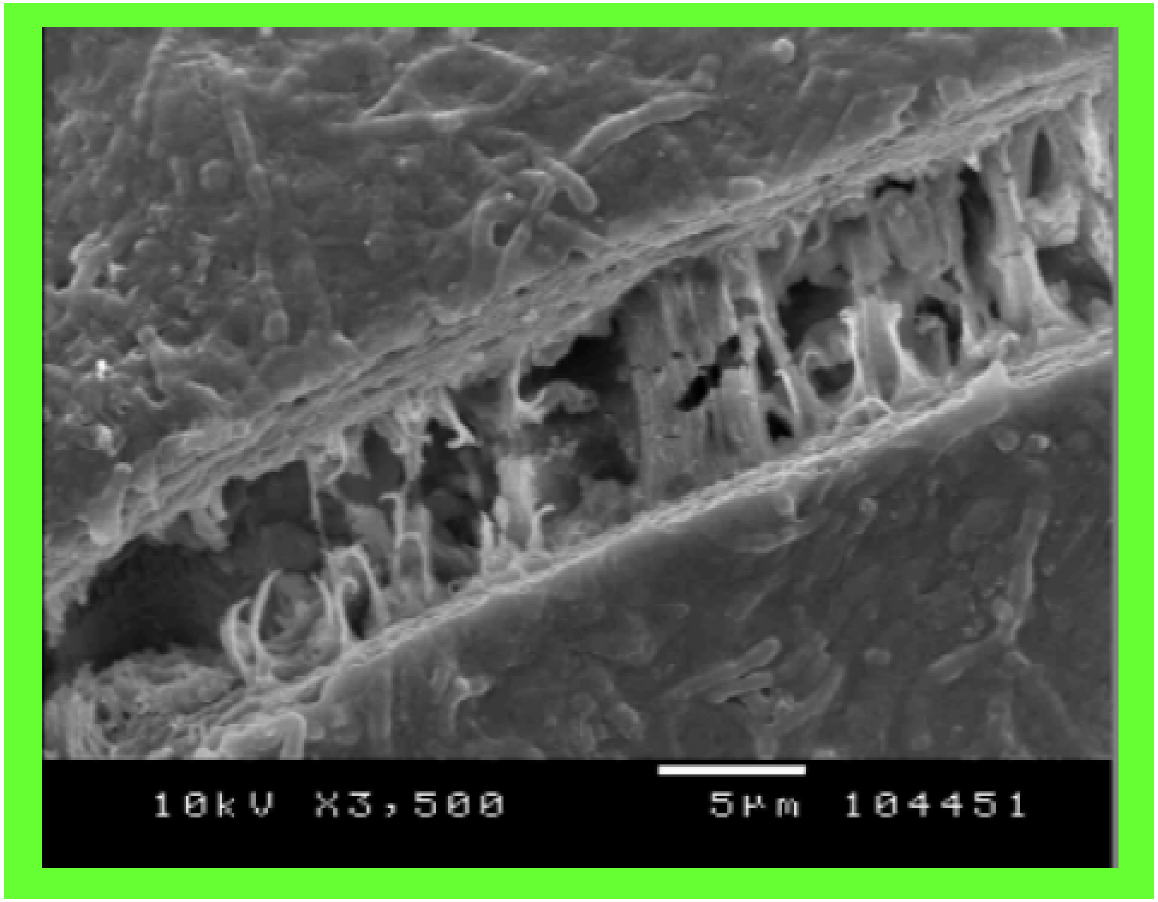
Back washing or relaxation

- Backwashing:
  - Probably more efficient ,but
  - A pump is needed
  - Consumption of treated water and risk of back clogging
  - More stressing for membranes

- Relaxation:
  - Simple (only one valve)
  - Useful for modules which cannot be backwashed, but
  - More important duration than backwashing and thus productivity decrease.
  - Less efficient

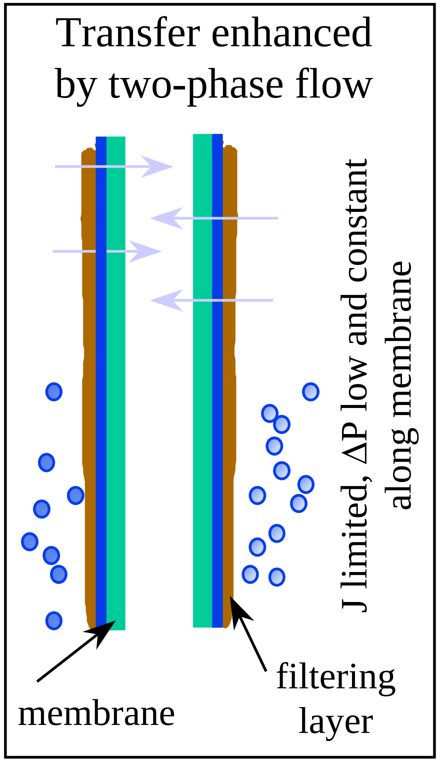

10kV X100
100μm 104452


10kV X2,000
10μm 104448

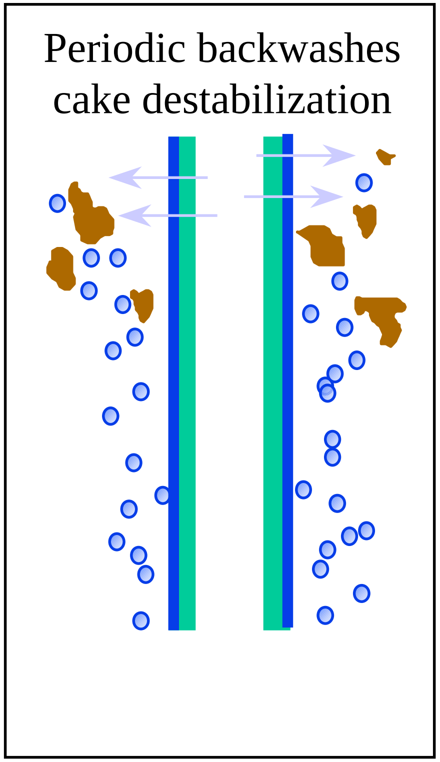

10kV X3,500
5µm 104451

Fouling Control with Immersed Membranes:

Filtration



Backwashing



- **Use of membranes with a lower cost, under conditions of low pressure and limited flux**
- **Use two-phase flow and permeate backwash to control fouling**

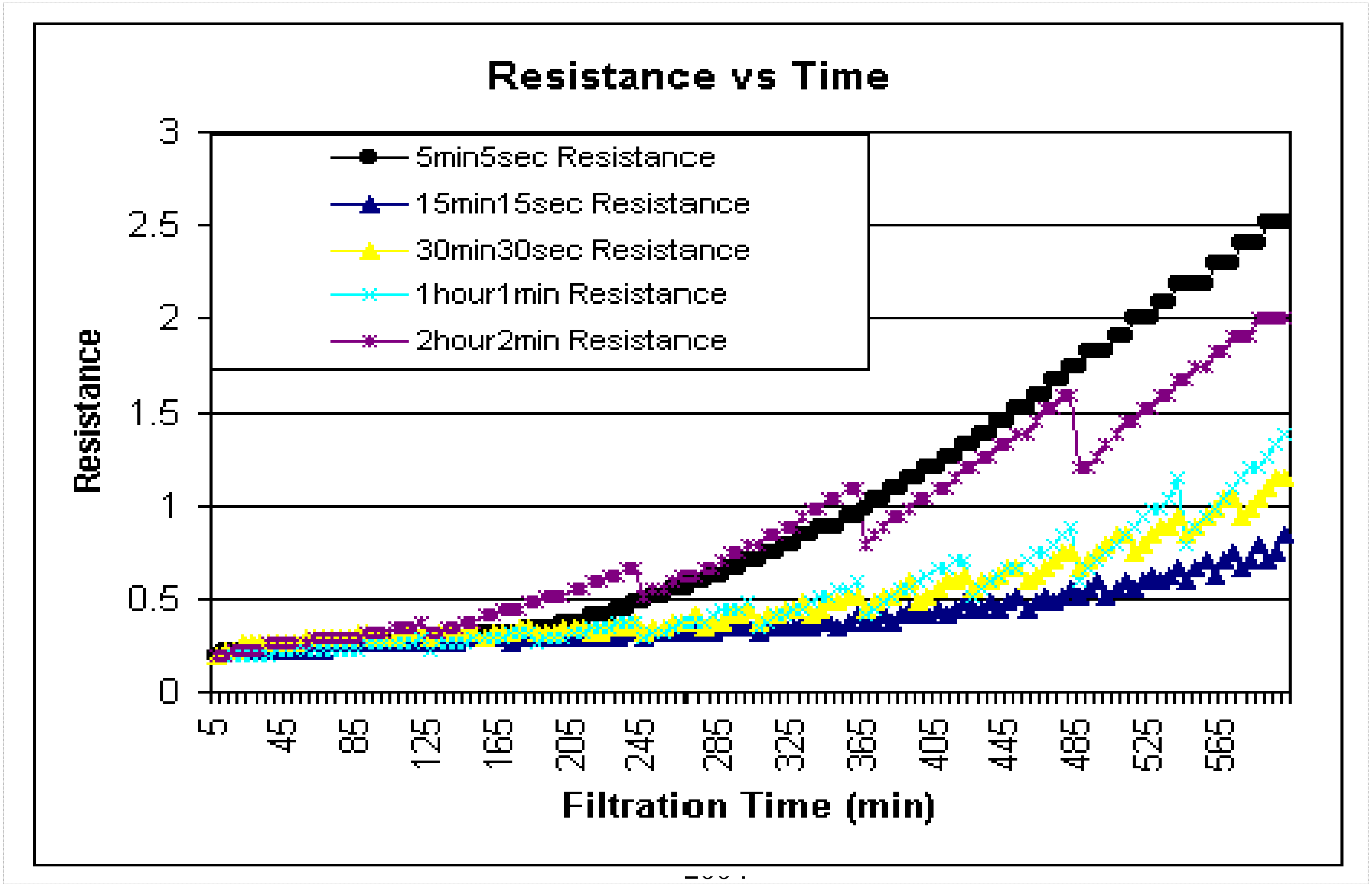
In both cases

- Periodic chlorination during this period is a key parameter for long term membrane operation : preventing the formation and at least the growth of a biofilm

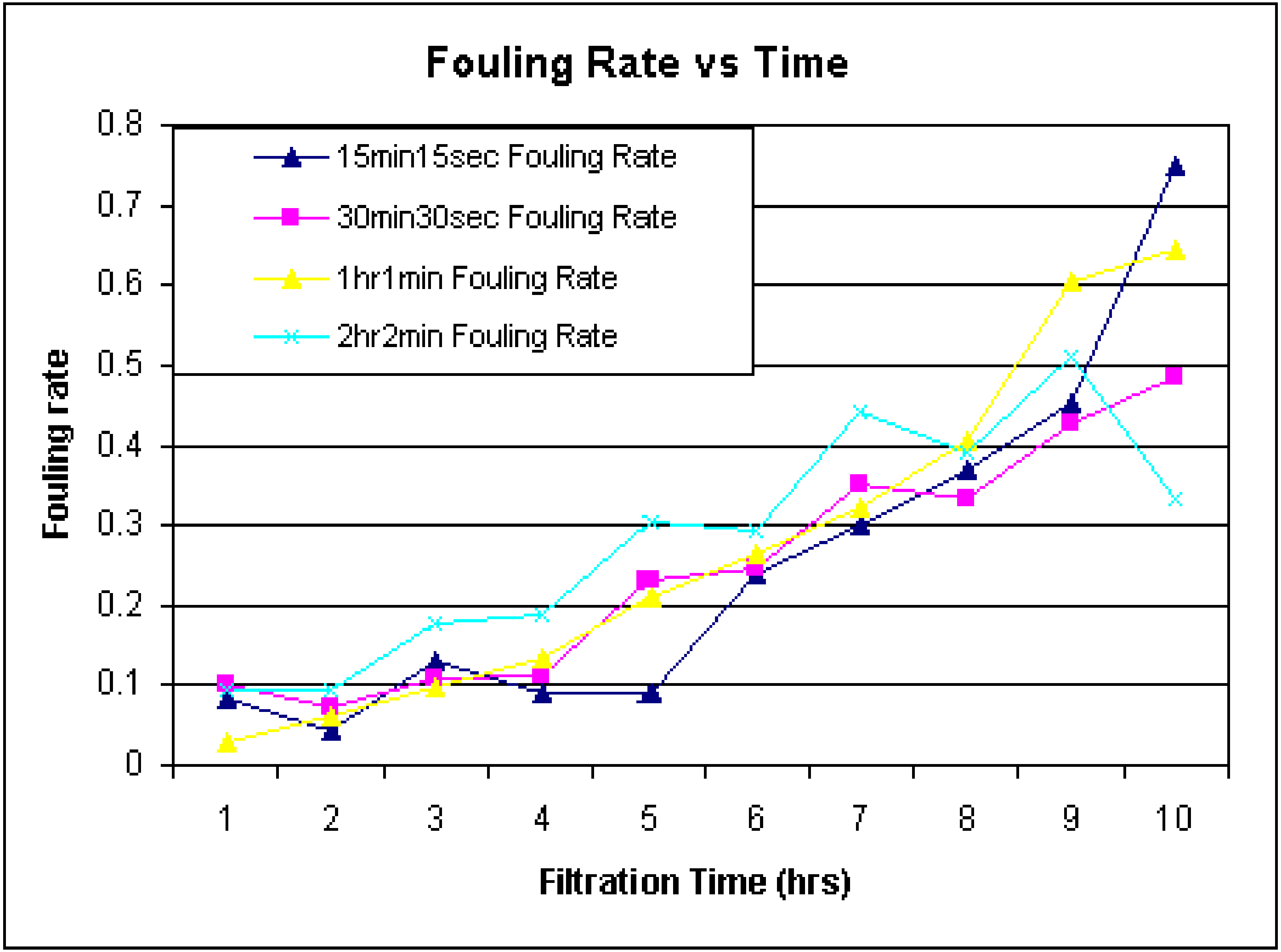
Optimizing backwashing operation

Some recent experimental results

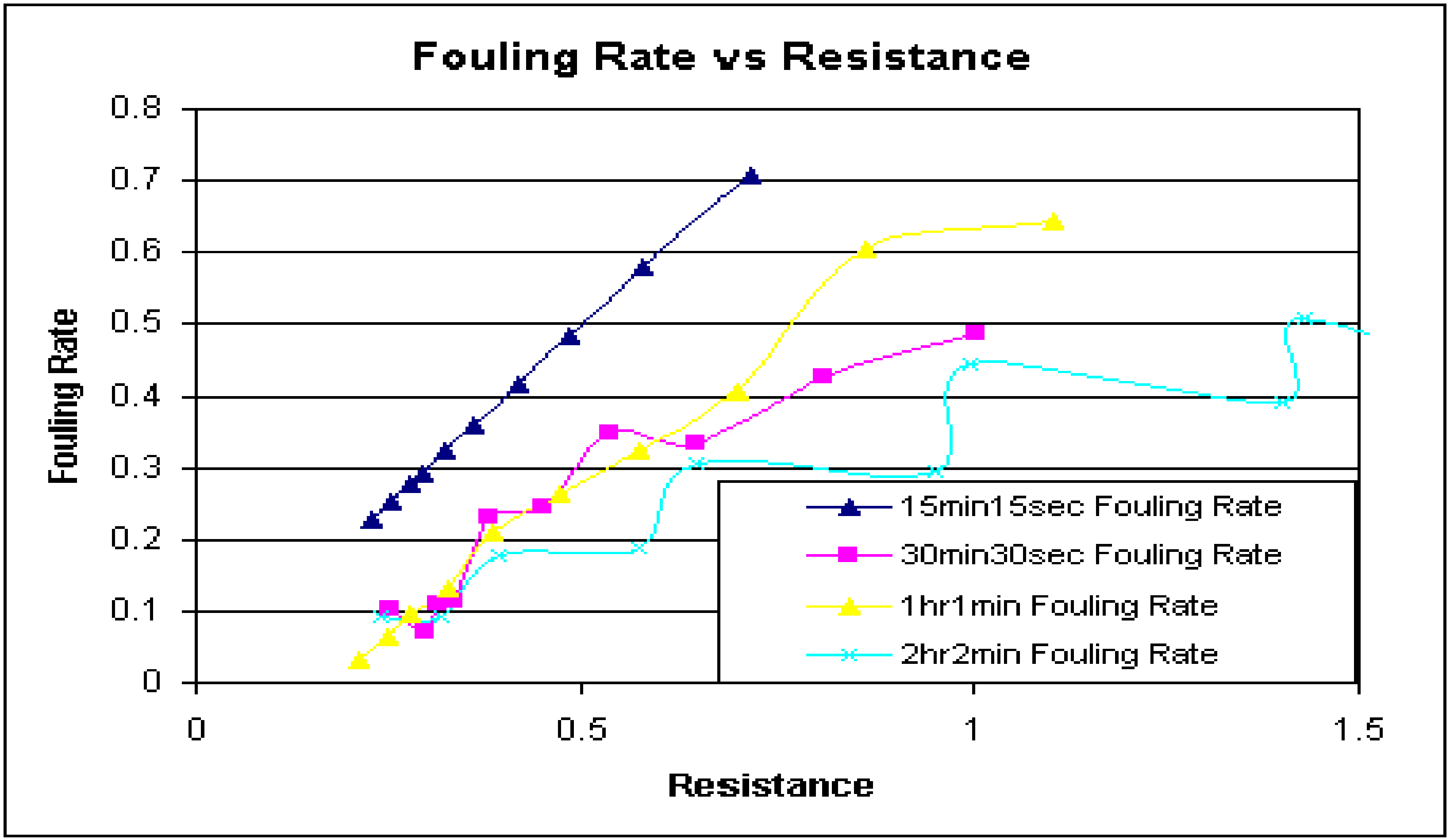
Influence of the periodicity of backwashing



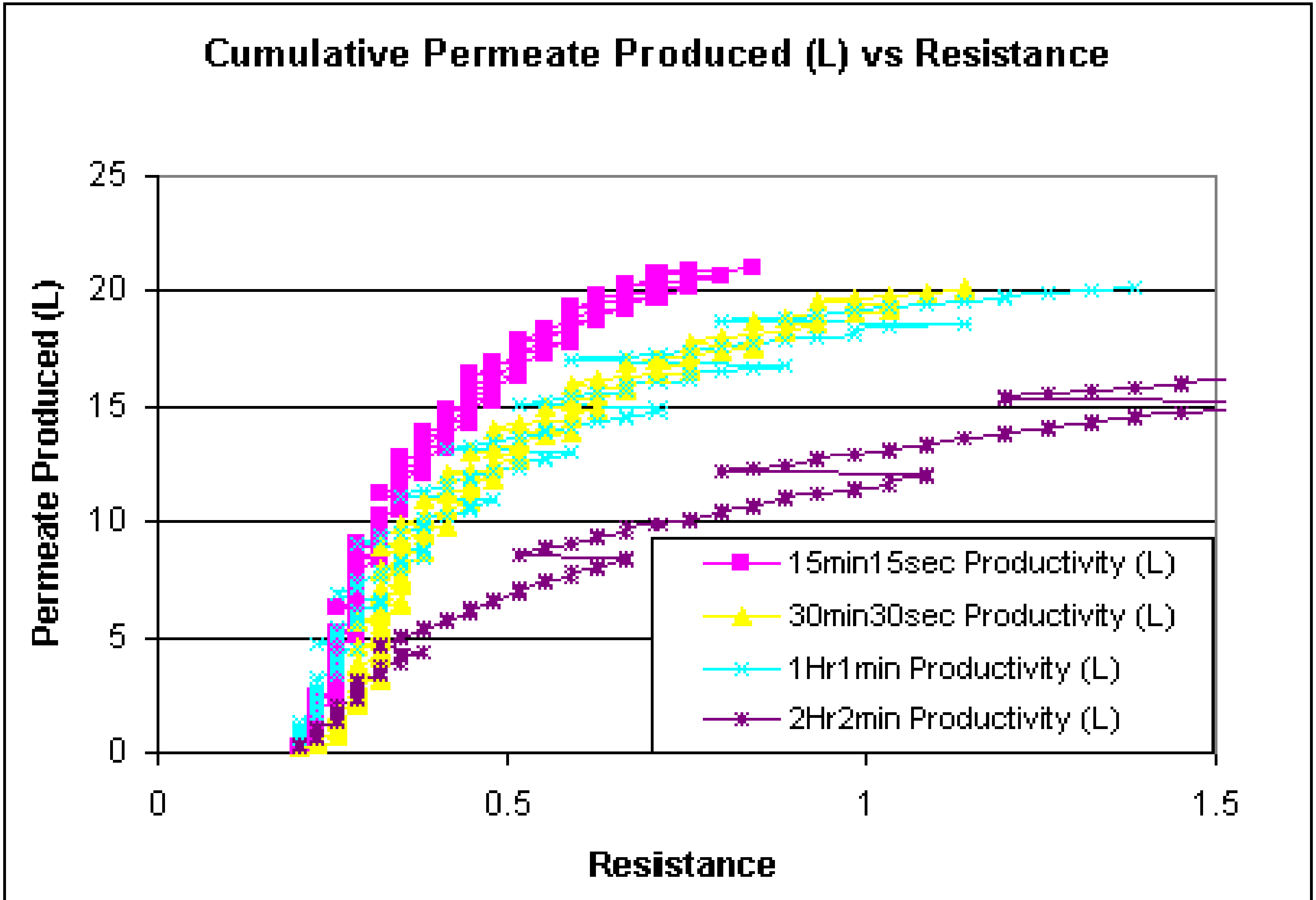
Evolution of the fouling rate between 2 successive backwashes



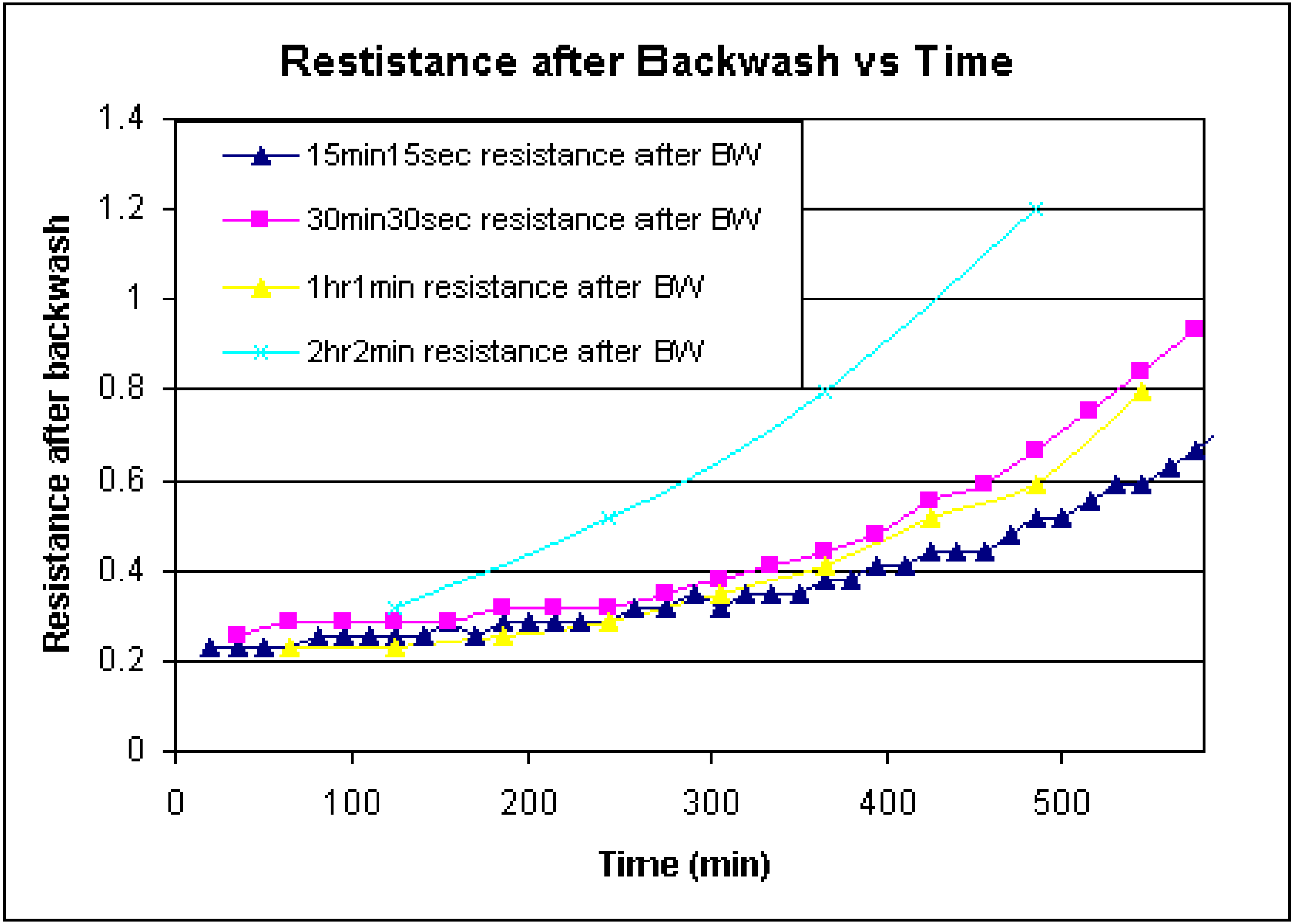
Relation between short term fouling rate and resistance



Influence of cumulative permeate volume produced



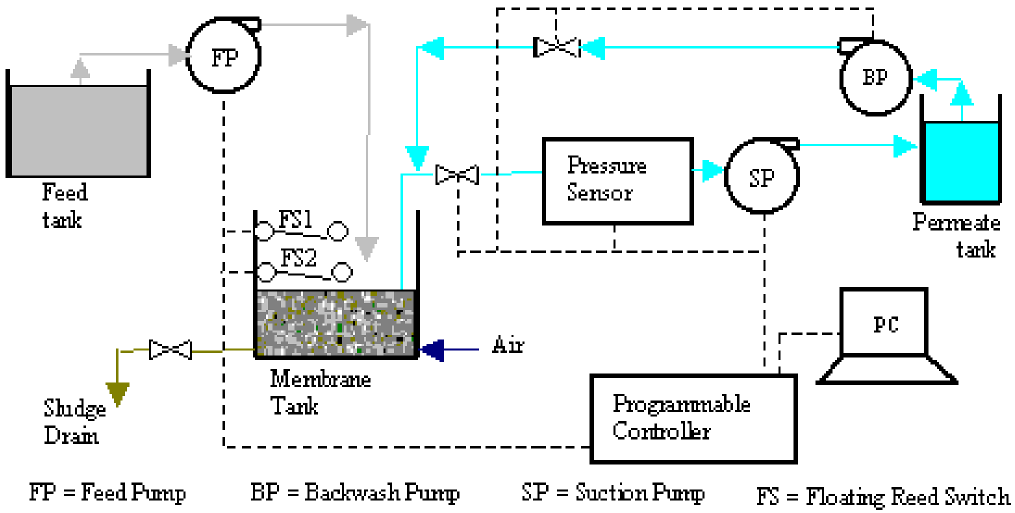
Evolution of “irreversible” fouling

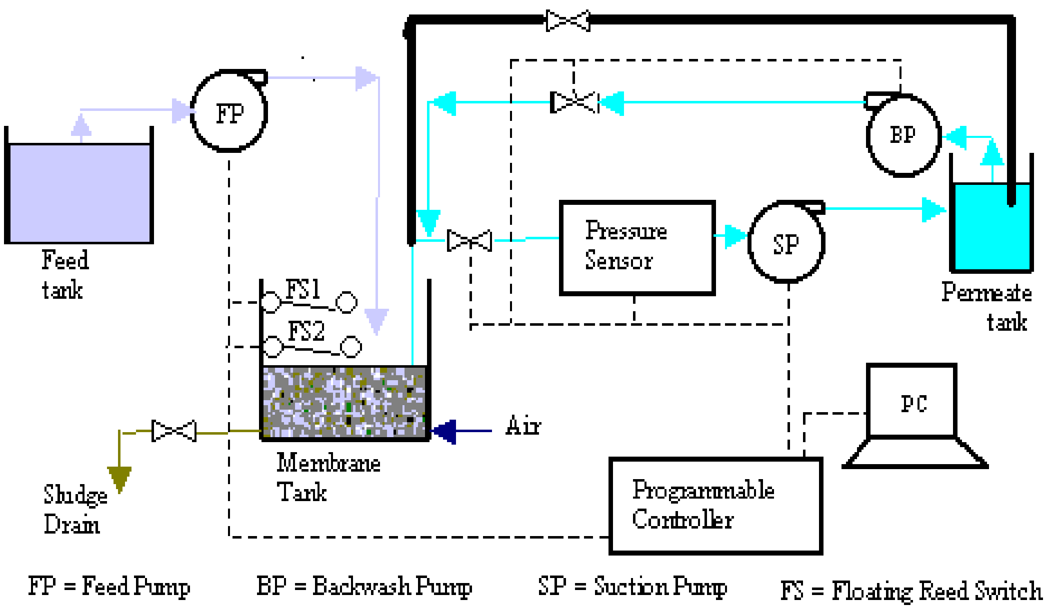


Relaxation

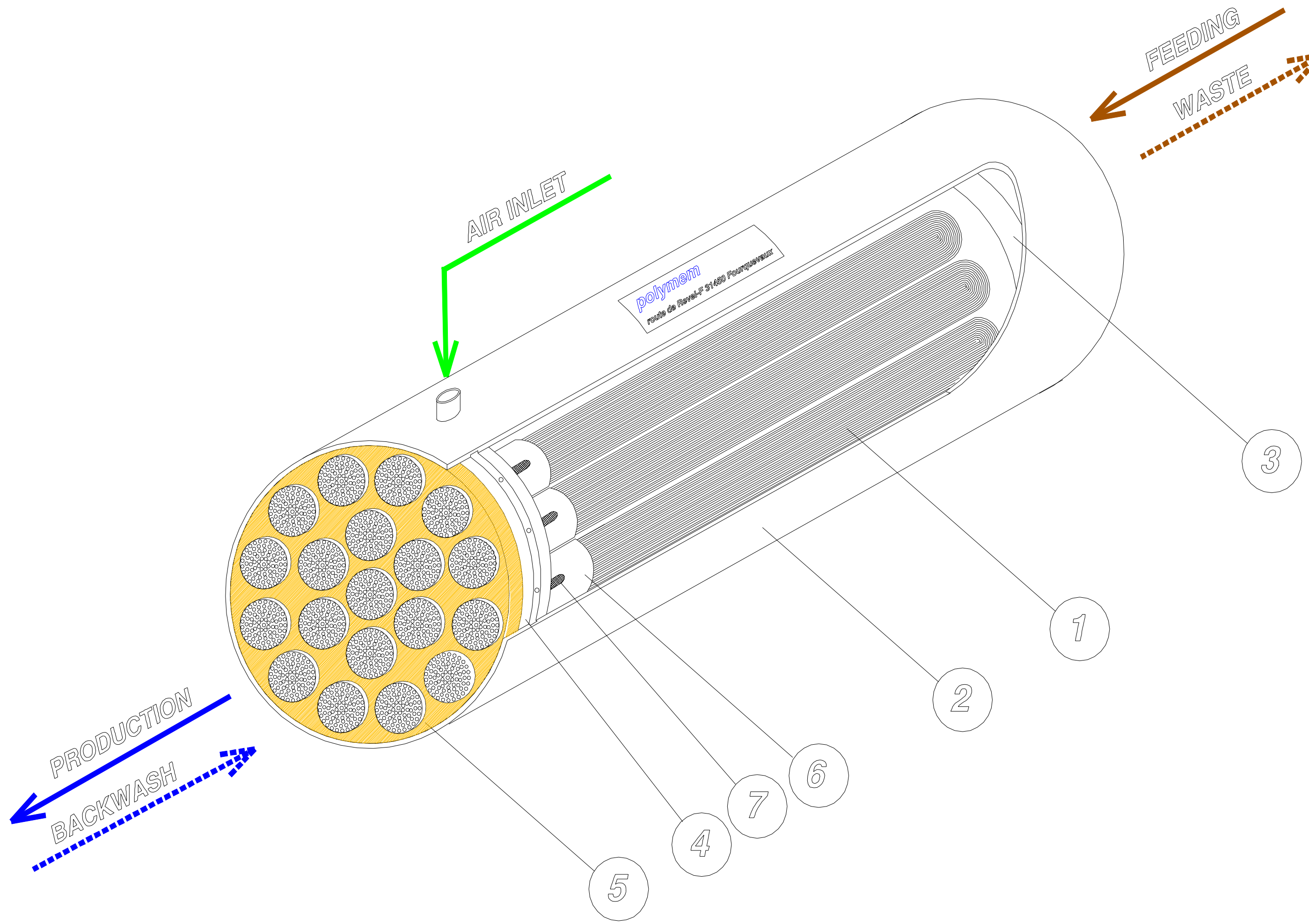
- Very often the condition of relaxation are not optimal .
- Modification of a pilot unit for optimizing the conditions of relaxation

Modification for optimal relaxation



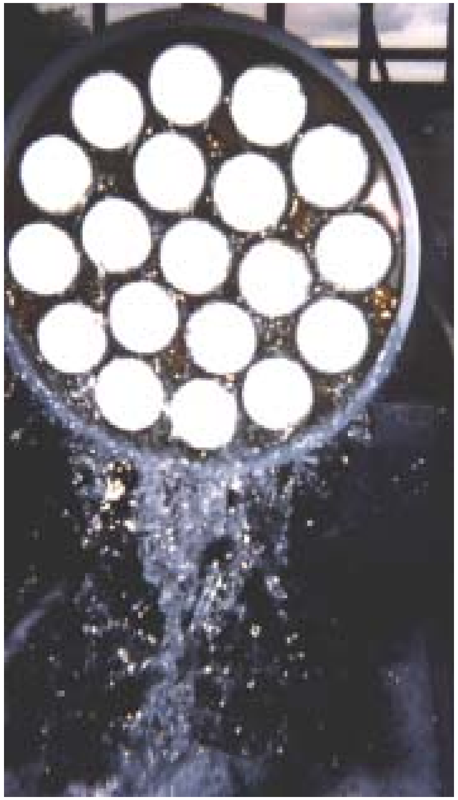


12 inches diameter Outside/in module A large membrane area for large scale applications (Polymem)



Wastewater MBR application
Immem process

- **Submerged modules versus non submerged modules**
  - Maintenance and safety problems for submerged systems
  - Polymem choice is for dead end filtration with continuous air scrubbing, periodic backwash with submerged or non submerged modules with a preference for non submerged modules



Membrane manufacturer
Contact : Polymem, Impasse de Palayré, 31100 Toulouse, France
Tel +33(0) 561 317 866, fax +33(0) 561 317 870. Email : o.lorain@polymem.fr

Immem pilot plant,
a New Concept of Membrane Bioreactor

Pilot filtration capability adapted to lab use	10 to 100 Liter per day
Membrane material adapted to frequent chemical cleaning	Polysulfone hollow fiber membranes
Membrane modules surfaces adapted to lab demands	0.1 m² to 0.3 m², from MF to UF
Separated air injection	Fine bubbles for aeration, coarse bubbles for fibres.
Filtration mode	Pression, succion or gravity

1 . Capital and operation costs reduction

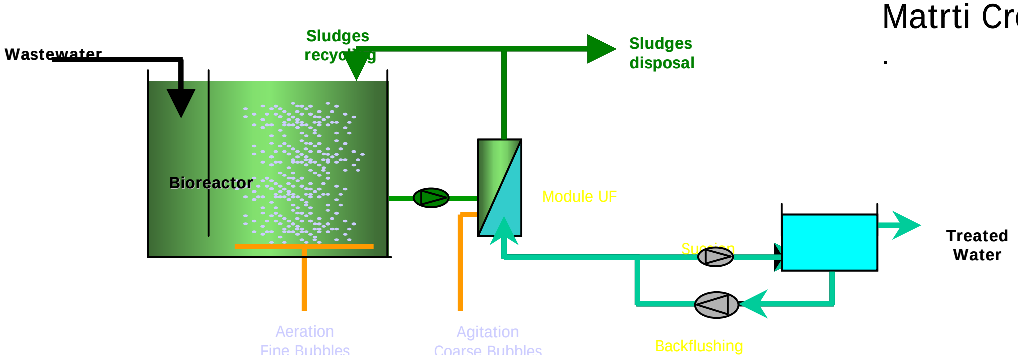
Dead-end hollow fiber ultrafiltration with periodic backwashes

2. Process safety and reliablity improvements

Membranes housed in modules shells located outside the bioreactor

Externalisation of the module has drastically reduced membrane maintenance duration while improving the health safety of the operators.

Easy Integrity testing



Example of the pilot scale unit installed in the lab of Prof. Matrti Crespi, Intexter, Universidad Politécnica de Cataluña, Spain
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Is there a future for small scale MBR?

Why are small scale MBR needed?

- They are a one of the solutions for going to more decentralised approach of water management.
- They are perfectly suited for onsite wastewater reuse.
- The standards for treated wastewater discharge are stricter and stricter : the existing septic tanks are becoming obsolete

Other reasons

- The scaling down is in favour of membrane processes compared to conventional
- The cost of a septic tank + tertiary treatment (Nordic countries) is quite high : 10 000 Euros for a family
- The cost of membranes and modules is decreasing
- Remote control is realistic and already put in opeation

More about scaling down effect

- The most recently designed large scale MBR have a capacity of about 24 000 M3/d.
- These plants are competitive with conventional wastewater treatment plant + additional tertiary treatment.
- Upscaling coefficient is between 0.4 to 0.8 for membrane processes (decreasing with the size of the unit) : it is smaller (close to 0.4) for conventional processes.
- Membrane processes should be more competitive than conventional ones for small scale units.

TABLE 9. Comparison of MBR and Activated sludge Process (From MRC, 1998).

Assumption	Wastewater flow	: 20 m^3/h
	BOD of wastewater	: 2000 mg/L
	BOD of treated water	: 20 mg/L

	MBR (Submerged Type)		Conventional Activated Sludge Process	
Plant area (m^2)	Flowrate control tank	13.4	Flow rate control tank	13.4
	ASA-tank[1]	20.0	ASA-tank[2]	66.7
			Sedimentation tank	5.0
			Pre-sedimentation tank	10.0
			Sedimentation tank	1.7
			Thickener	13.5
			Total	110.3
	Total	33.4		
Energy electric power (kW)	Fine screen	0.1	Fine screen	0.1
	Flow control pump	0.25	Flow control pump	0.25
	Flow control blower	0.4	Flow control blower	0.4
	Blower for aeration	3.7	Blower for aeration	5.5
	Suction pump	0.2		
	Total electric power	4.65	Total electric power	6.25
Sludge (m^3)	Quantity (per day)	0.0693	Quantity (per day)	0.966
Running cost electrical[3] ($/day)	8.37		11.25	
Sludge treatment[3] ($/day)	34.65		48.30	
Running cost	72 %		100 %	
Space	30 %		100 %	

1 Activated sludge aeration tank (load 2 kg/m^3 day)
2 Activated sludge aeration tank (load 0.6 kg/m^3 day)
3 The price for electricity assumed at US $ 0.075 (Exchange rate of 40 B/$)
From MRC, 1997.

Low cost design for small scale MBR

- Low cost system for bubbling : hydro-ejector (venturi) , air-lift ?
- Supported biomass for long periods of inactivity (week ends , holydays)?
- Sludge extraction?
- Innovative design required , not just down scaling of existing MBR.