Use of a hybrid Biofilm- Suspended biomass Membrane Bioreactor for the treatment of wastewaters

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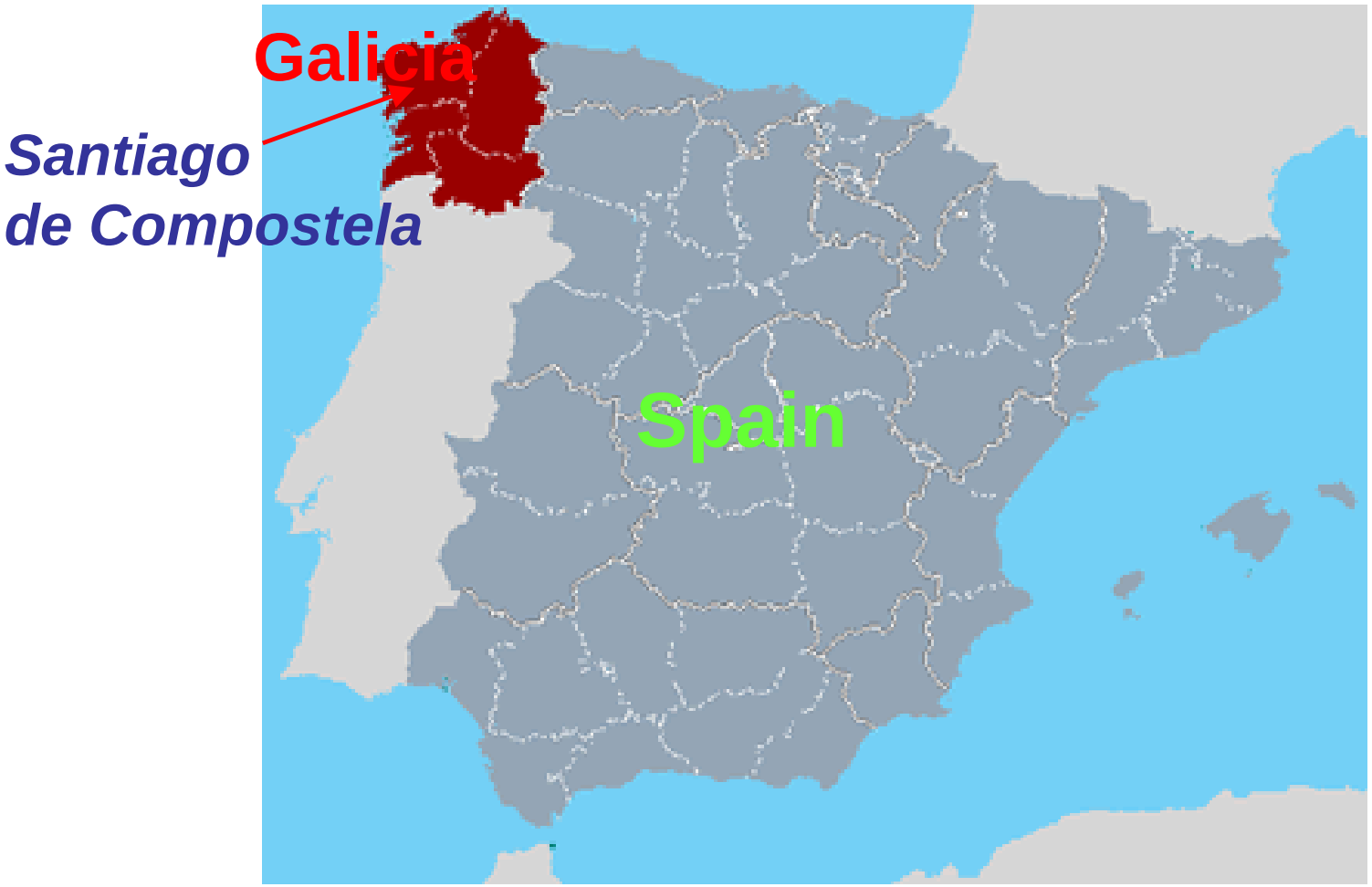
Where I come from ?



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Where I come from ?

Santiago de Compostela

Where I come from ?: Galicia

Group of Environmental Engineering and Bioprocesses

Head: Prof. Dr. Juan M. Lema

Department of Chemical Engineering

University of Santiago de Compostela (Spain)

www.usc.es/biogrup

STAFF

8 Professors

- 3 Full Professors
- 5 Associated Prof.

5 Technicians

1 Technological Manager

6 Post-docs

27 PhD Students

RESEARCH TOPICS

- Application of enzymes and fungi to the degradation and production of compounds
- Development, operation and control of wastewater treatment technologies
- Environmental Management: Life Cycle Assessment and carbon footprint
- Biological treatment of gaseous waste streams

Development, operation and control of wastewater treatment technologies

- Removal of micropollutants contained in municipal wastewater
- Removal of nitrogen
- Membrane bioreactors
- Monitoring, control and operation of anaerobic digesters
- Aerobic granulation
- Recovery of phosphate as struvite

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Hybrid Biofilm-Suspended biomass MBRs

a little of history...

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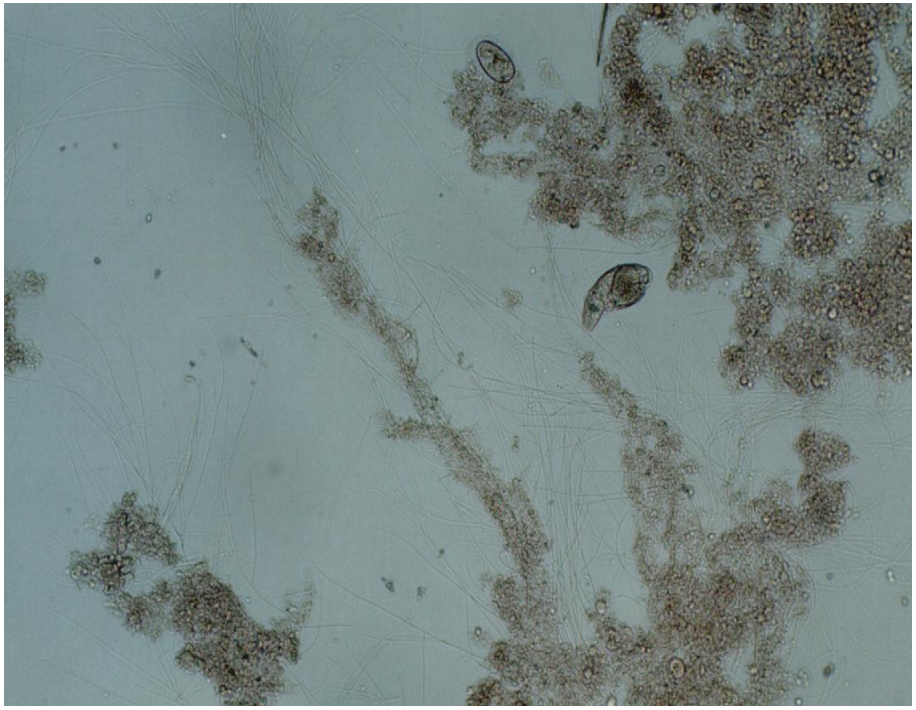
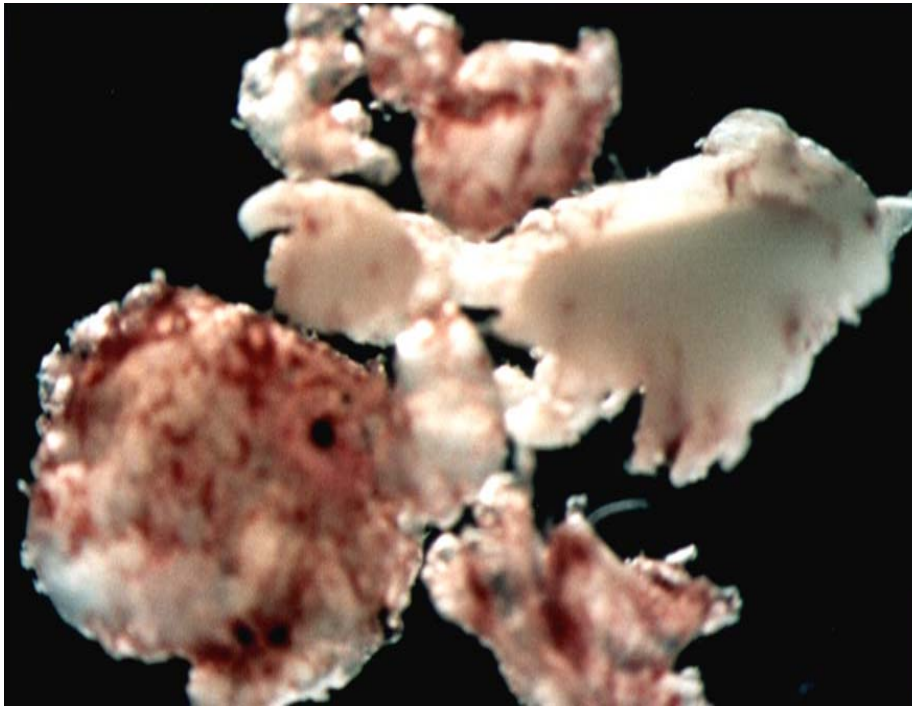
Hybrid MBR
Suspended and Adhered Biomass





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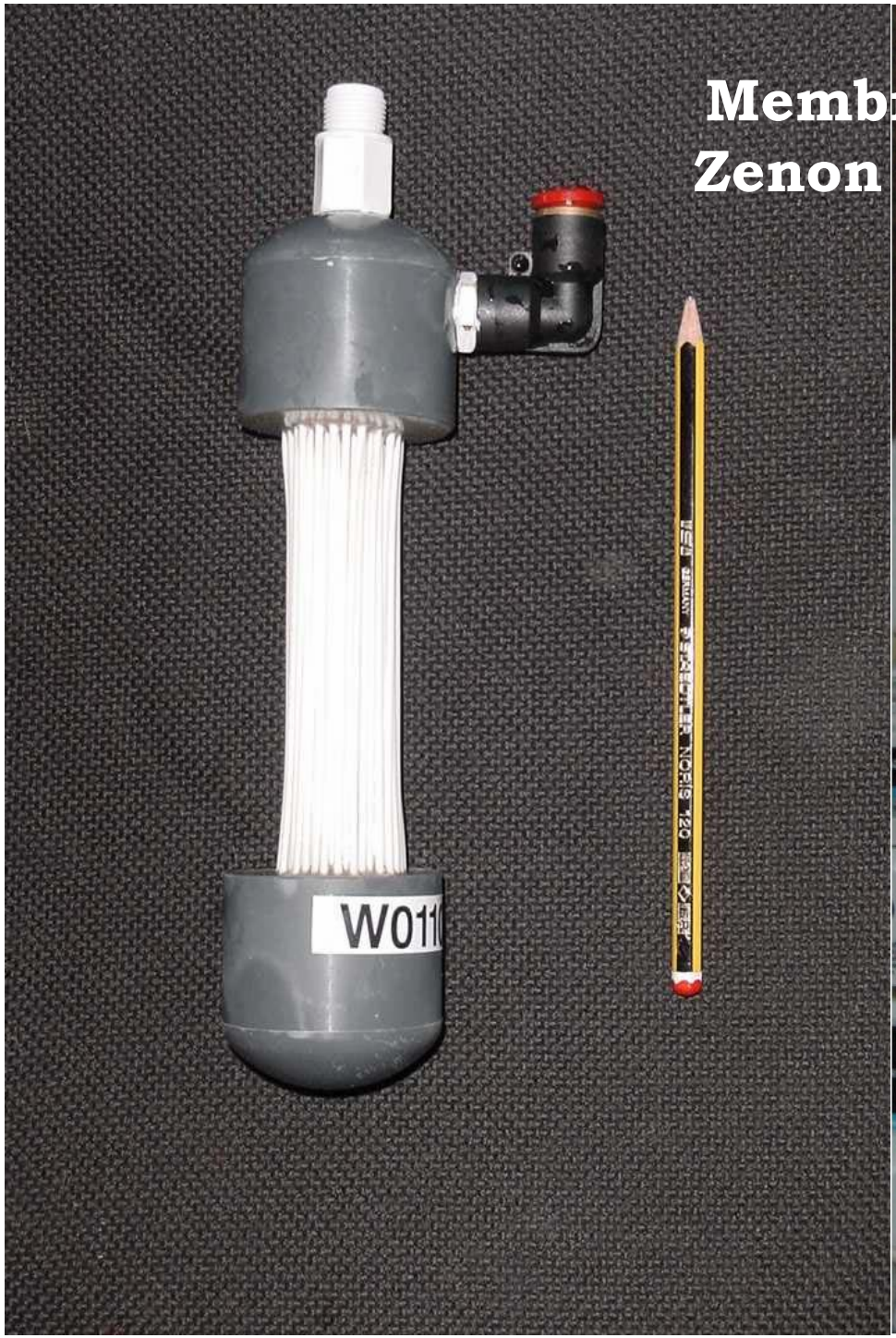
Lab-scale, Hybrid MBR


Membrane:
Zenon ZW-1

Lab-scale experiments

Wastewaters fed during the lab-scale experiments:

Synthetic (Readily biodegradable COD)

Fish-canning factories

Tanning factories (suspended COD ↑)

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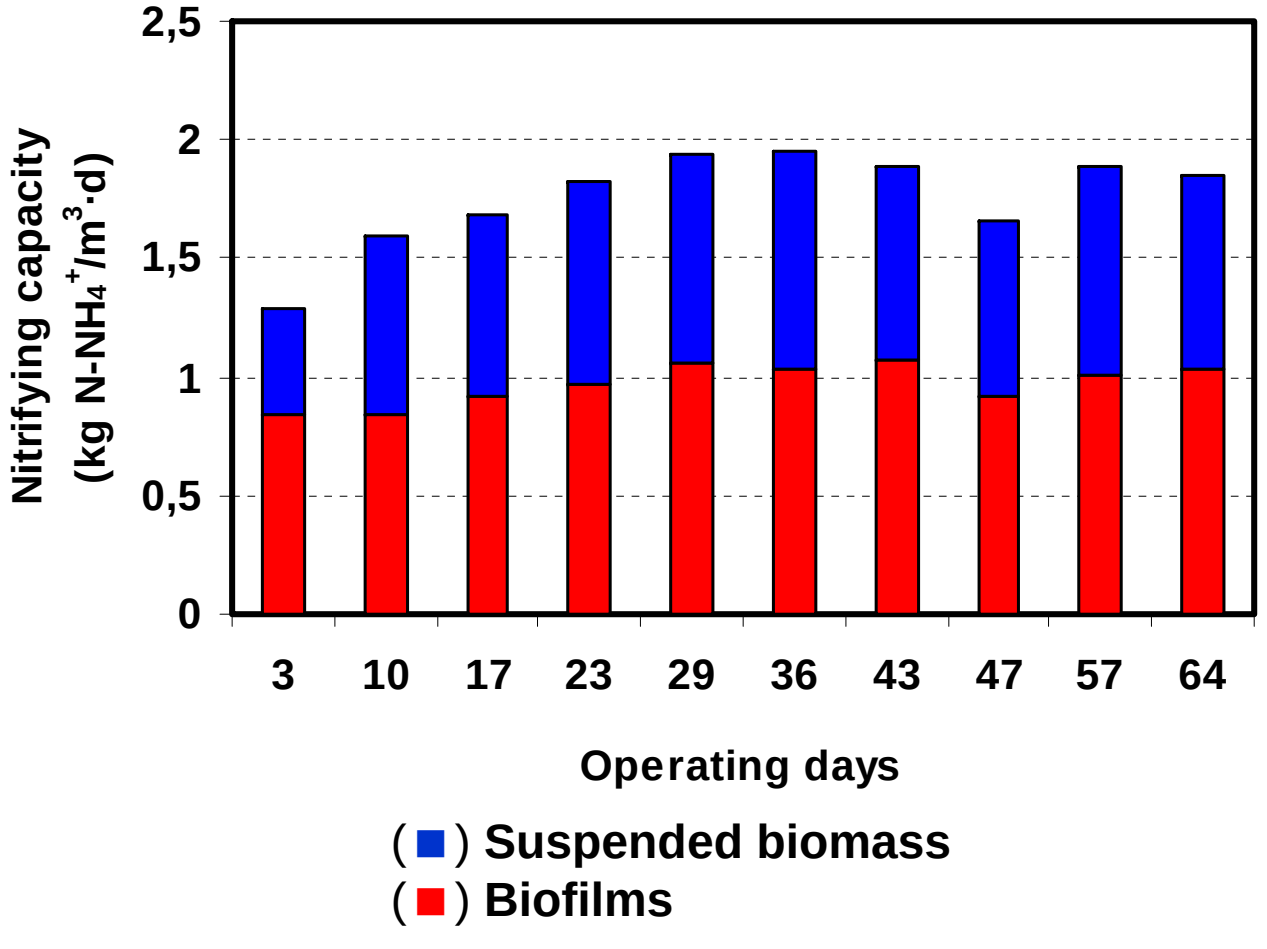
Fish canning factory ww, OLR and NLR

Days	NLR (kg N/m^3·d)	OLR (kg COD/m^3·d)
0-45	0.8	3.2 – 4.7
46-68	0.4	2.1 - 2.3

Nitrifying capacity: Biofilm & Suspended biomass

Wastewater from a Fish canning factory



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Urban Sewage

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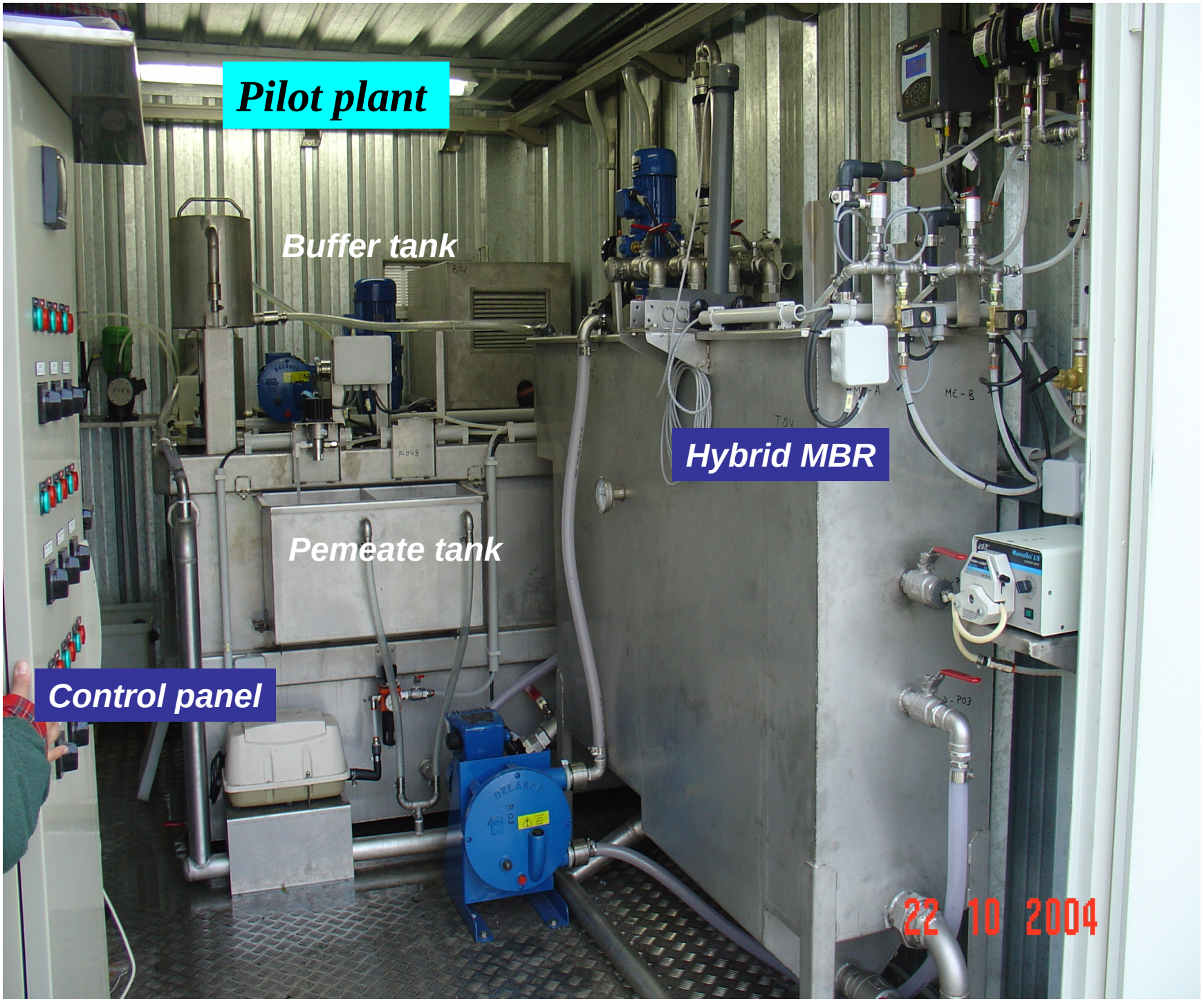
Pilot plan in the Sewage Treatment Plant (Bertamiráns, Galiza)


Pilot plant
Buffer tank
Hybrid MBR
Pemeate tank
Control panel
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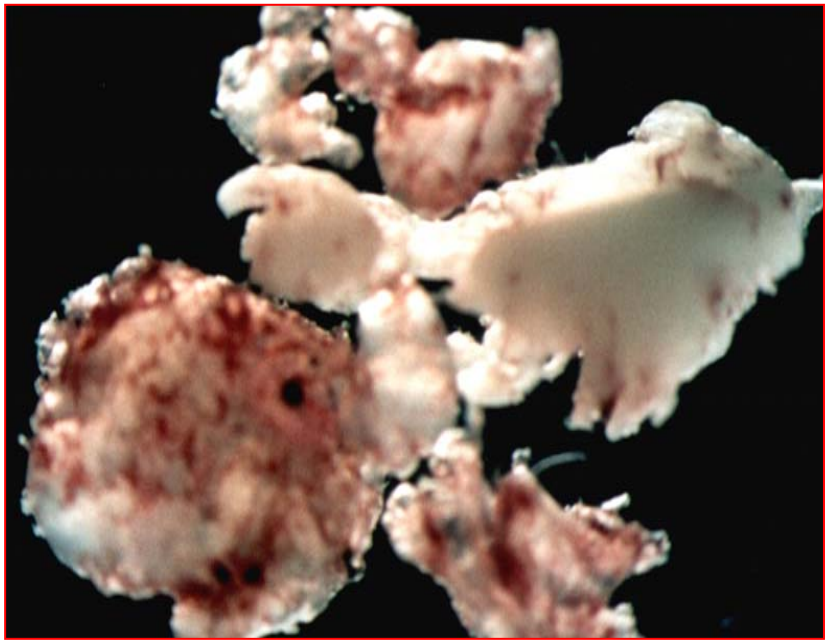
Urban Sewage

Support:

Granular rough particles of high density polyethylene (HDPE)

Size 1-3 mm

Density 0.89 g/cm^3



Filtration Membranes

MF
Porous Fibers (País Vasco)

UF
Zenon Inc. ZW-10 (Canadá)

Characteristics of the membranes

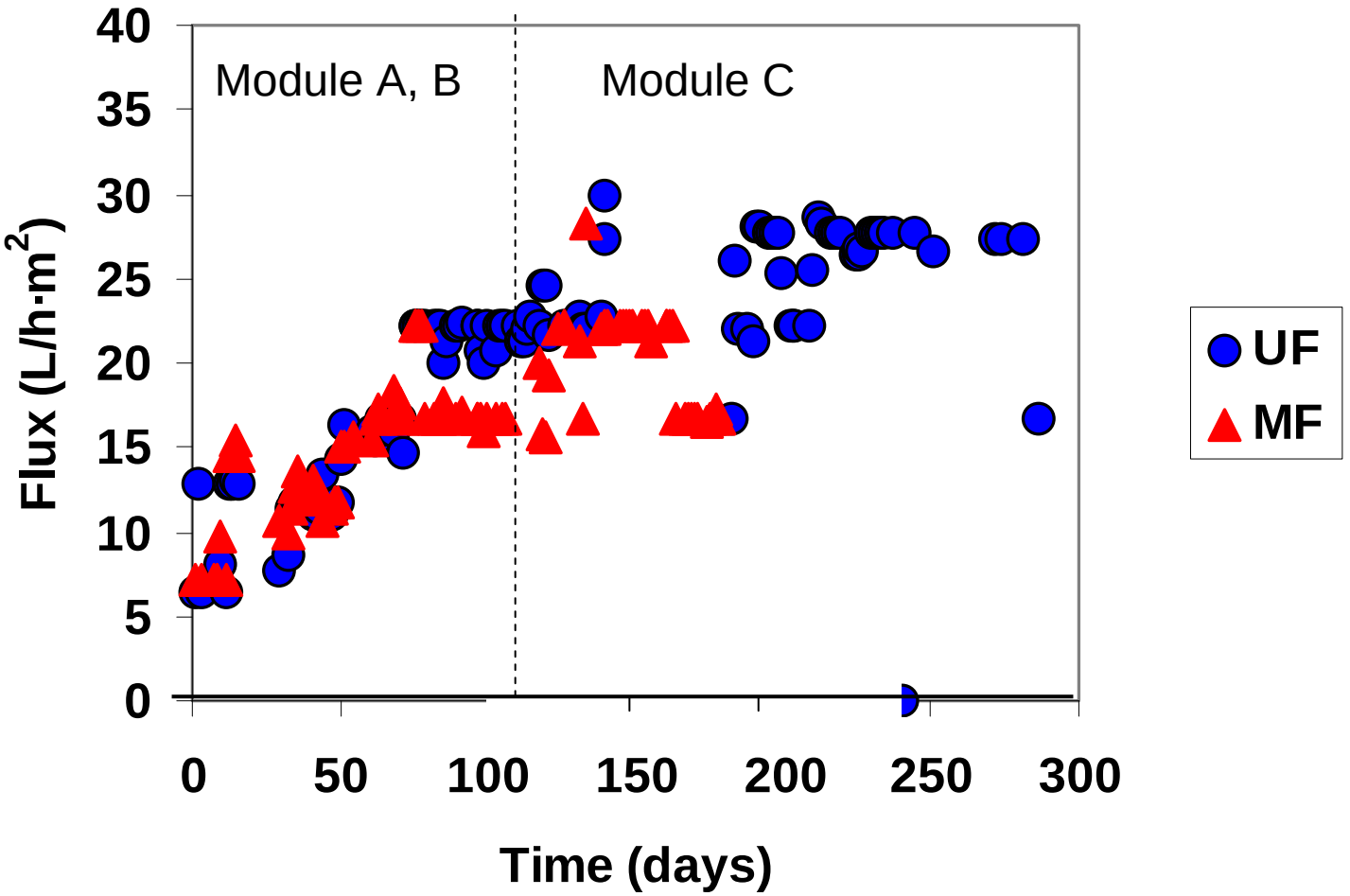
Membrane module	Module	Characteristics	Operating time (d)
Microfiltration (MF) Porous Fibers (Spain) Pore size 0.4 µm	A	3% "looseness" Length 350 mm	0-42 54-117
	B	350 mm length 3% "looseness"	43-53
	C	550 mm length 6% "looseness"	118-182
Ultrafiltration (UF) Zenon (Canada) Pore size 0.04 µm	ZW-10		0-286

RESULTS

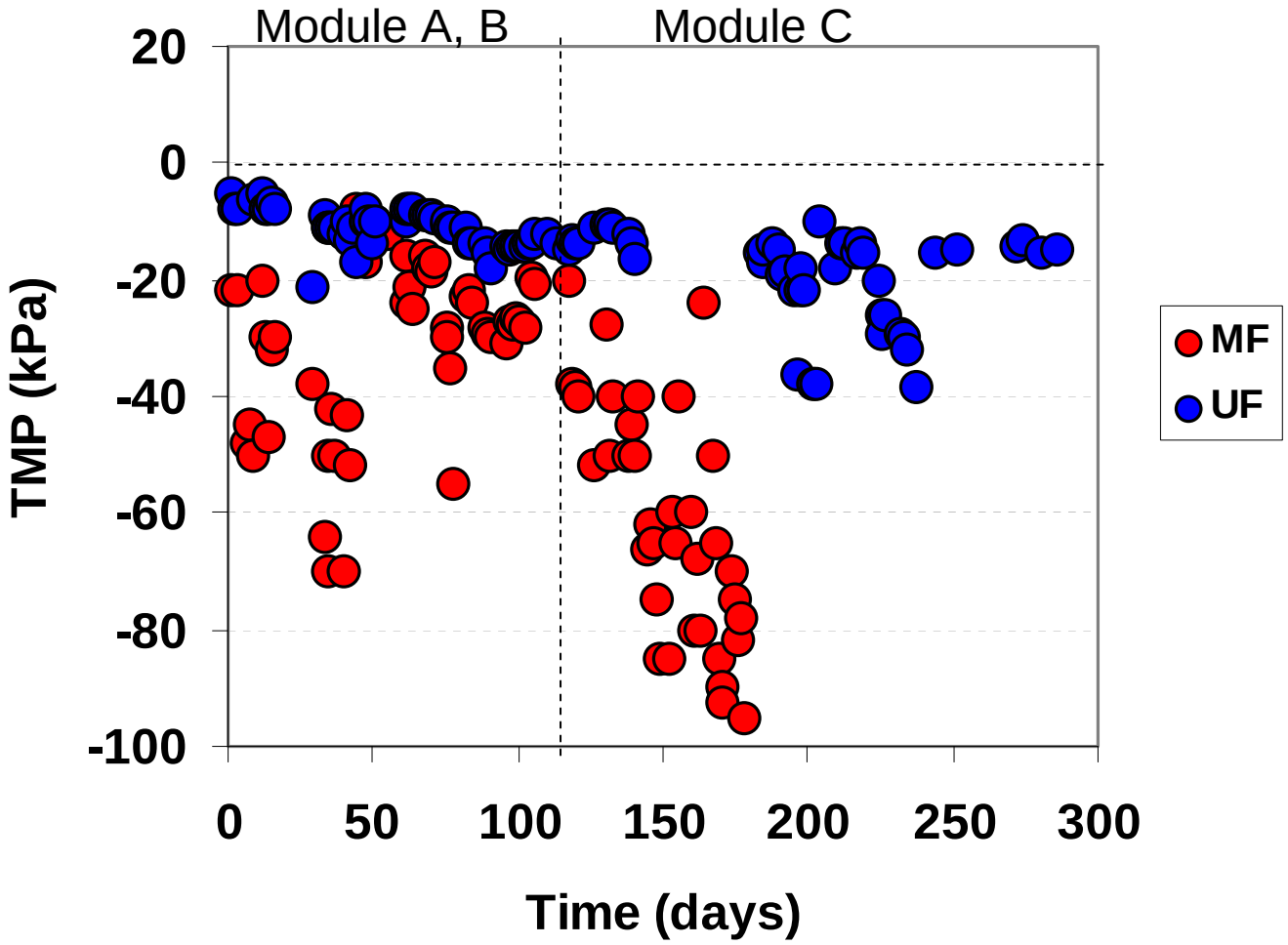
UF and MF Membranes:

- Flux
- Transmembrane pressure
- Permeability
- Microscopical observations

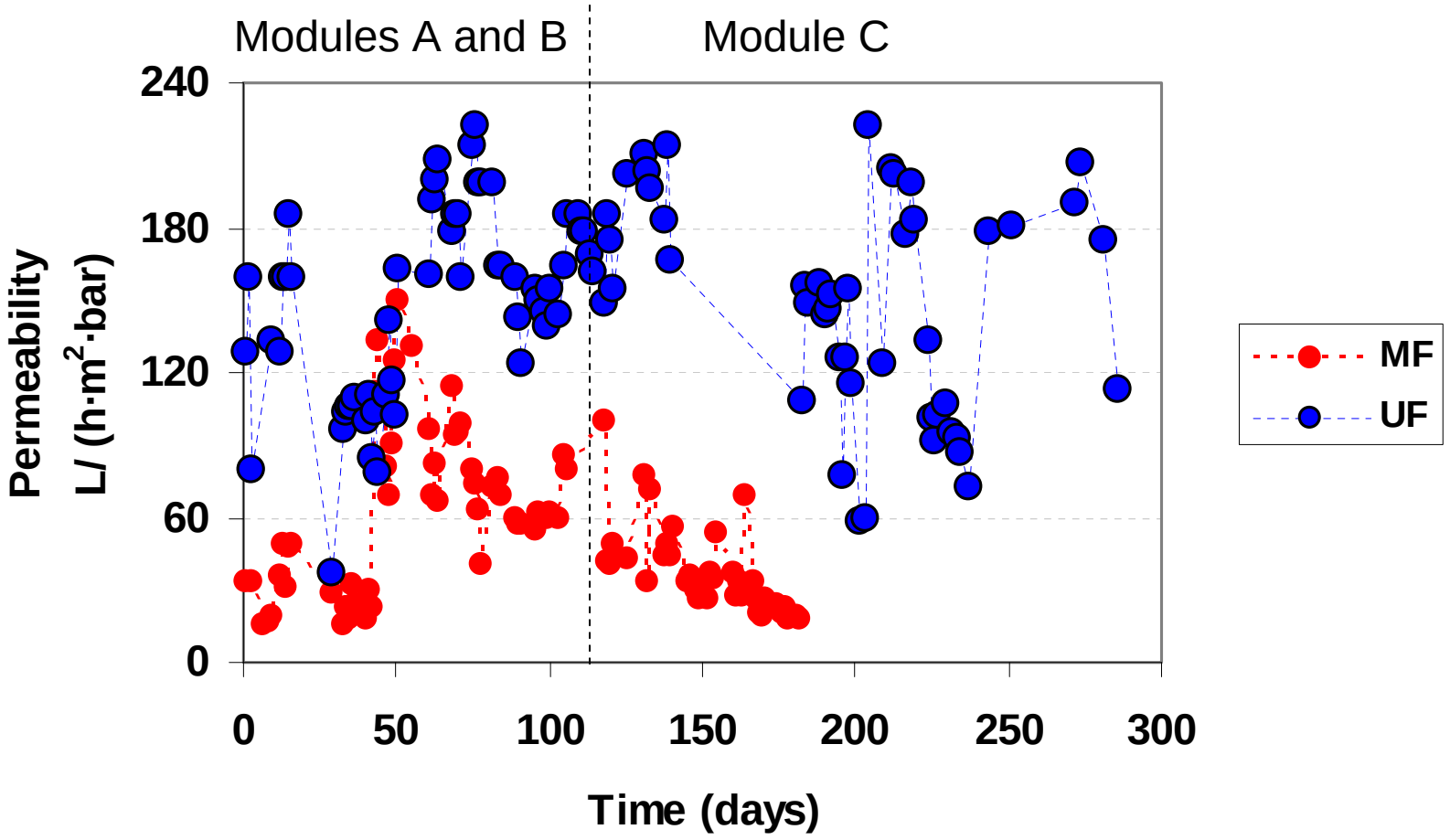
Flux of permeate in UF and MF membranes

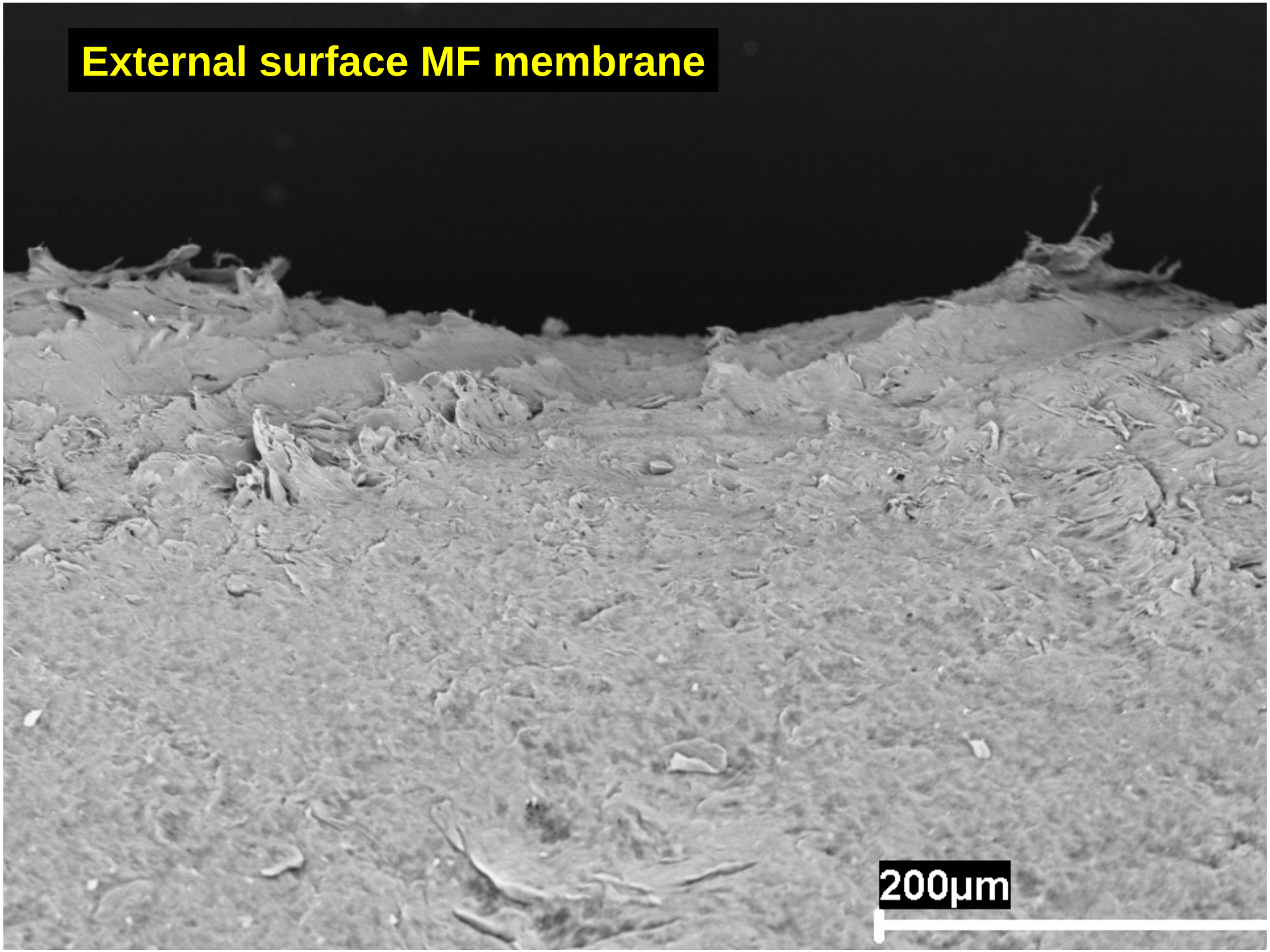


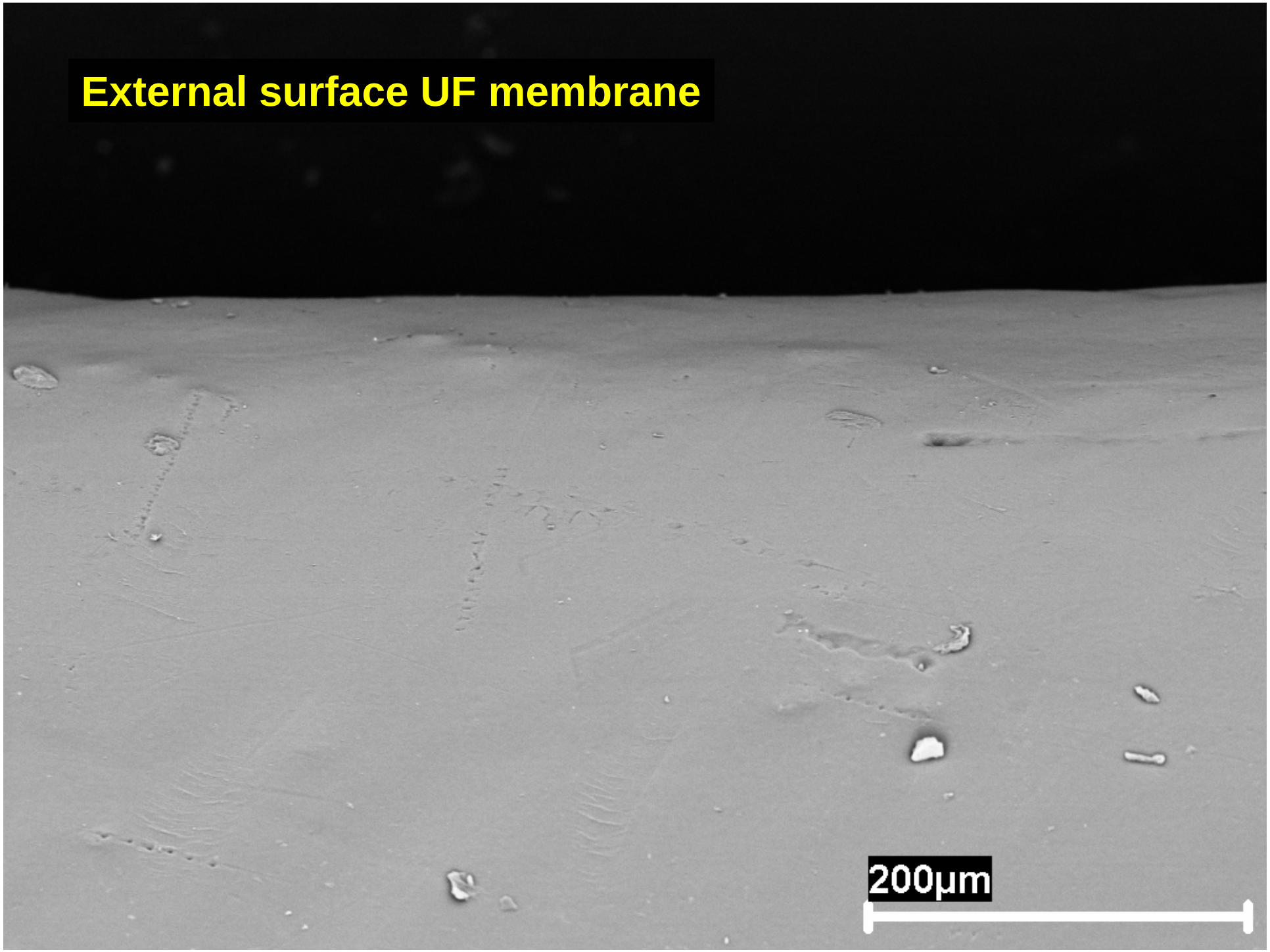
Transmebrane Pressure (TMP)



Permeability of both membranes




External surface MF membrane
200µm

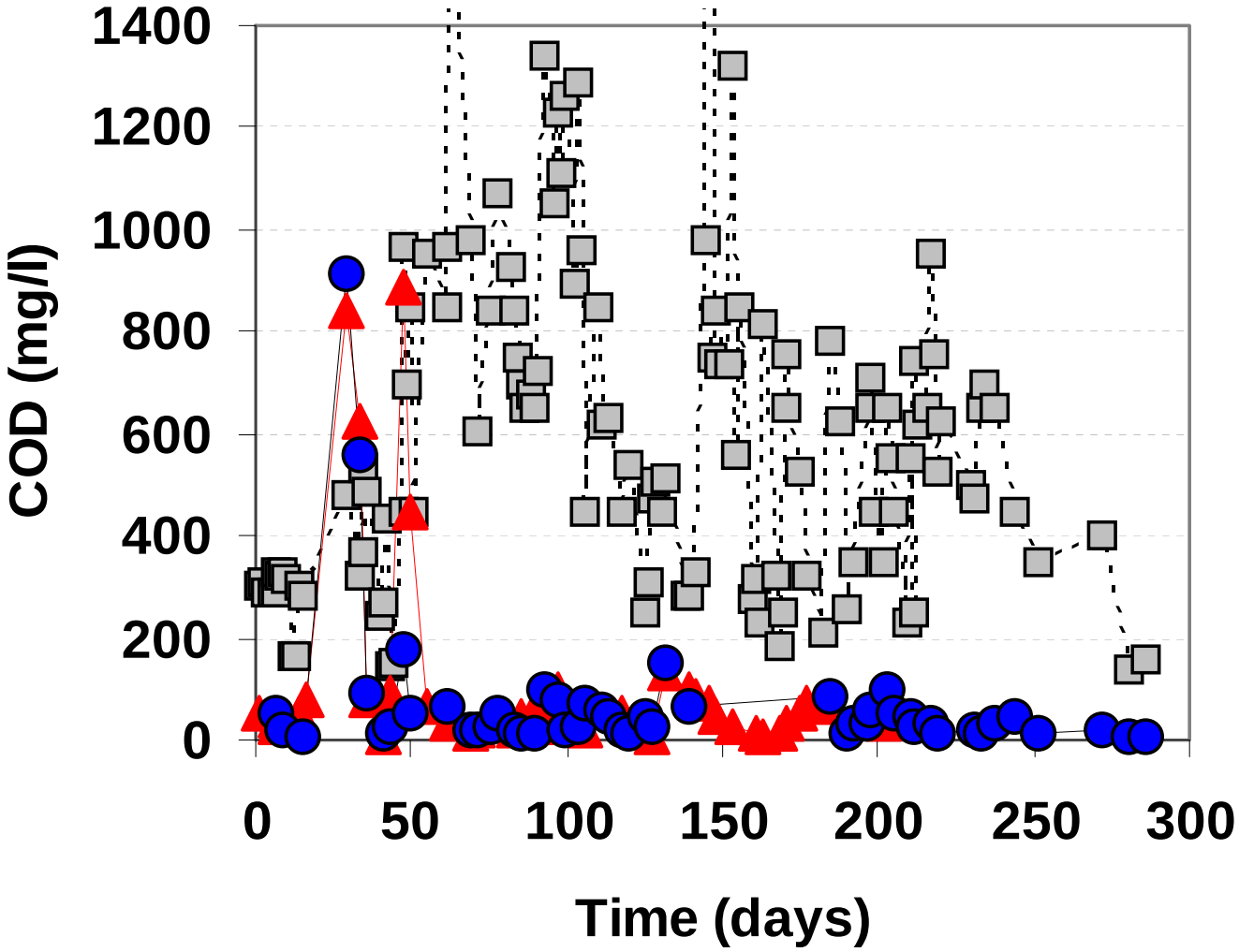

External surface UF membrane
200µm

RESULTS

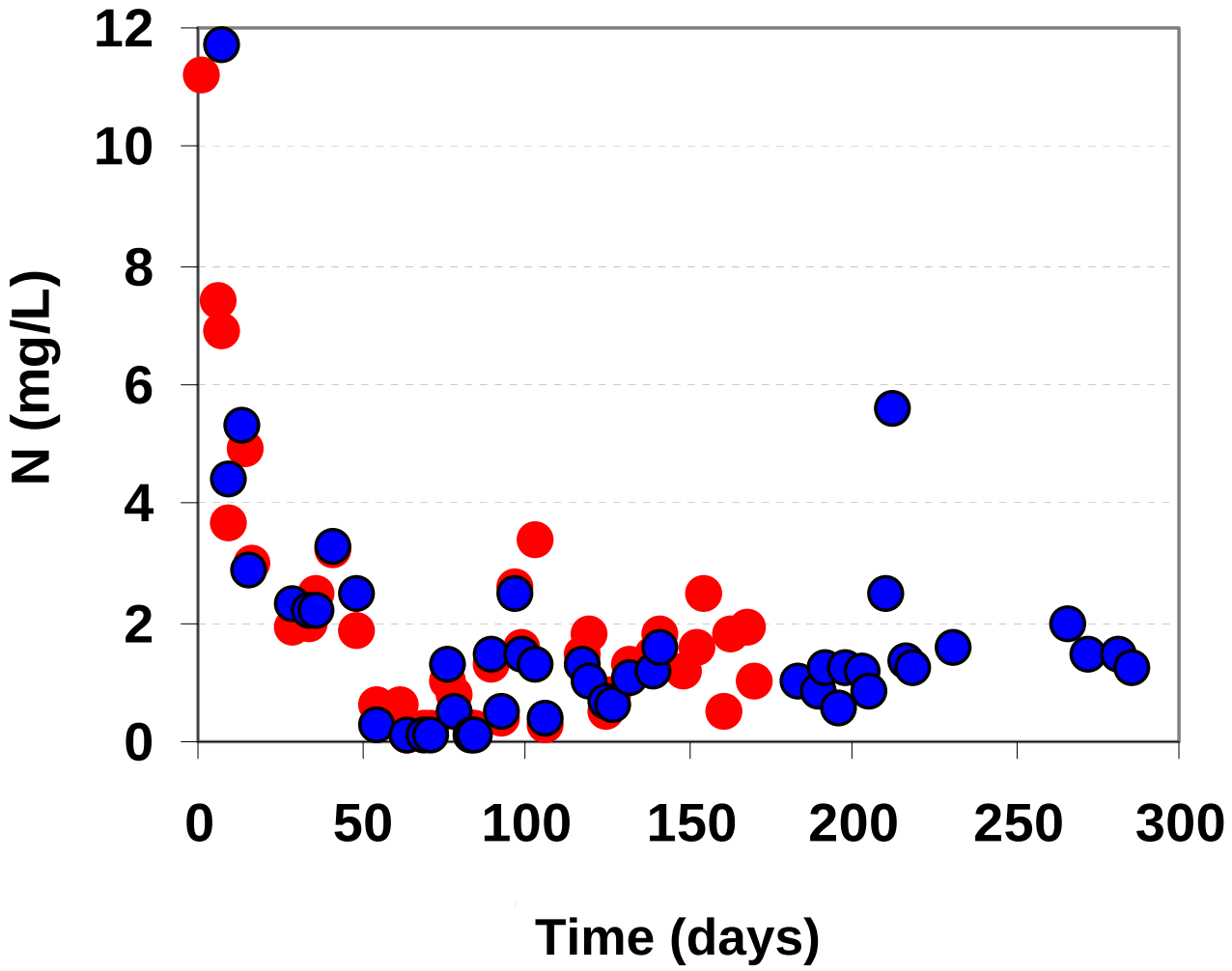
Chemicals, biomass, microorganisms:

- COD
- OLR and COD efficiency
- Ammonia nitrogen
- Nitrate
- Biomass
- Turbidity
- Microorganisms (Total Coliforms, E. Coli, Nematodes eggs)

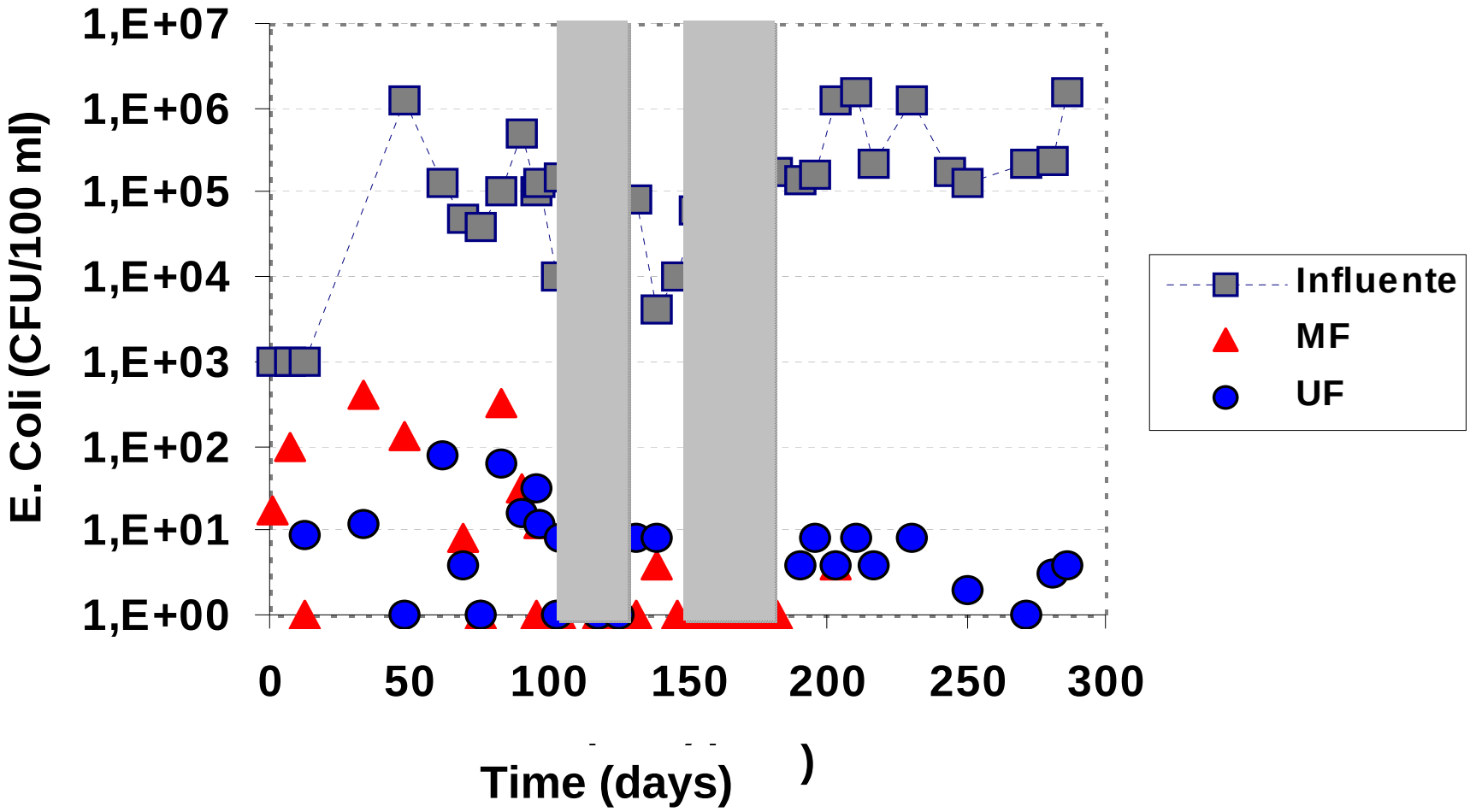
Organic matter (COD)



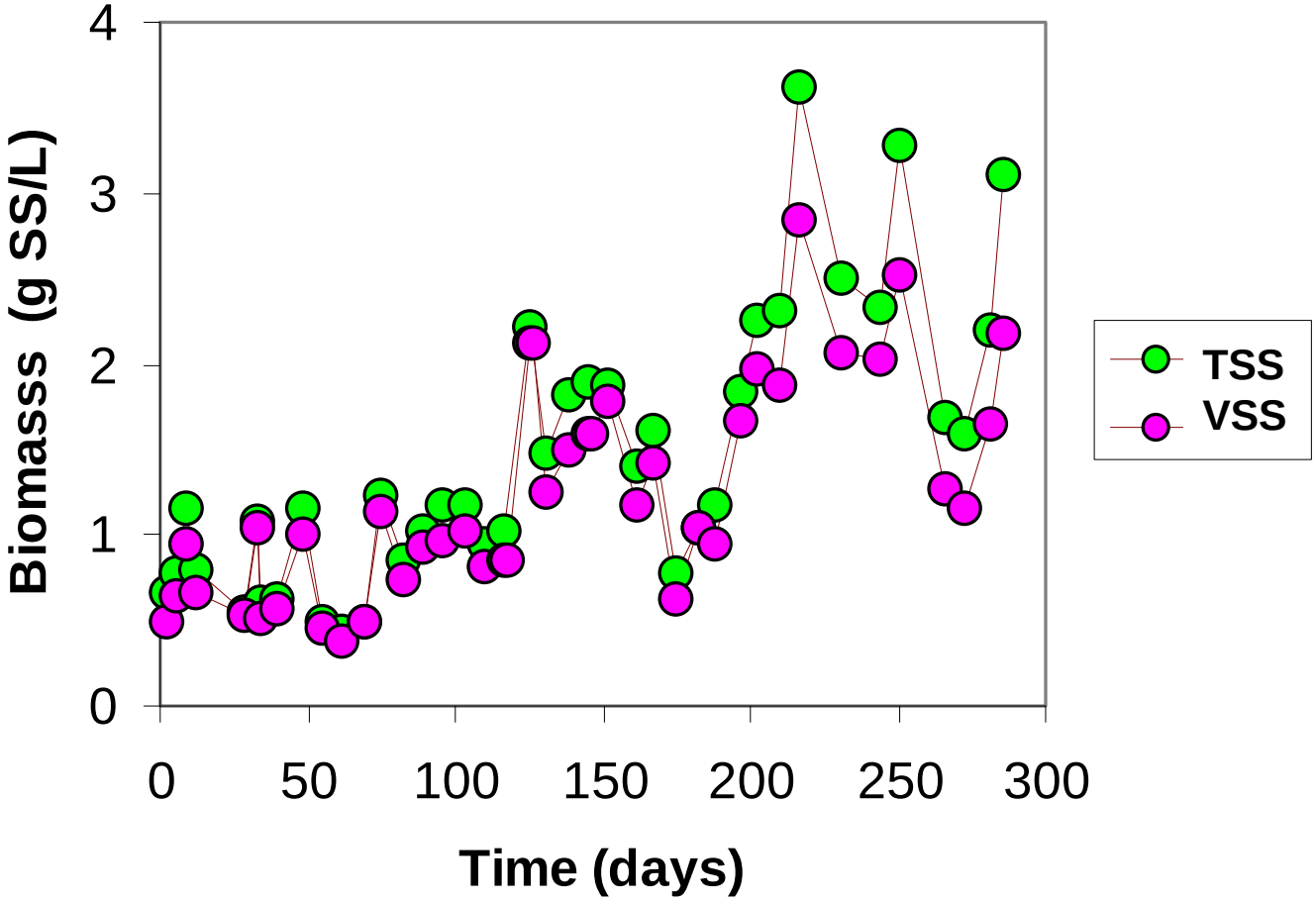
Ammonia Nitrogen in the permeates



Nitrate in the influent and permeates

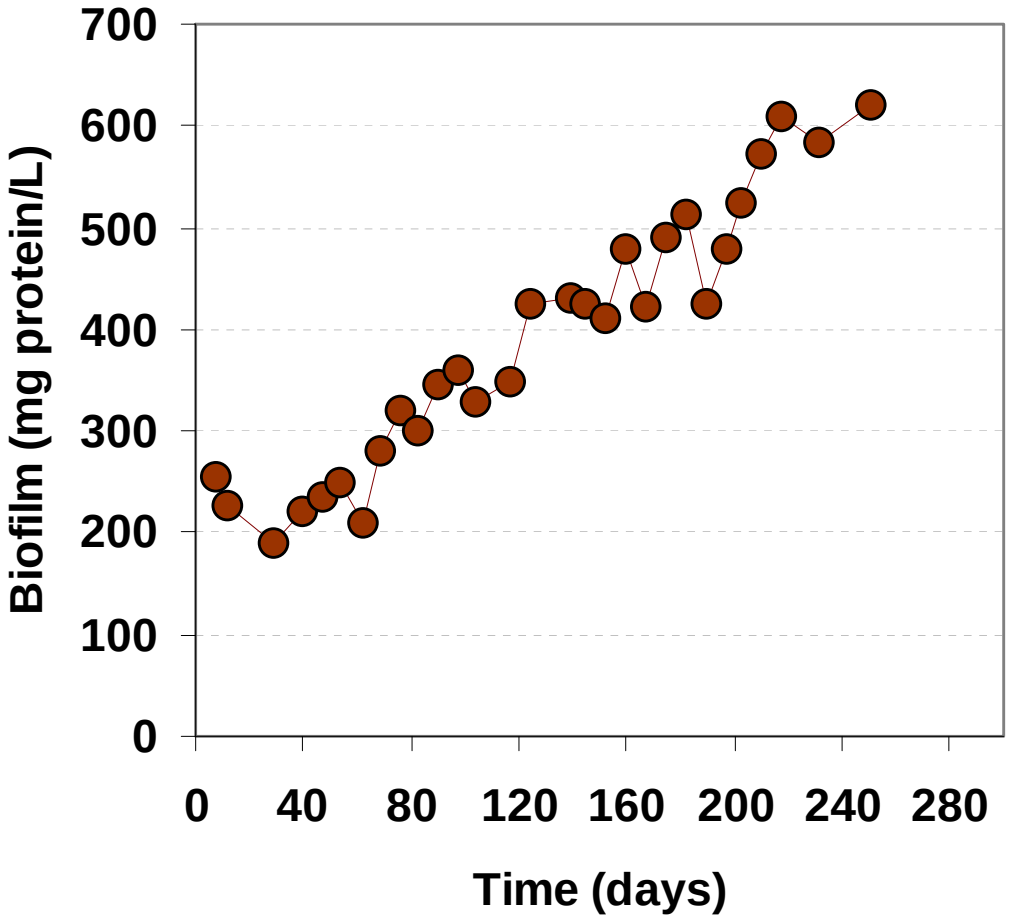


Suspended Biomass Concentration

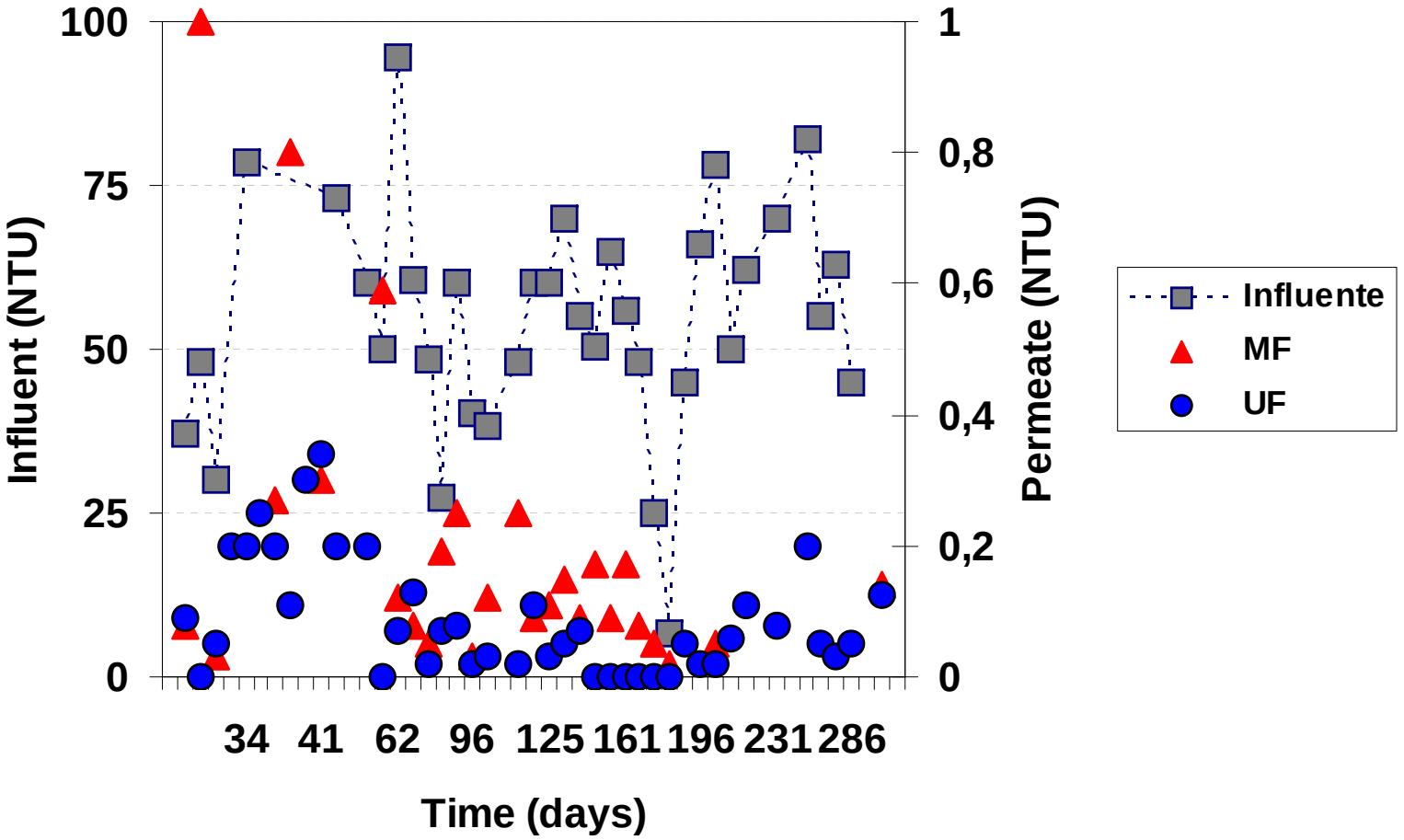


Biomass was not wasted from the plant during the experiments!

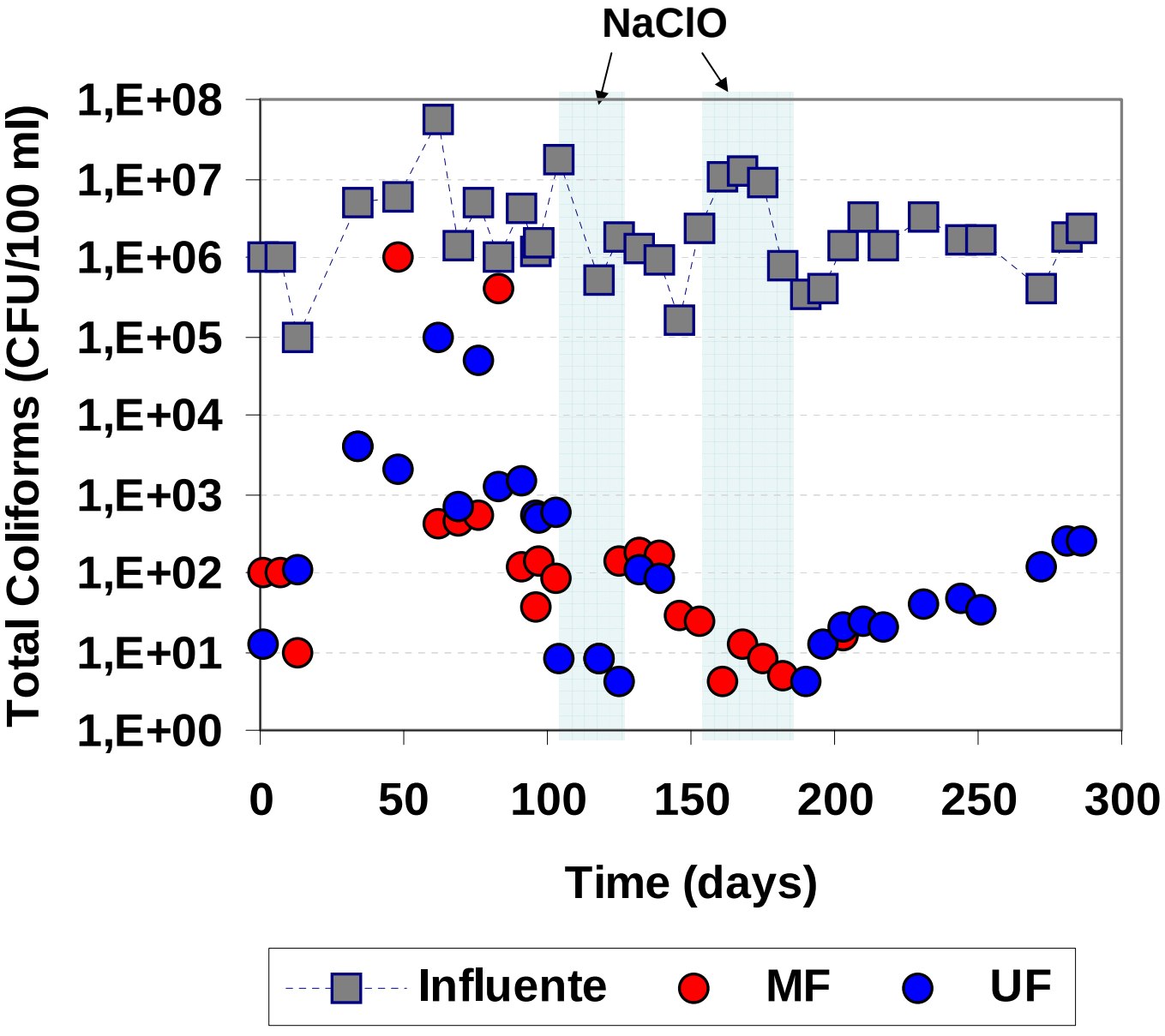
Biomass adhered to the biofilm



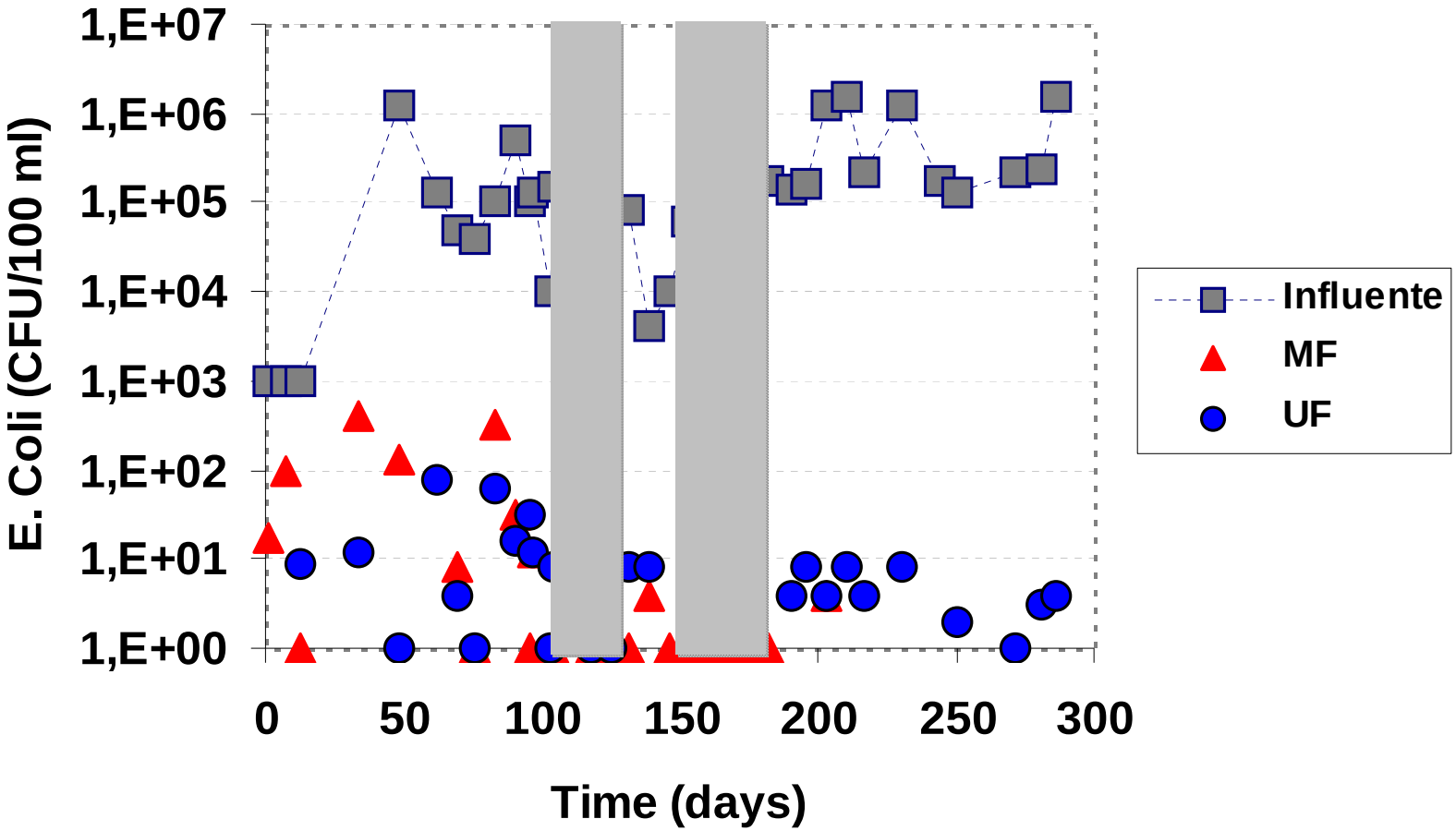
Turbidity in the influent and permeates



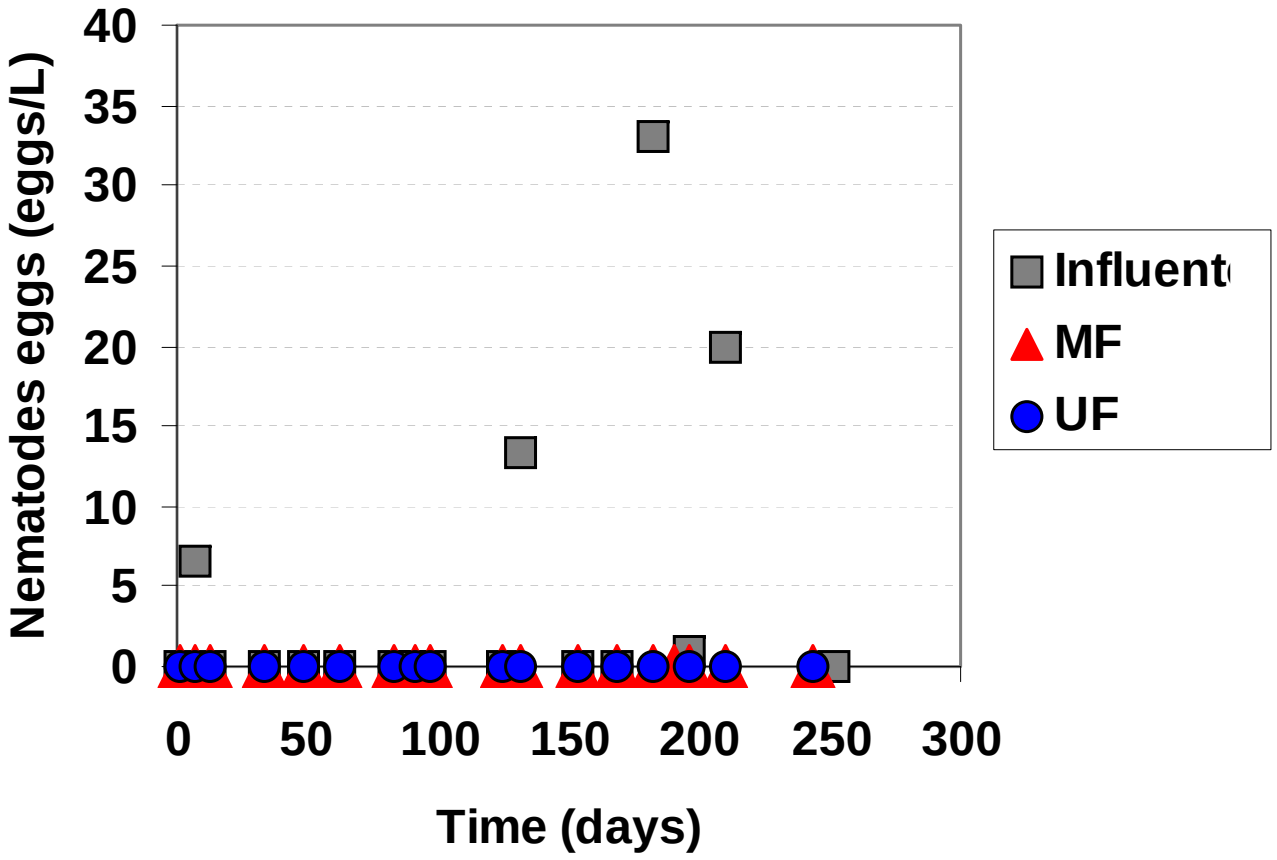
Total Coliforms in the influent and permeates



Escherichia Coli in the influent and permeates



Nematode eggs in the influent and permeates



	California Water Reuse Guidelines		Results in the MBR plant
	Unrestricted Urban Reuse	Restricted Urban Reuse	
Treatment	Oxidized, coagulated, filtered, and disinfected	Secondary, oxidized and disinfected	**Secondary, filtered**
BOD_5	NS	NS	**COD Eff = 88%** **COD 70 mg/L (Avg)**
TSS	NS	NS	**ND**
Turbidity	2 NTU (Avg) 5 NTU (Max)	NS	**0.12 NTU (Avg)** **1 NTU (Max)**
Total Coliforms	2.2/100 ml (Avg) 23/100 ml (Max)	23/100 ml (Avg) 240/100 ml (Max)	**4-28/100 ml**

NS: Not specified

Water reuse experiments:

4 Plant Pots. Growth of grass irrigated with:

Permeate of the UF membrane
Permeate of the MF membrane
Tap water
Tap water and nutrients (added)

Conclusions

Membranes:

The operation of the MF was problematic.

The UF module has shown to be reliable.

MF operated below 22 L/m^2·h.

UF module can be operated up to 30 L/m^2·h.

Conclusions

Very low biomass production. Biomass was not wasted.

Suspended biomass lower than 3 g/L TSS.

Biofilm concentration lower than 600 mg/L protein.

COD effluent < 100 mg COD/L.

N efficiency: 75%

Amonia < 3 mg N-NH_4^+/L and Nitrate < 10-15 mg N-NO_3^-/L.

OLR < 2 kg COD/m^3·d.

Conclusions

Permeates with low Turbidity (Often below 0.2 NTU)

Membranes retained the nematode eggs

Secondary contamination of the permeates detected

Lower E. Coli or Total Coliforms when NaClO used (Once per week)

Disinfection still required for unrestricted urban reuse

Experiments in plant pots: No significant difference observed

Fish canning Wastewaters

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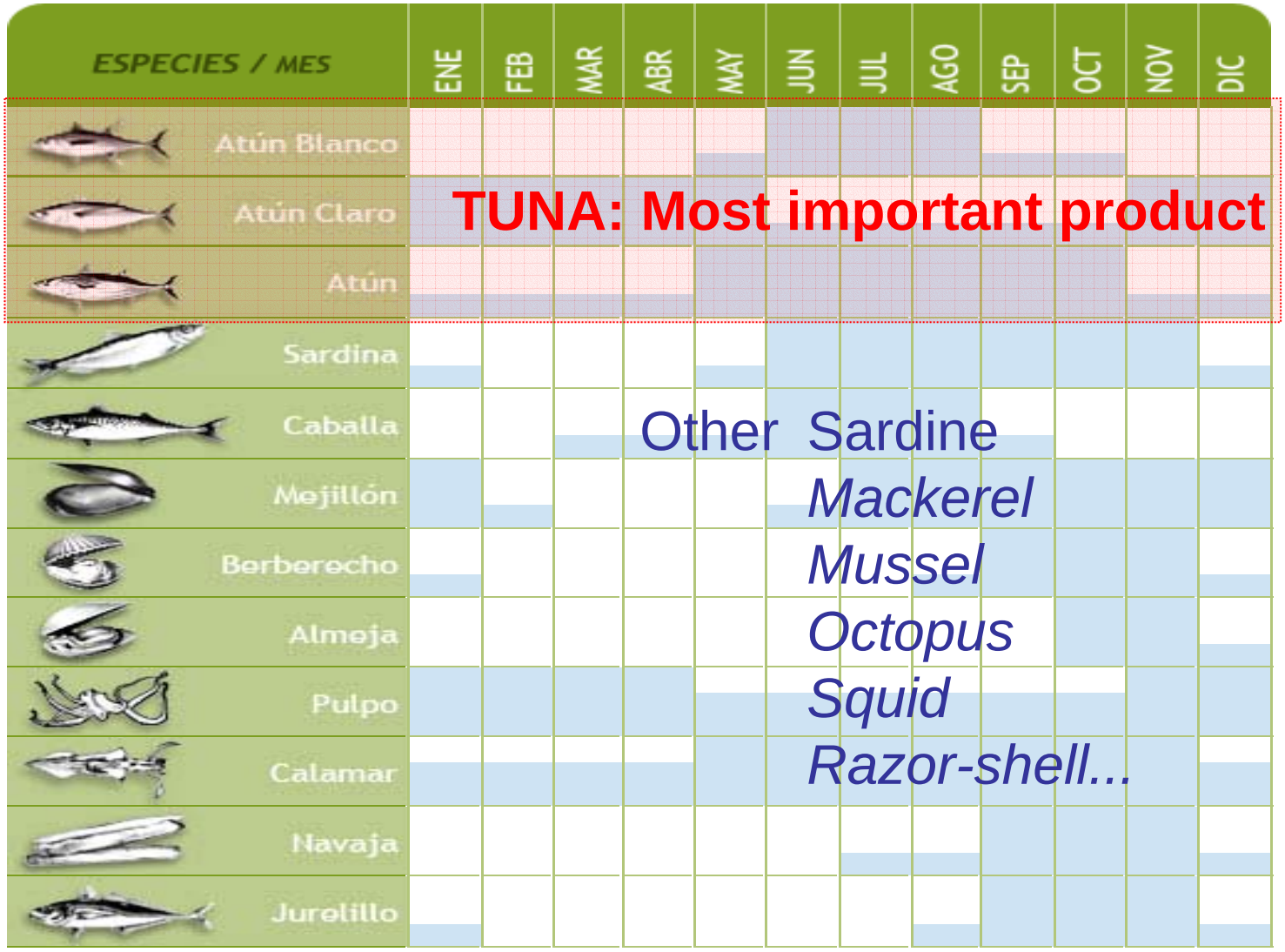
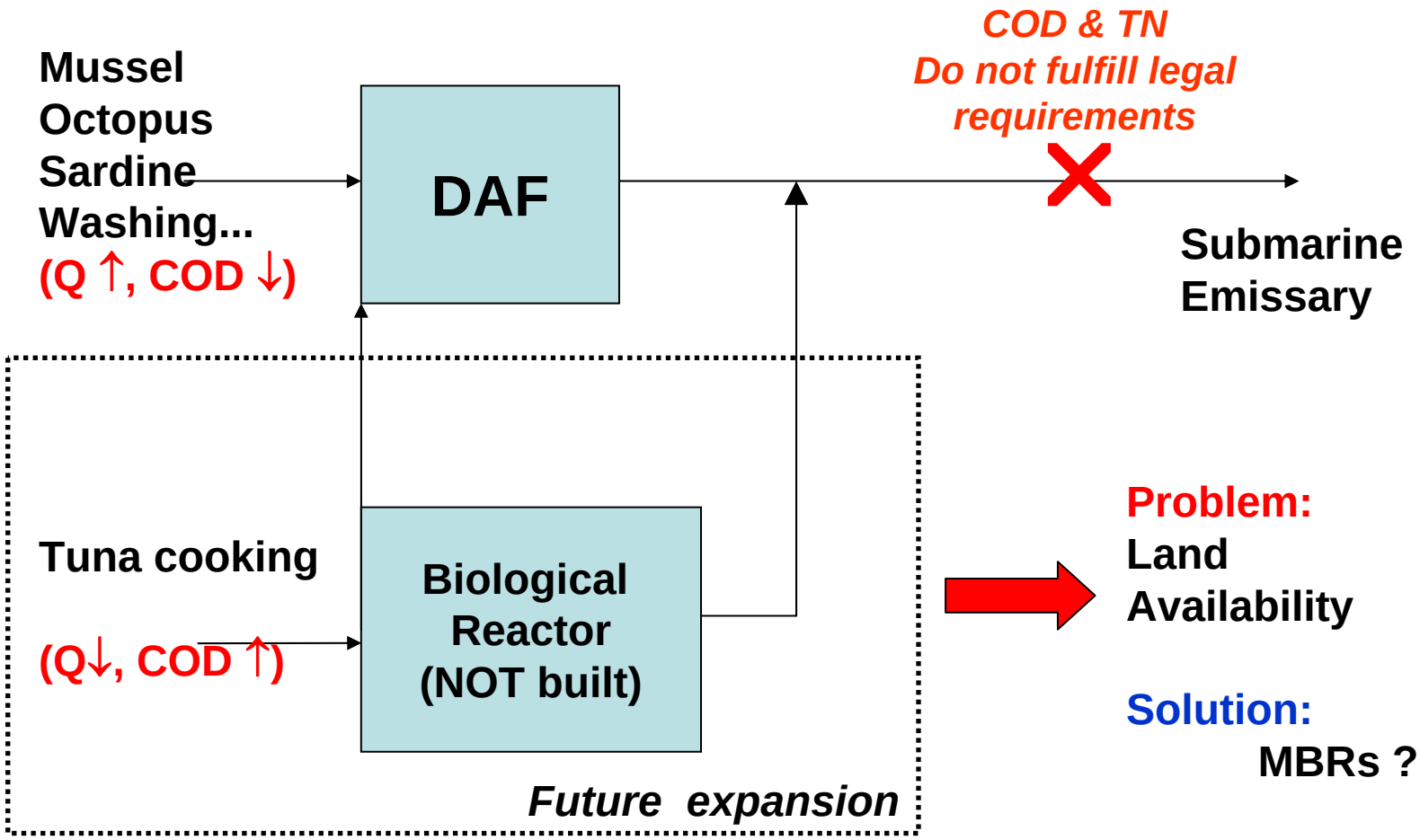
Fish canning factories in Spain

Processed Fish Products



DIFFERENT Wastewater Streams GENERATED !

Wastewater treatment plant: Process flowsheet



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Objective

- To evaluate the use of a Hybrid Biofilm-Suspended Biomass MBR for treating the wastewaters generated during tuna cooking.

- 2 different Tuna cooking processes are used by Fish Canning Factories:

  - **Brine Immersion (high salinity)**

  - **Steam injection (lower salinity)**

Pilot Scale Hybrid MBR & Wastewater

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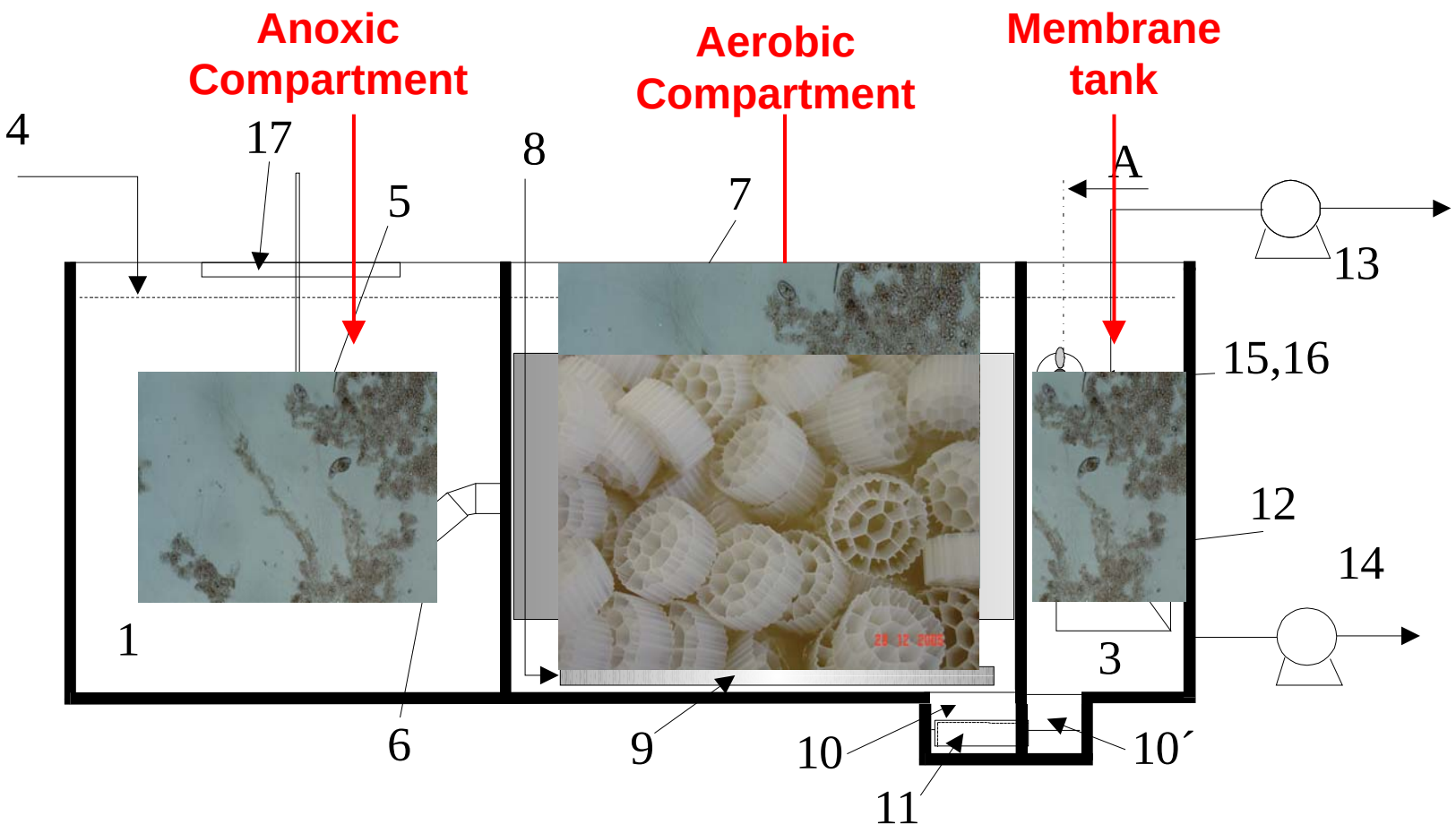
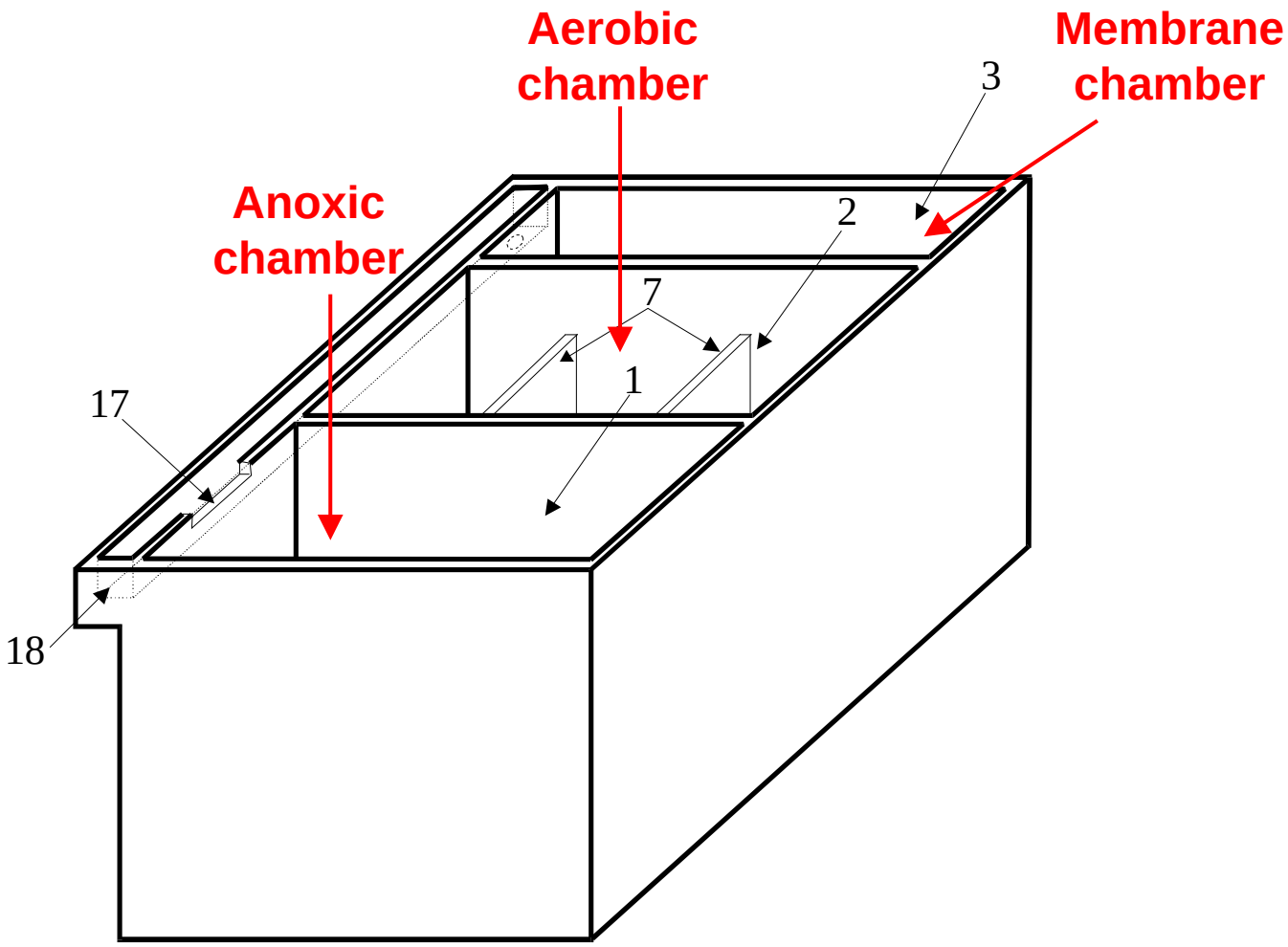
Schematic of the Hybrid MBR (pilot scale)



European Patent 1.484.287; University de Santiago de Compostela

Schematic of the Hybrid MBR (pilot scale)



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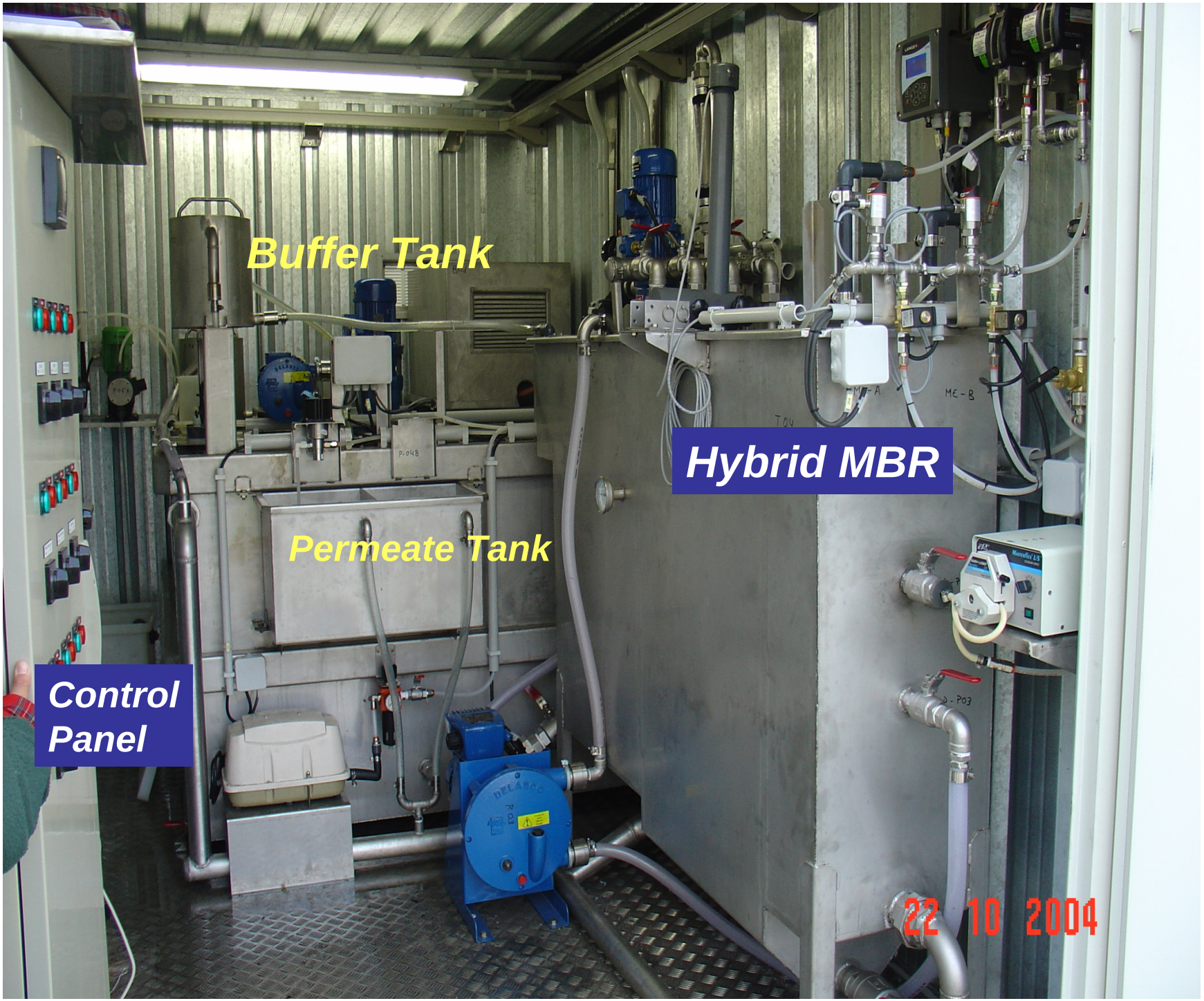
Pilot Plant in the Fish Canning Factory (Vigo's Fjord, Galicia)


Buffer Tank
Hybrid MBR
Permeate Tank
Control Panel
22 10 2004

Support: Kaldness K-3

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Materials and Methods

Hollow fiber membrane

Module: Zenon ZW-10

Average pore size: 0.04 μm

Nominal surface area: 0.9 m^2

Operation

15 min permeation

45 s backwashing with permeate

Materials and Methods

Hollow fiber membrane

Module: Porous Fibers

Average pore size: 0.4 μm

Nominal surface area: 0.9 m^2

Looseness: 6 %

Length: 350 mm

Operation

15 min permeation

45 s backwashing with permeate

Materials and Methods

External tubular membrane

Module: X-Flow, model 11 PE

Average pore size: 0.03 μm

Nominal surface area: 0.150 m^2

Diameter of the tubes: 8 mm tubes

(7 tubes)

X-Flow

Wastewater streams

Characterization of the 2 wastewater employed during the study

Parameters	Brine wastewater First stage	Steam wastewater Second stage
Period (days)	0-98	100-225
Conductivity (mS/cm)	Up to 89	< 20
Total COD (g/L)	8-12	17-26
Soluble COD (g/L)	7-11	16-25
Oil and Fats (g/L)	0.5-0.7	0.7-1.7
TSS (g/L)	1.1-2.1	1-1.2
Total Nitrogen (g/L)	1.2-1.8	2.5-4
Membrane Module used	Zenon ZW-10	Zenon ZW-10 (100-112 d) Porous Fibers (day > 112) X-Flow (117-176 & 218-327)

Results: First stage, Brine Wastewater

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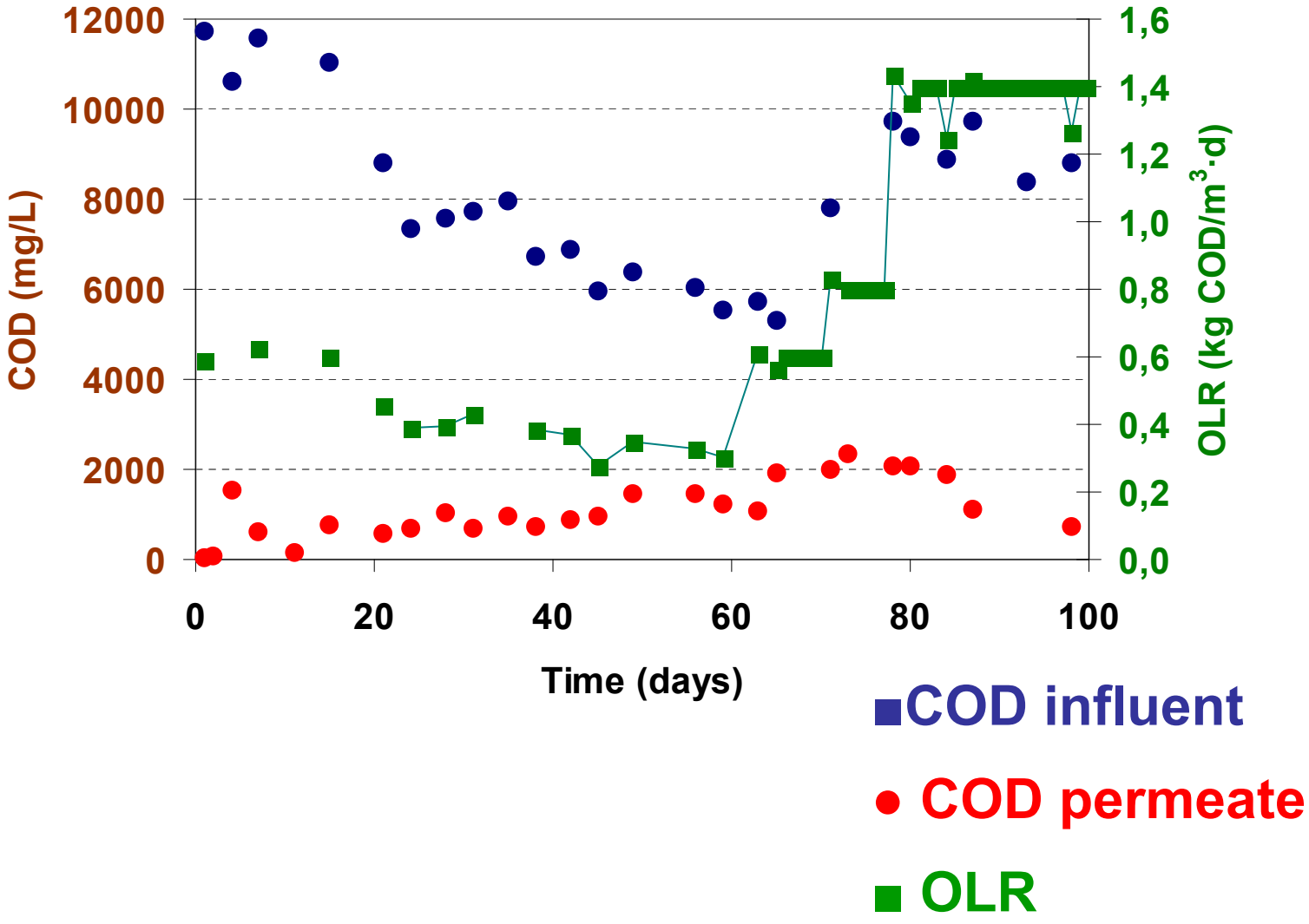
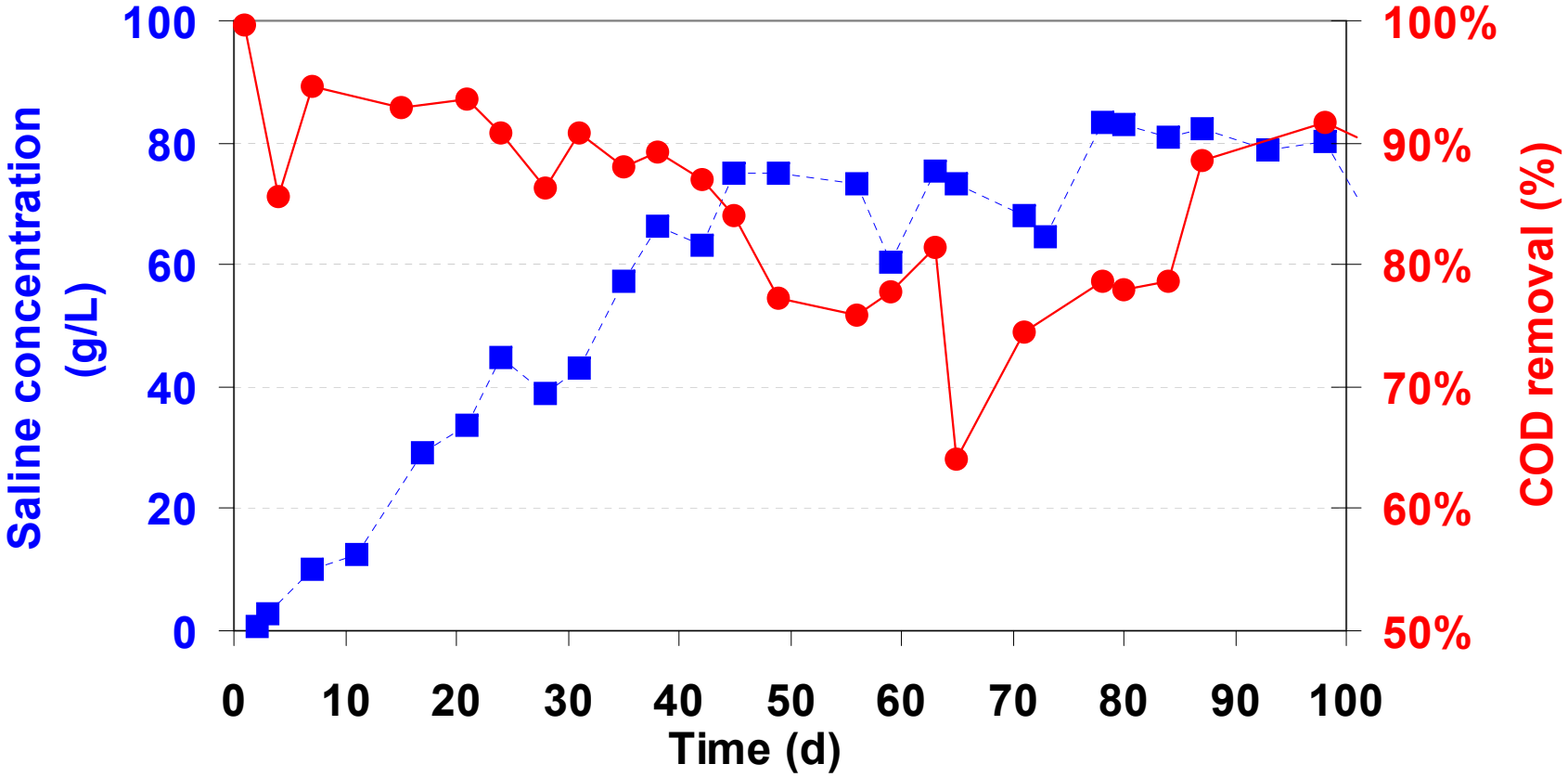
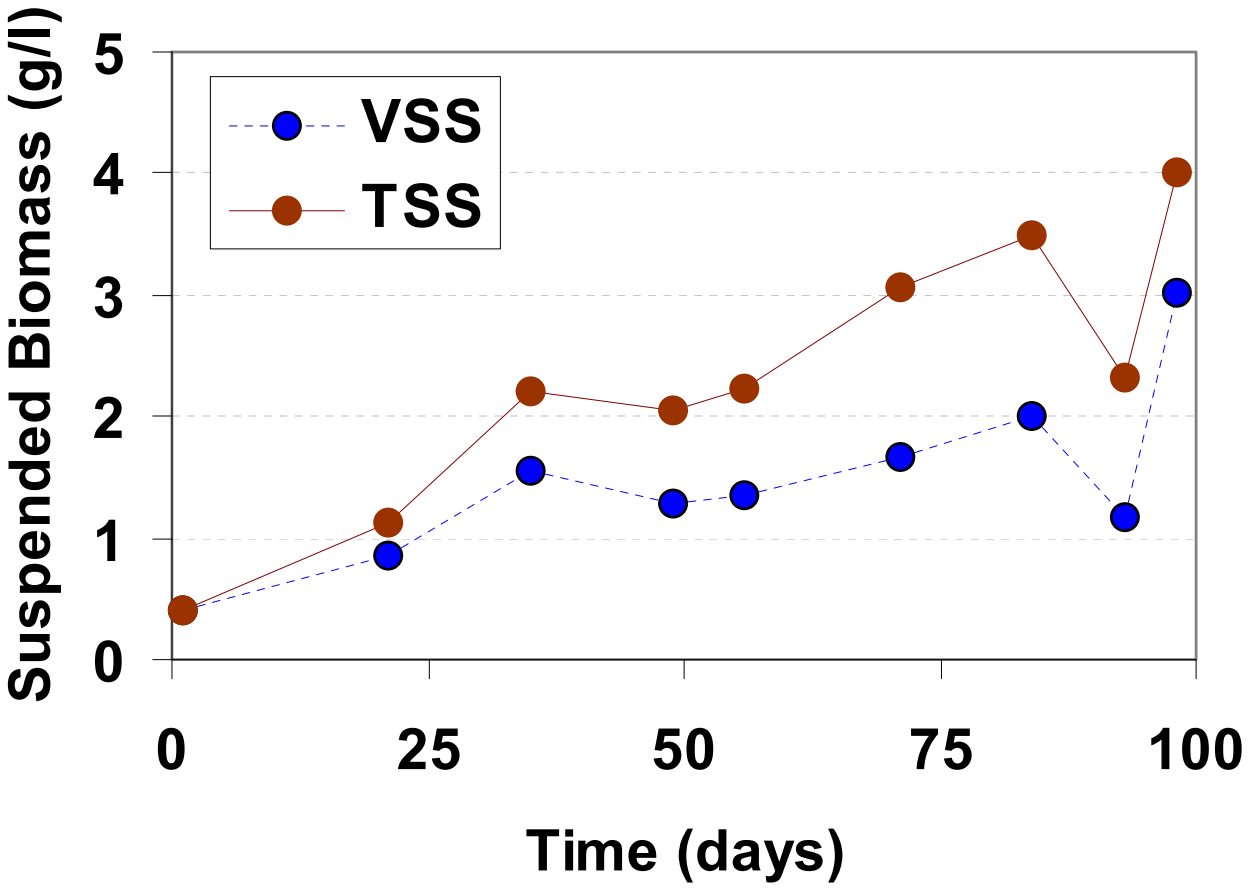
First stage: Brine stream



First stage: Brine stream

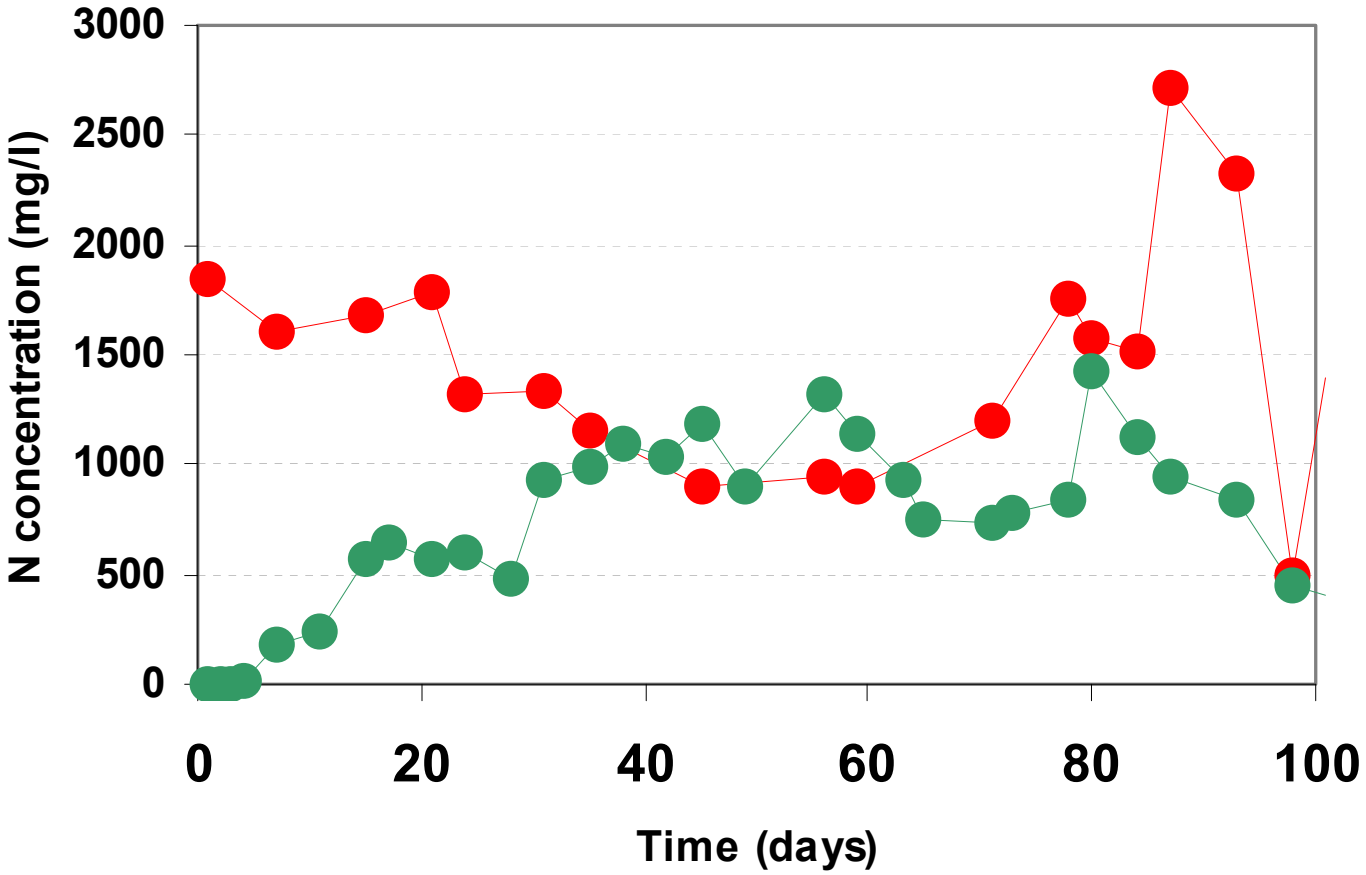


First stage: Brine stream



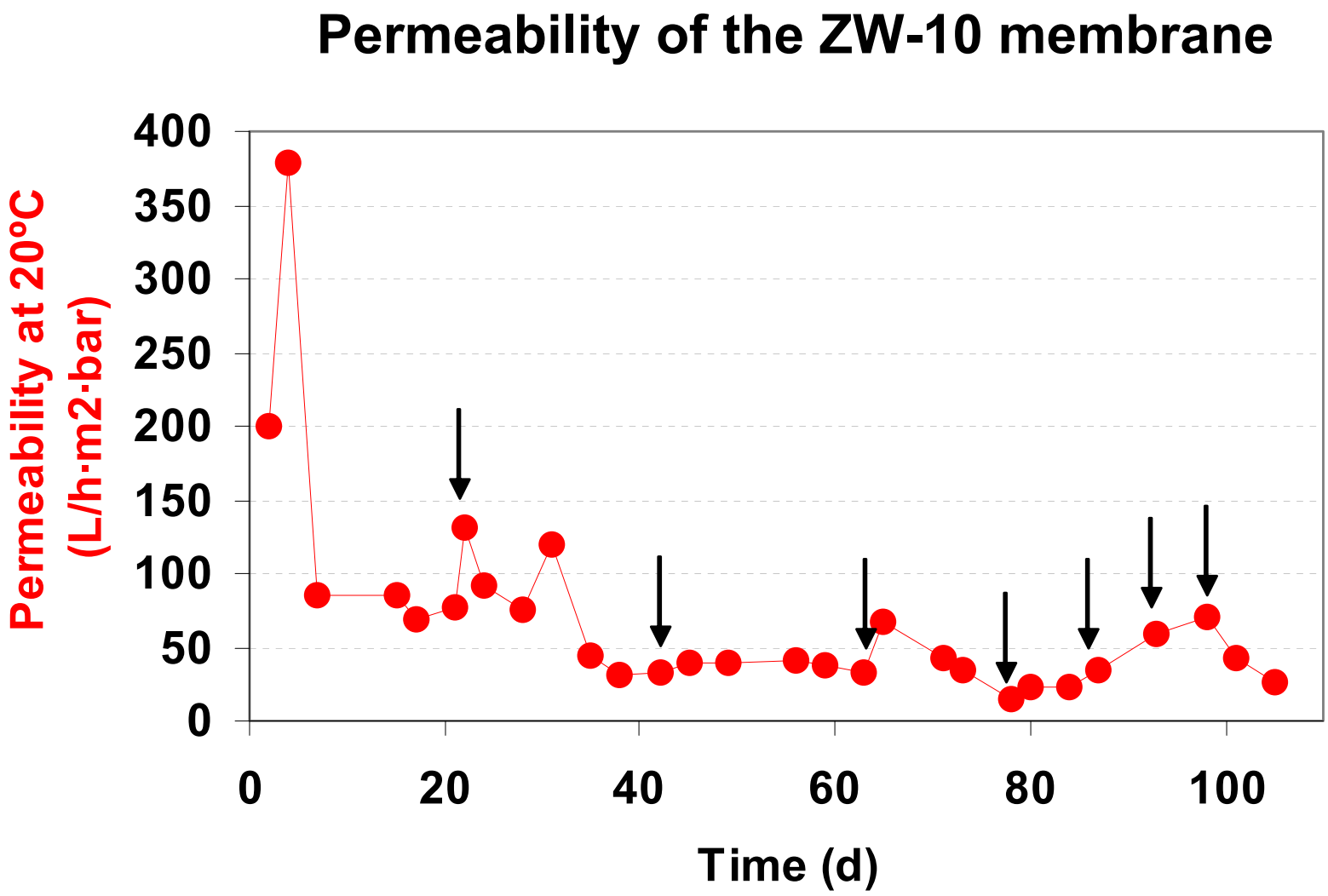
Apparent biomass yield: 0.03 g VSS/g COD

First stage: Brine stream



- N-NH_4^+, Permeate
- Total N, Influent

First stage: Brine stream



Results: Steam injection Wastewater

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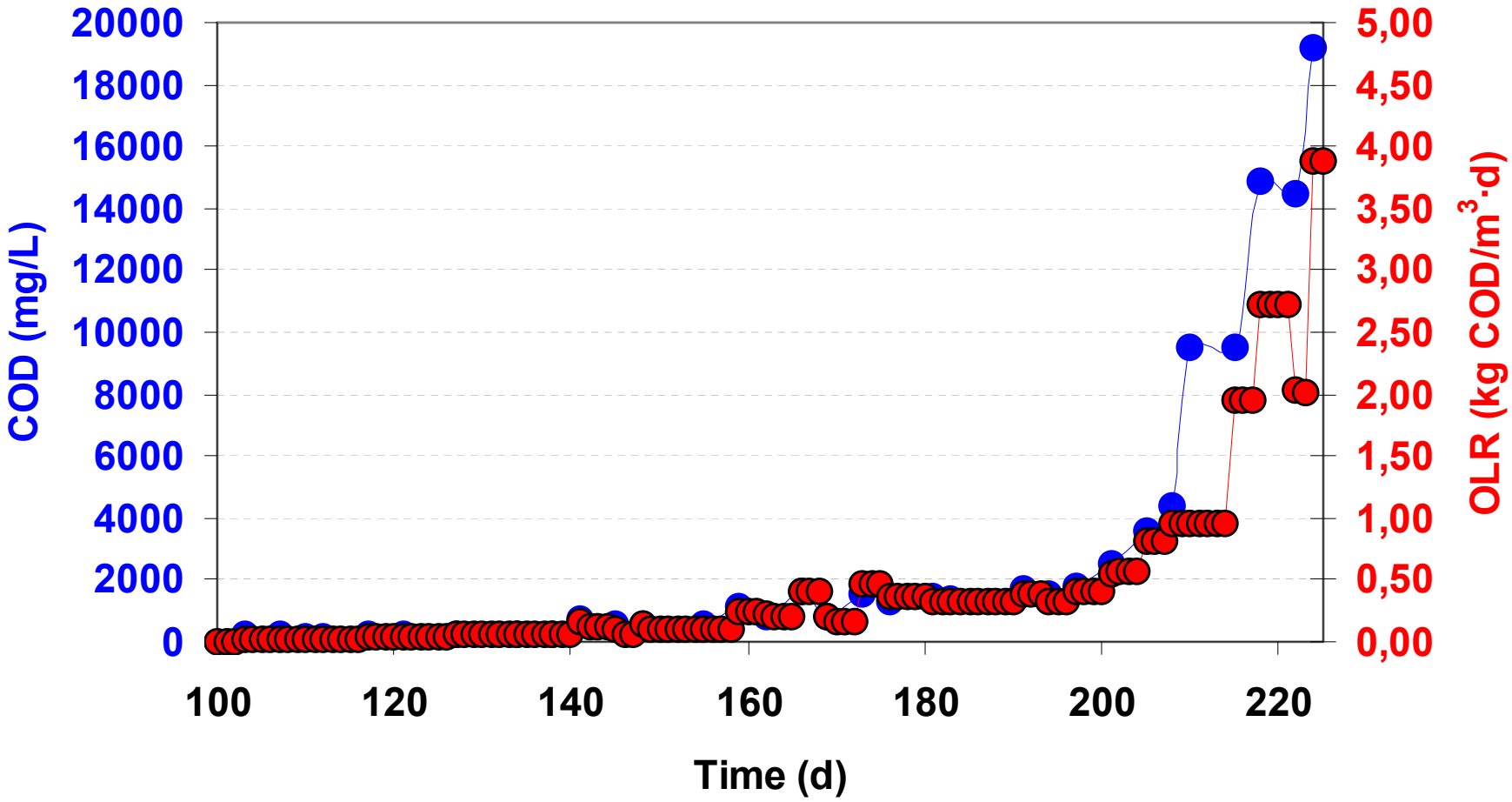
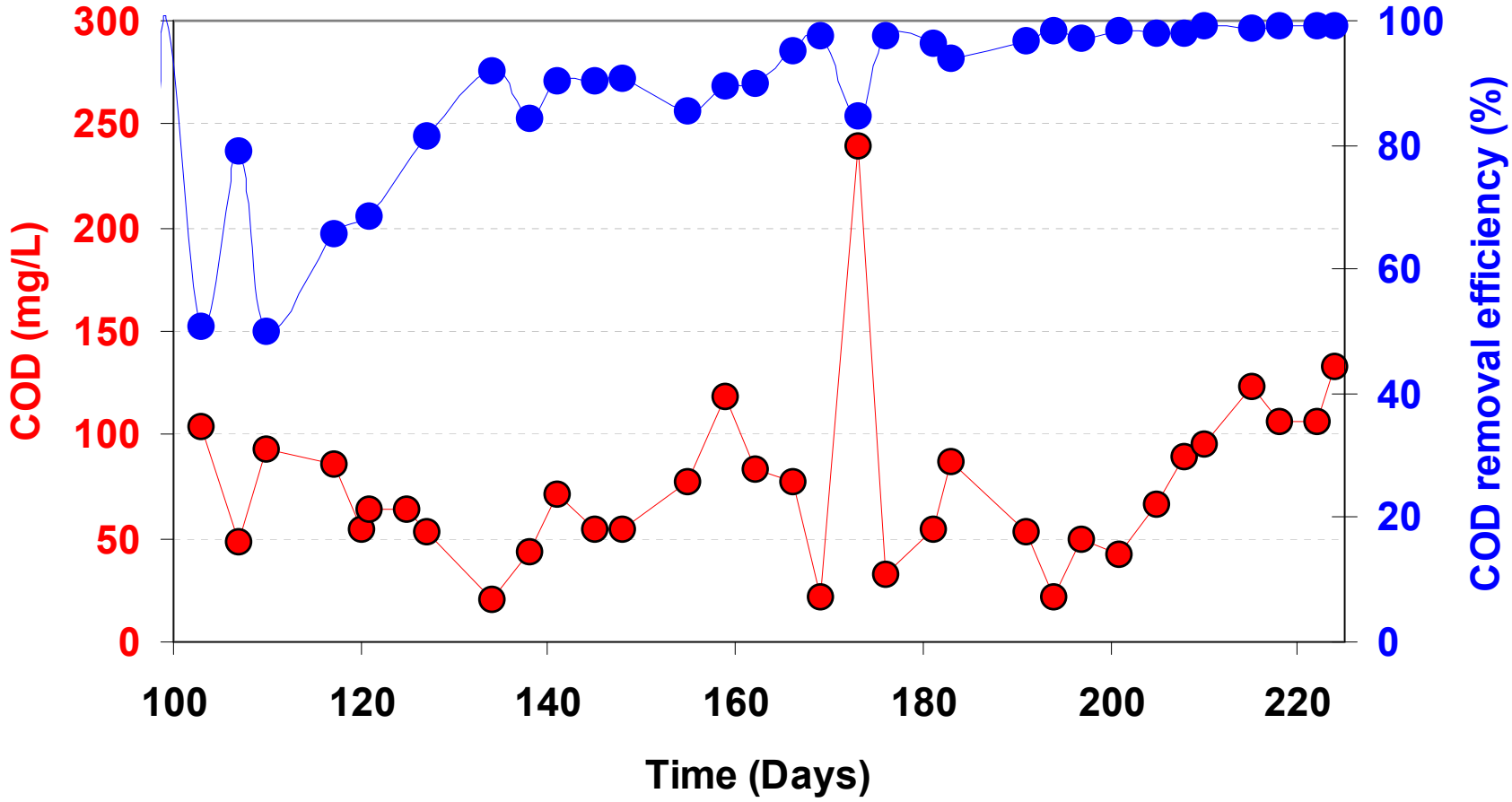
Second stage: Steam injection stream

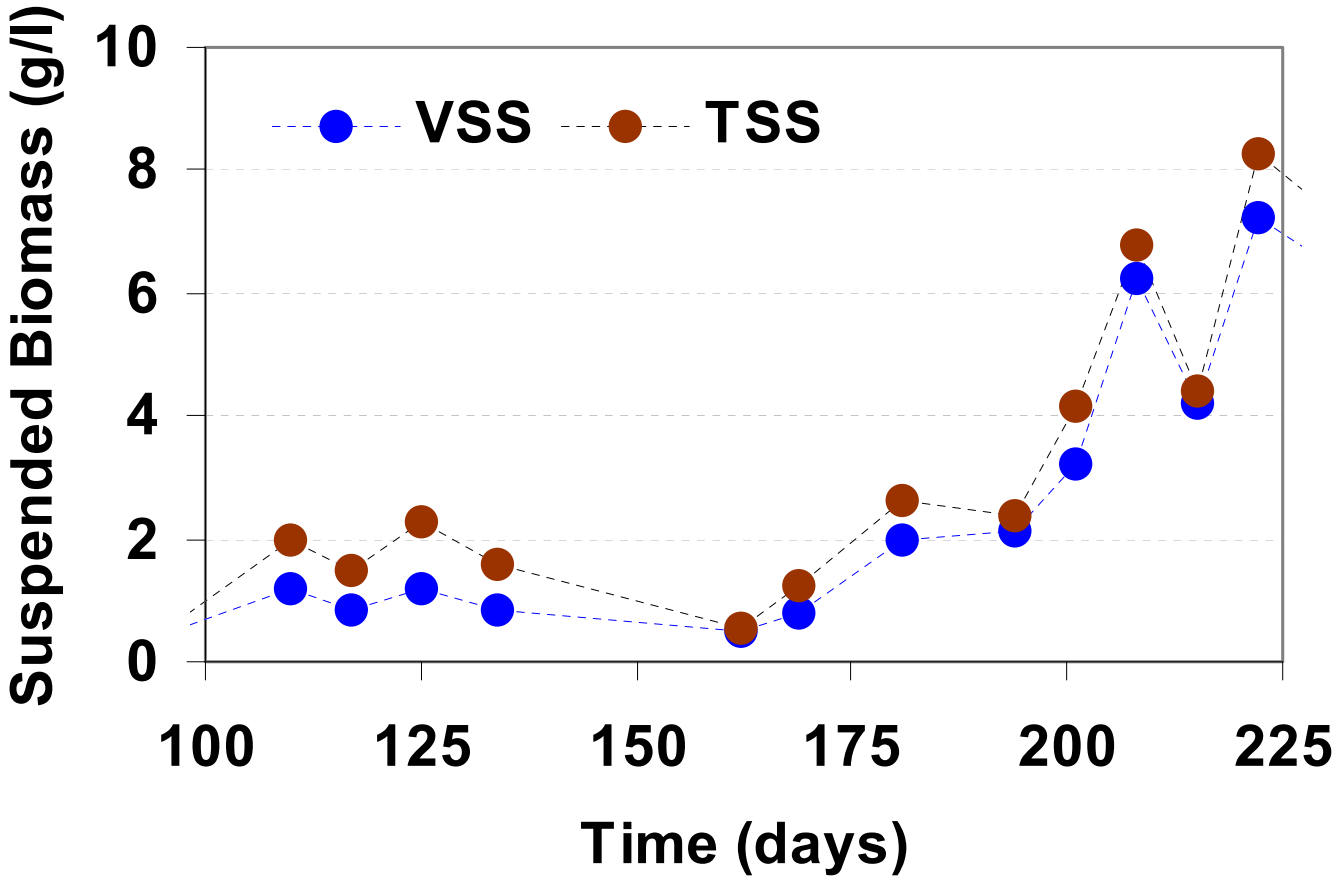


Operation strategy: Wastewater diluted with Tap water

Second stage: Steam injection stream

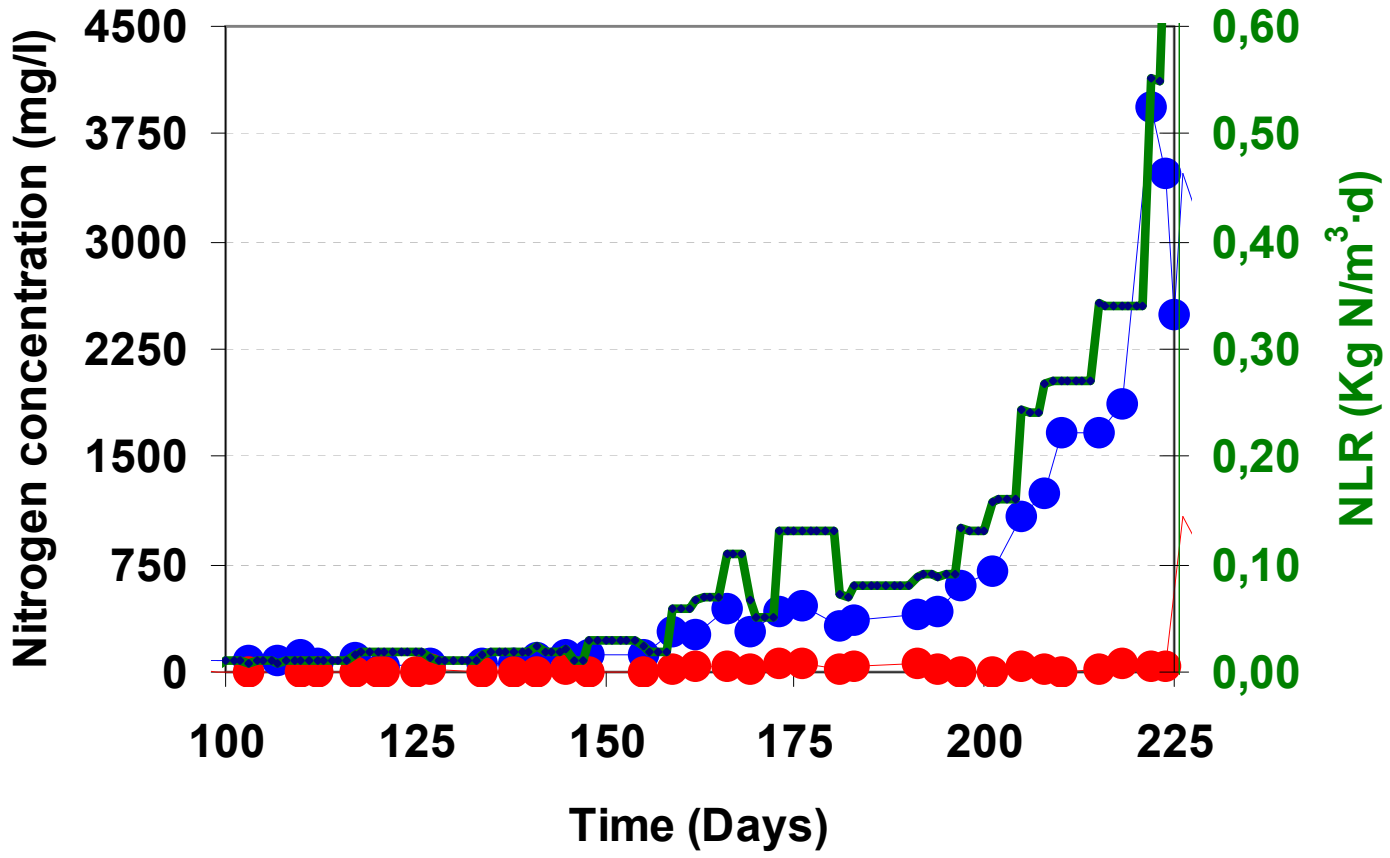


Second stage: Biomass concentration



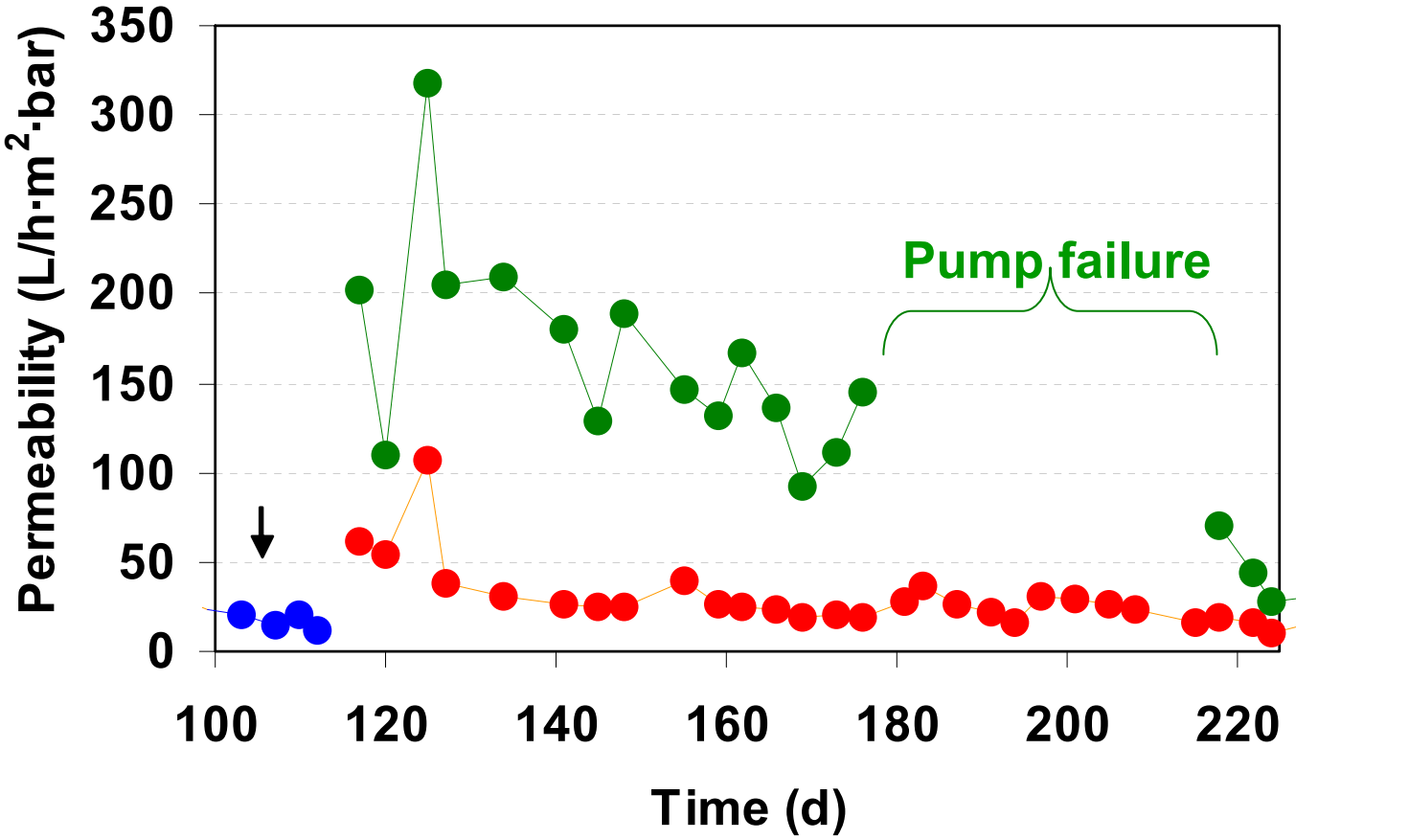
Apparent yield: 0.12 g VSS/g COD

Second stage: Nitrogen and Nitrogen Loading Rate



- Total N influent
- Ammonia permeate

Second stage: Steam injection stream



Conclusions First Stage: Brine stream

- **Salt concentration, up to 84 g/L affected COD efficiency, but after operating day 73 adaptation to the hypersaline conditions was observed.**
- **COD efficiency of 92% was obtained at the end of the experiment, at OLR of 1.4 kg COD/m^3·d.**
- **Organic nitrogen was hydrolyzed to ammonia, but salinity inhibited nitrification.**
- **Low permeability, 20-50 L/m^2·h·bar was obtained (Zenon ZW-10).**
- **Very low biomass yield: 0.03 g-VSS/g-COD.**

Conclusions second stage: Steam injection stream

- **COD in the permeate not affected by COD in the influent and was lower than 100-150 mg/L.**
- **OLR up to 4 kg COD/m^3·d & NLR up to 0.55 kg N/m^3·d.**
- **Nitrogen concentration in the permeate lower than 100 mg/L.**
- **Biomass yield around 0.12 g-VSS/g-COD.**
- **Permeability of the tubular membrane higher than in the Hollow fibre membrane.**

Acknowledgements

Regional government: Xunta de Galicia

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Espina y Delfín S.L.

Sonia Barros y Elena García

3R Ingeniería Ambiental

THANK YOU !