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Application of high frequency powerful vibration (HFPV) on fouling limitation in submerged membrane modules of a pilot MBR system

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Presentation Outline

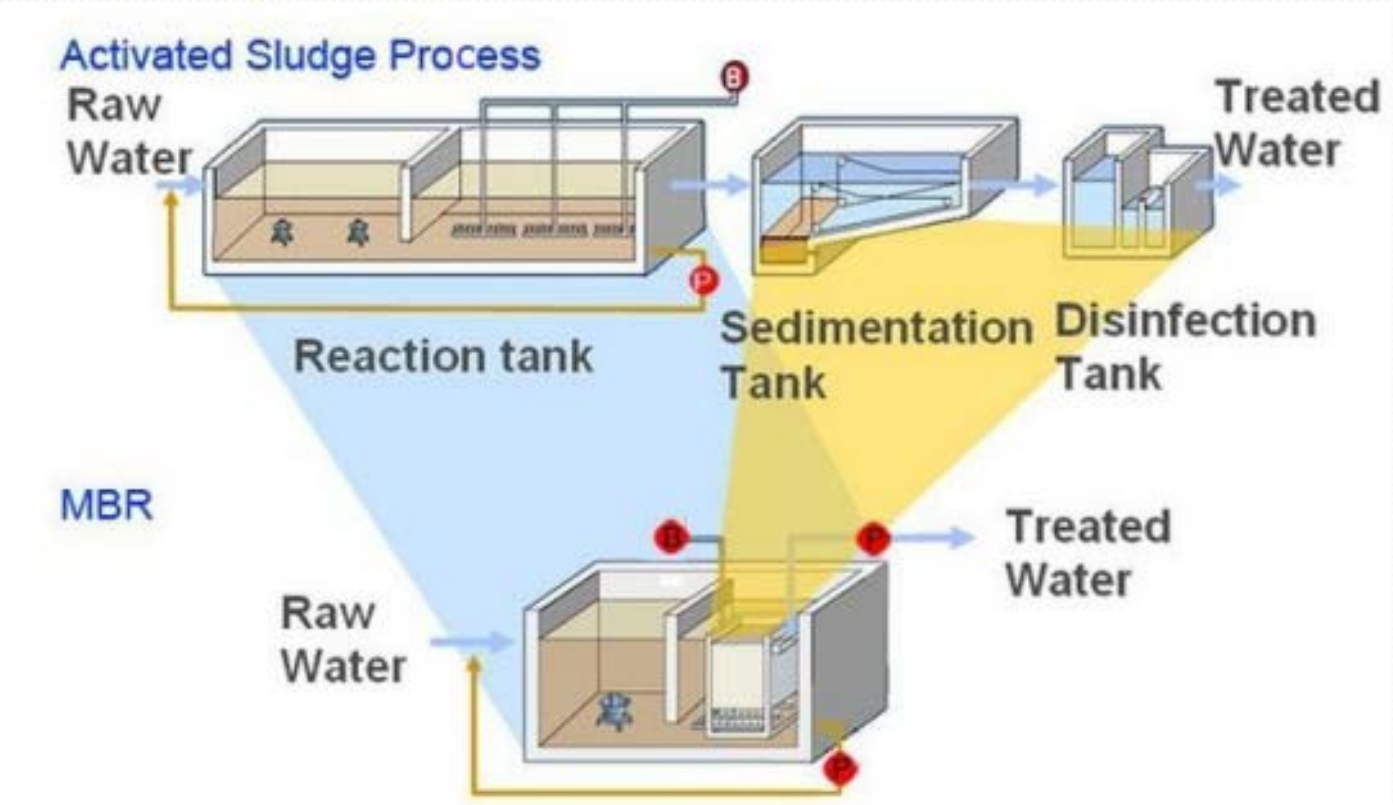
- MBR Technology Overview
- Membrane Fouling – Number One Issue Facing MBR Operation
- Factors Influence MBR performance
- Pilot Study Results
- HFPV Control of Membrane Fouling
- Summary

What is a Membrane Bioreactor?

A combination of a membrane process (micro/ultra filtration) with a suspended growth bioreactor.

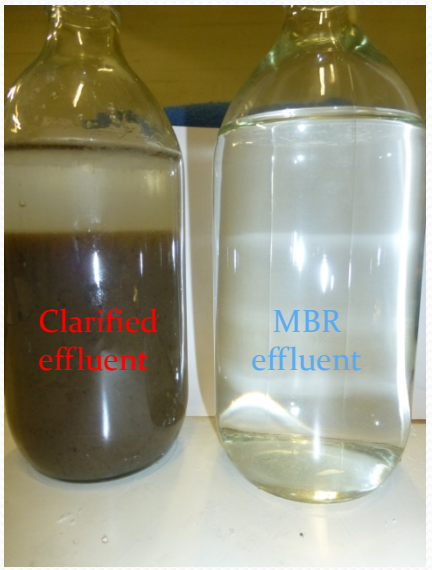
CONVENTIONAL ACTIVATED SLUDGE PROCESS

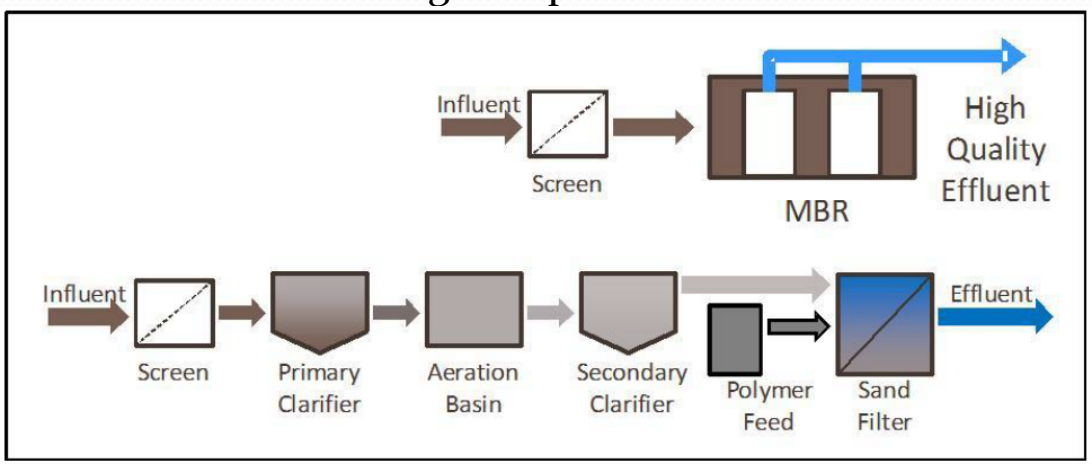
MBR PROCESS



Value over Conventional Treatment

- Fewer process steps to achieve comparable effluent
- Eliminates sludge settling issues (filamentous)
- Smaller Footprint
- Modular expansion capability
- Reduced sludge yield
- Higher quality effluent
  - Low turbidity
  - Excellent nutrient removal
  - High rejection of organics, solids, and microorganisms
  - More resistant to biological upset

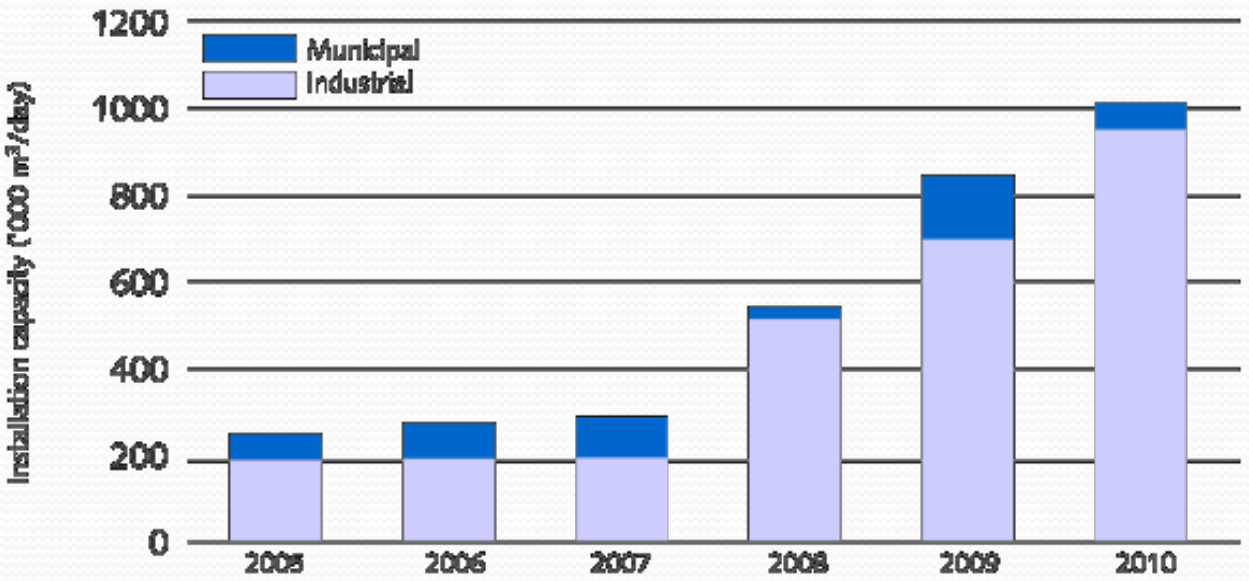




MBR Technology driving forces

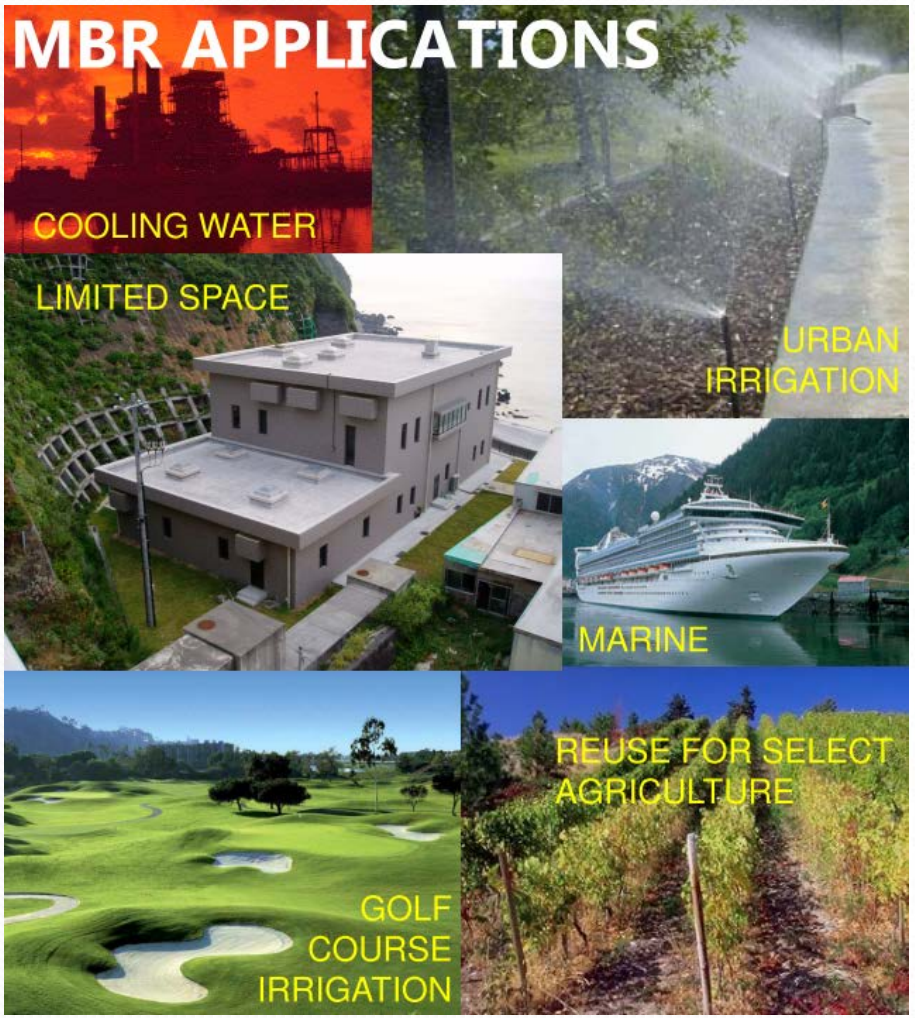
- Water reuse necessity
- Increasingly stringent legislation
- Need for footprint savings
- Penetration of technology in the market combined with Reduction of membrane cost and reliability of method

Figure 1. MBR market: Market evolution of MBR systems in municipal and industrial end-user segments by installed capacity (China), 2005-2010



(Adapted from Water World)

MBR Technology Propels into Water Reuse Era



Application Fields of MBR


Domestic Sewage


Industrial Wastewater


Hospital Wastewater


Food Processing Wastewater


Landfill Leachate


Reuse of Grey Water

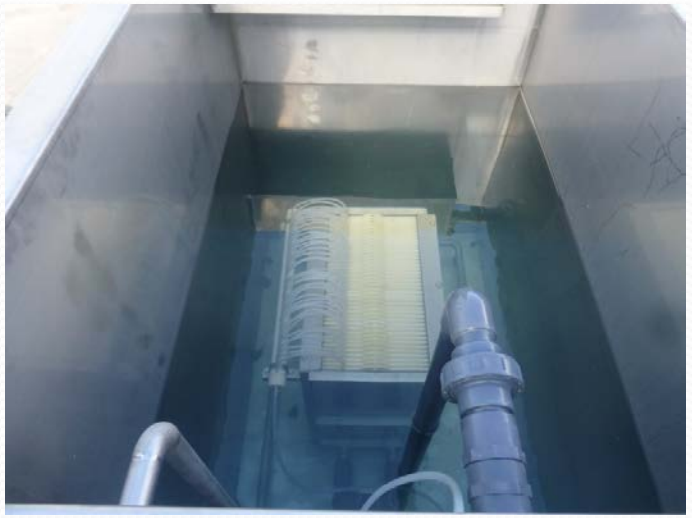
Membrane Bio-Reactors (MBRs)

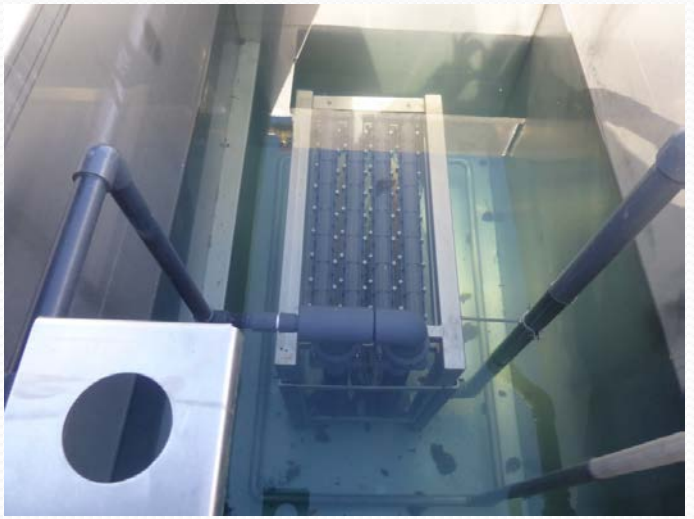
The Future of Wastewater Technology?

MBR installations

Flat sheet

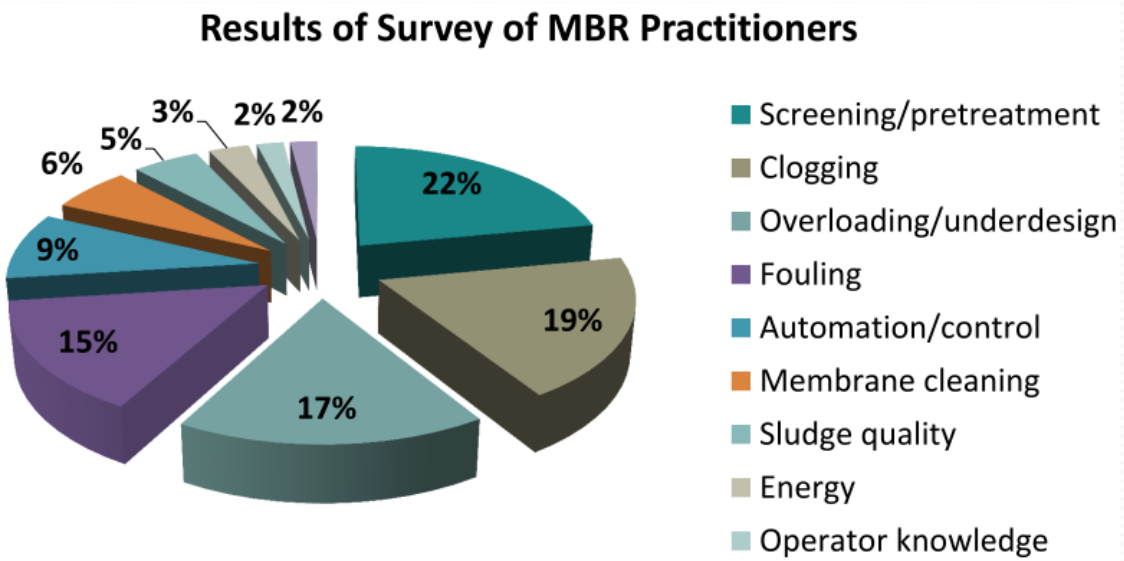
Hollow fiber





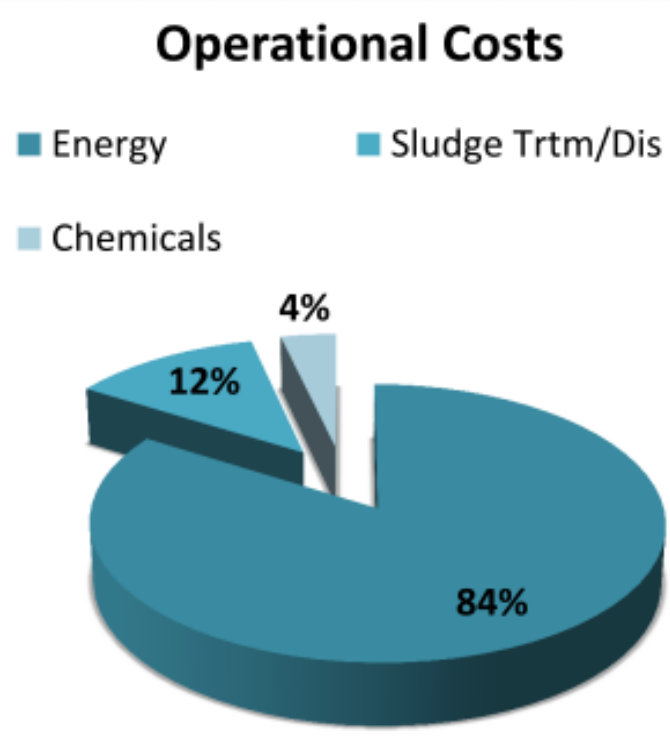
MBR Technology Challenges

- Decrement of higher operational and capital costs as compared to conventional activated sludge (CAS)
- Fouling/clogging control in membrane elements
- Expansion of membrane lifespan
- Optimization of membrane physical and chemical cleaning

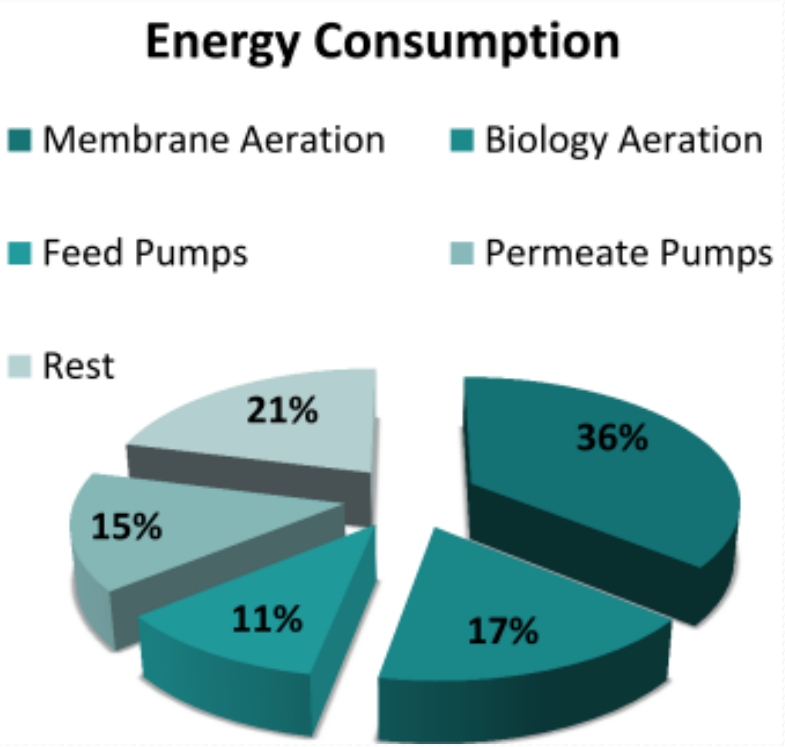


(From Santos et al., 2011)

Operational Costs in MBR Systems



(Adapted from Judd, 2011)

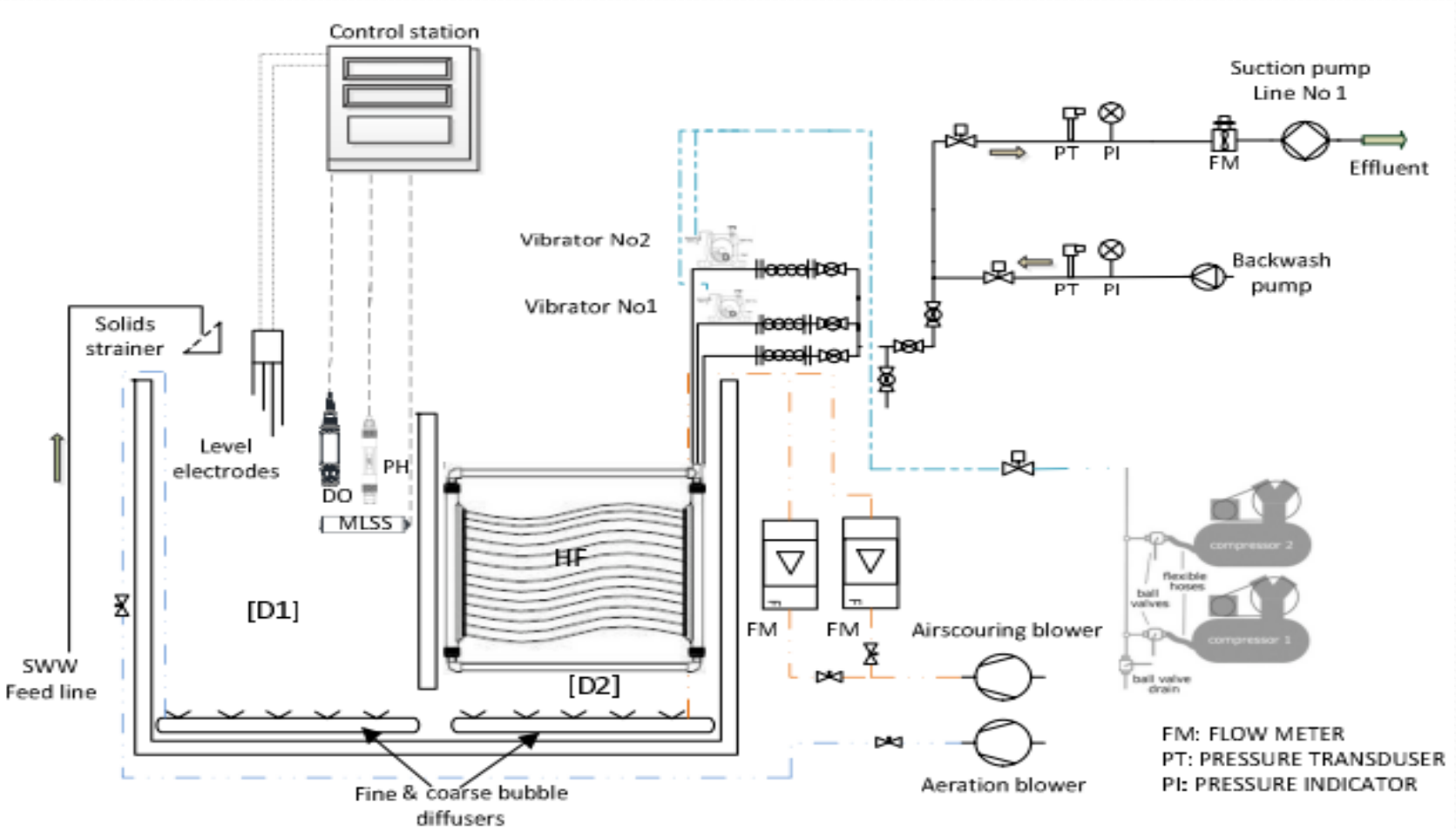


(Adapted from Krzeminski, 2013)

Focus of our research

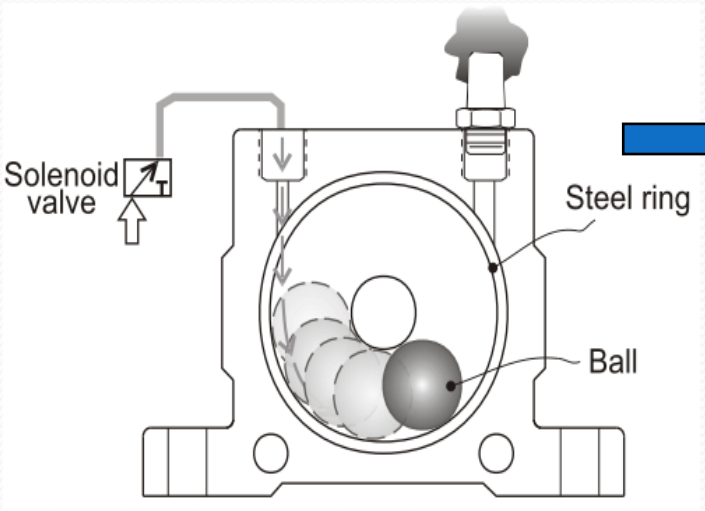
- Contribution to overtake the aforementioned barriers which ultimately determine the extent of implementation, through the technological development and innovation.
- The promotion of effective technologies and safe practices in order to add value, reduce costs and improve the environment.
- Adoption of energy-efficiency strategies of membrane fouling and blockage control, using high frequency vibrators in a low air scouring mode.
- Monitoring realistic experiments in a pilot scale unit in long time periods.
- Continuous observation of the main features of the pilot MBR unit, to record and intervene either from near or from distance.
- Effectiveness control by Standard Analytical Techniques of the unit operating efficiency.
- Effectiveness observation of vibration technique in different type of membranes.

Pilot unit

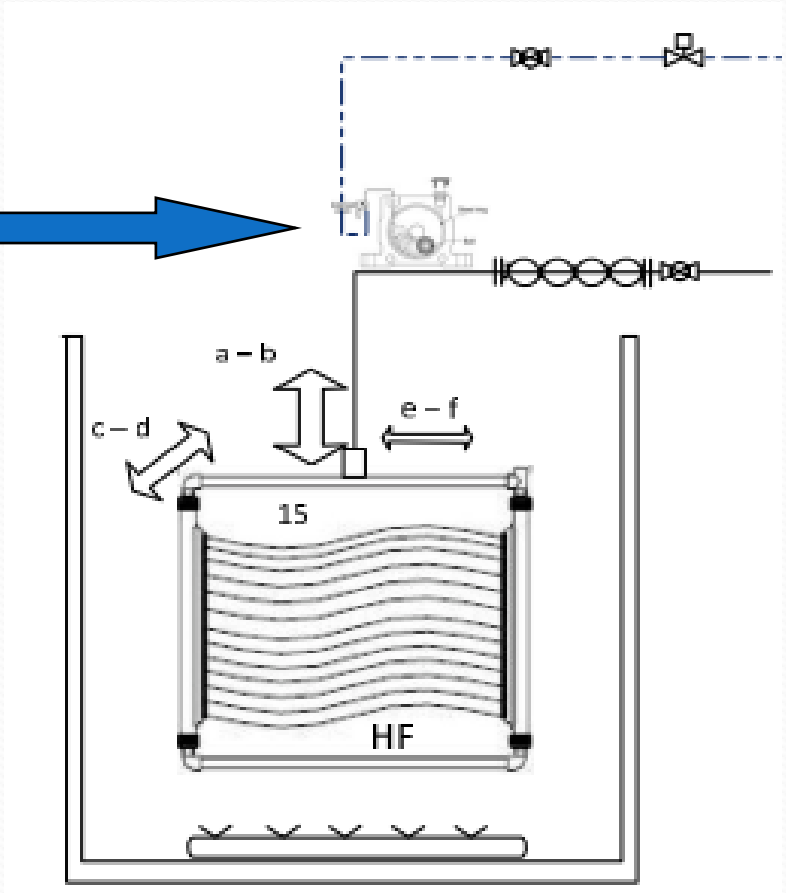


Schematic overview of the SMBR pilot system

Pilot unit



Pneumatic ball vibrator header scheme



Schematic overview of the powerful vibration moves of the membrane

Pilot unit and HFPV vibration effects

BEFORE

VIBRATION IMPLEMENTATION EFFECTS

BEFORE

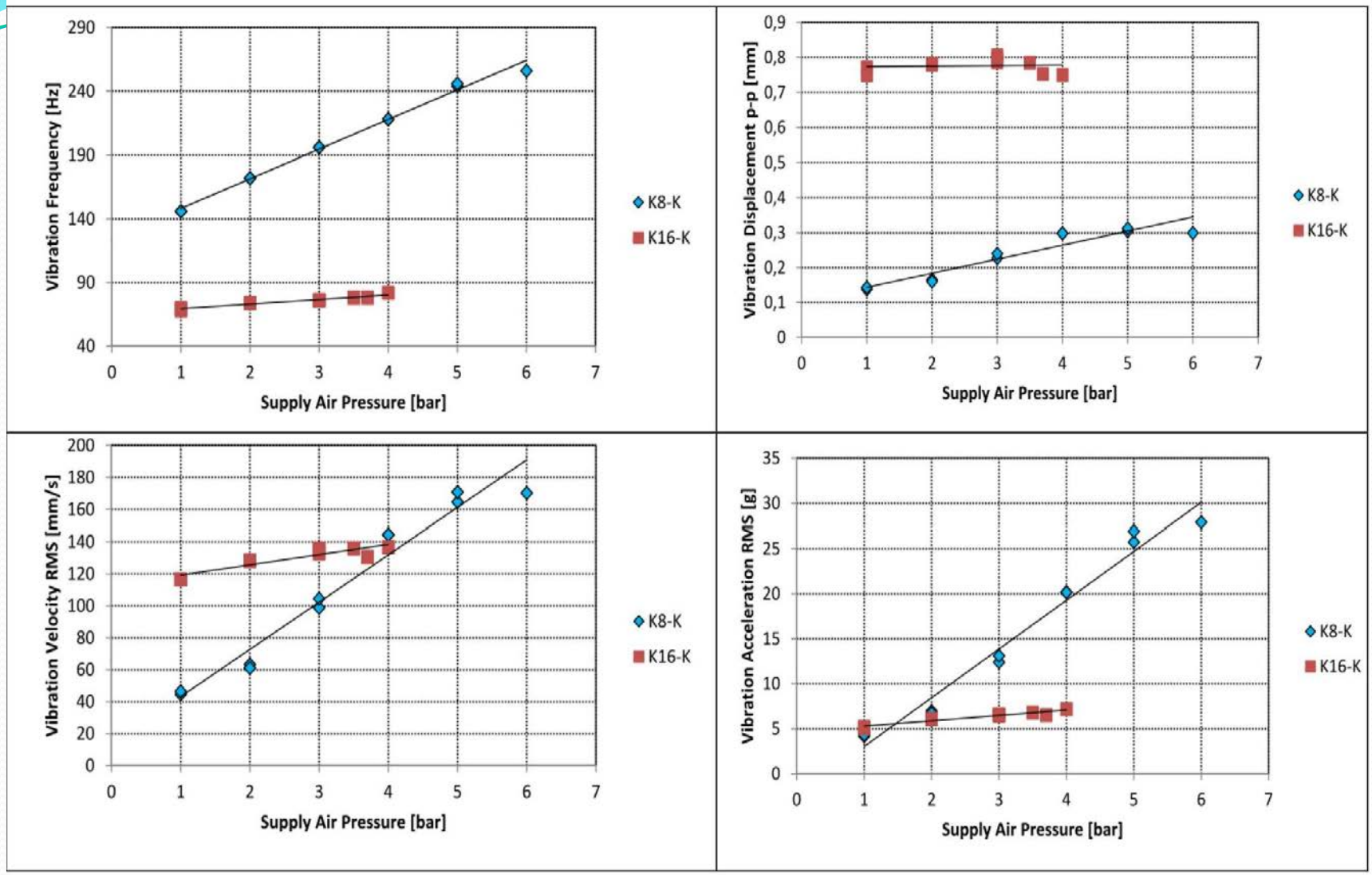
AFTER HF A' TYPE

AFTER HF B' TYPE

Membrane module's vibration types and characteristics

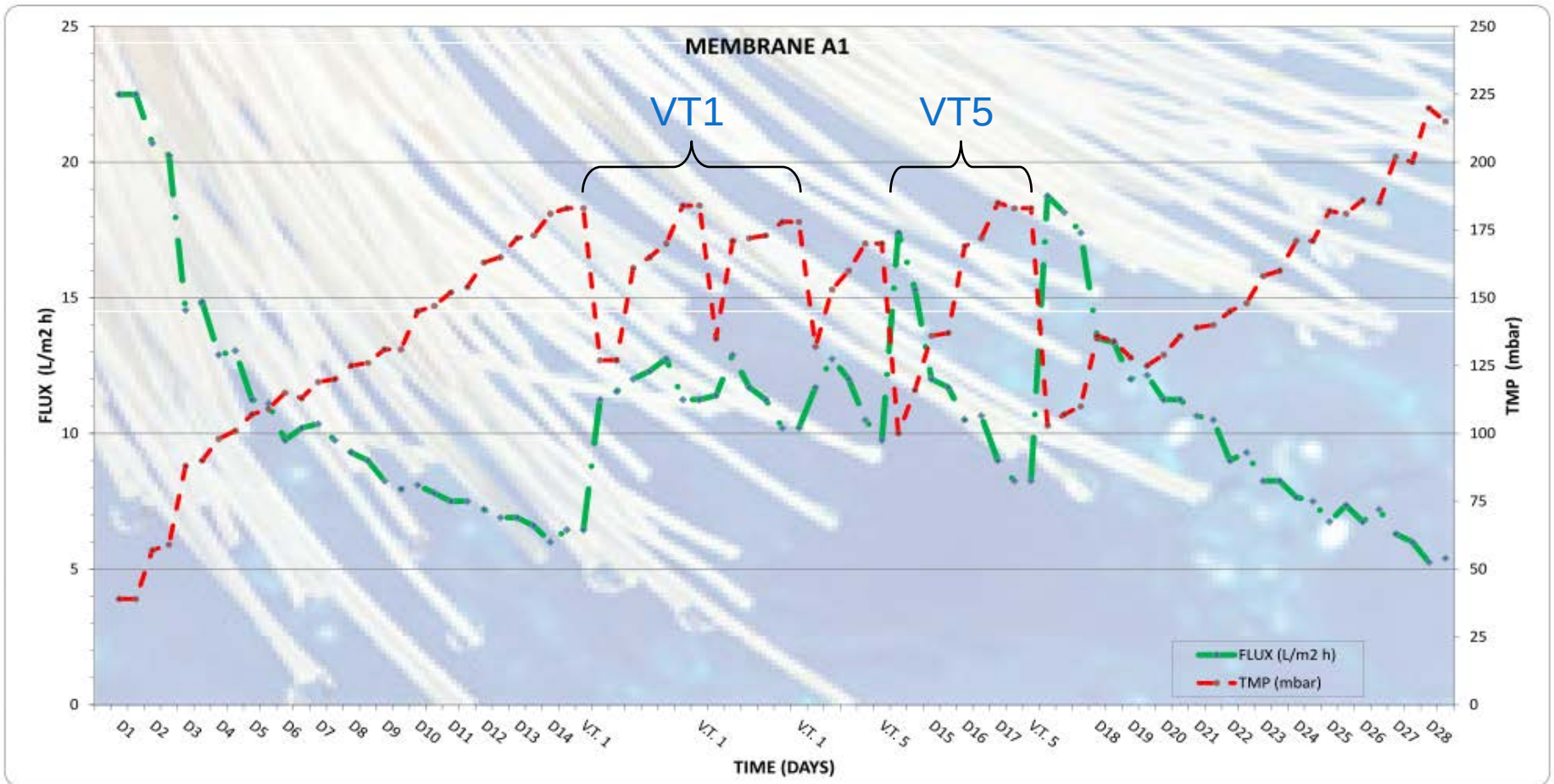
Vibrator type	Membrane type	Compressor's pressure (bar)	Vibrator's air pressure (bar)	Vibration frequency (Hz)	Vibration velocity RMS (mm/s)	Vibration Acceleration RMS (g)	Vibration Displacement p-p (mm)
K8-K	H.F.	7	4	223	142	20	0.3
K16-K	H.F.	5	3	76	134	6.6	0.78

HFPV vibration characteristics



Results and discussion

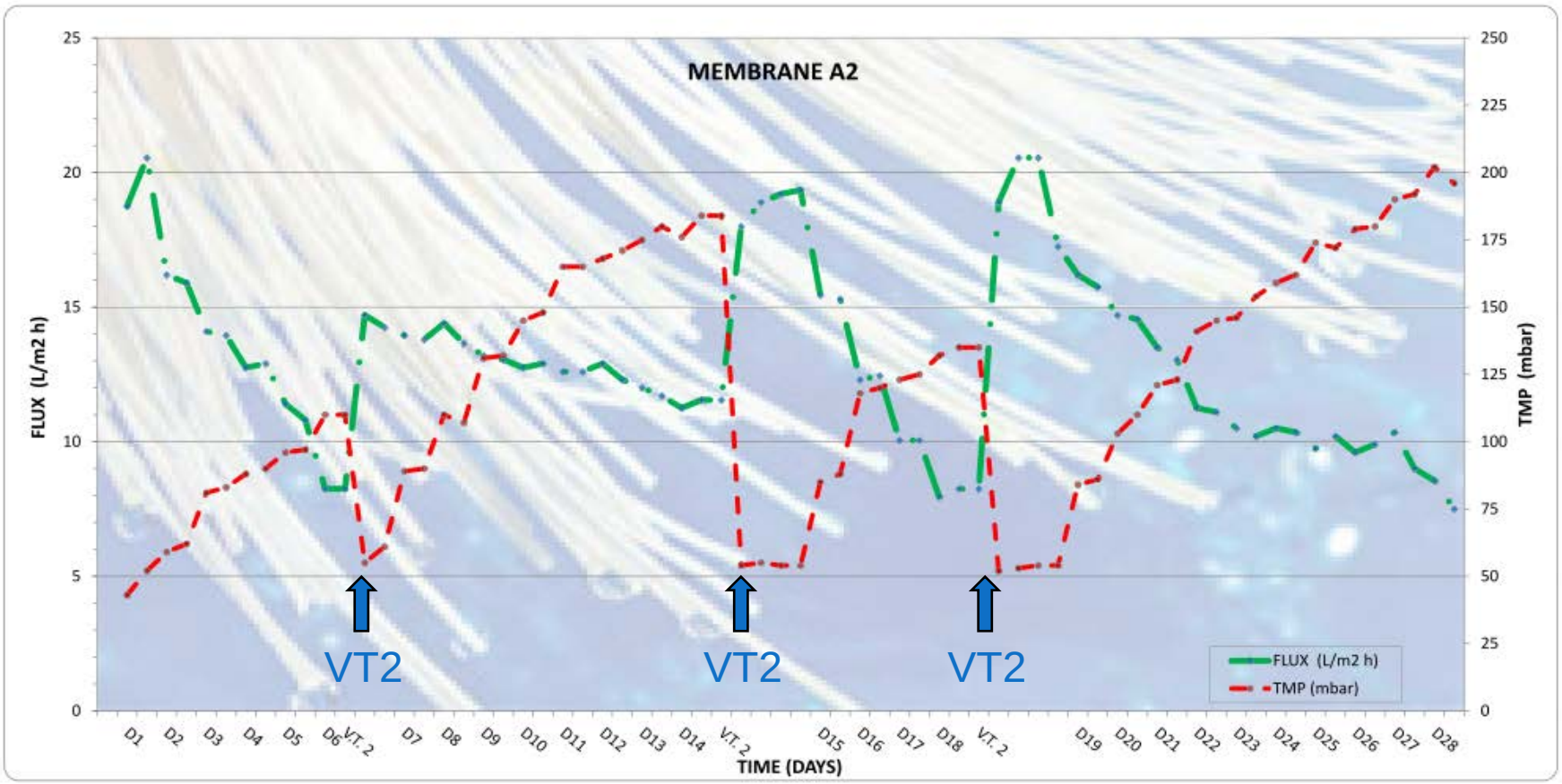
Vibration implementation with K8-K vibrator for 5' (VT1) & 10' (VT5) on A1 HF membrane



TMP and permeate flux profiles vs. time on A1 HF membrane

Results and discussion

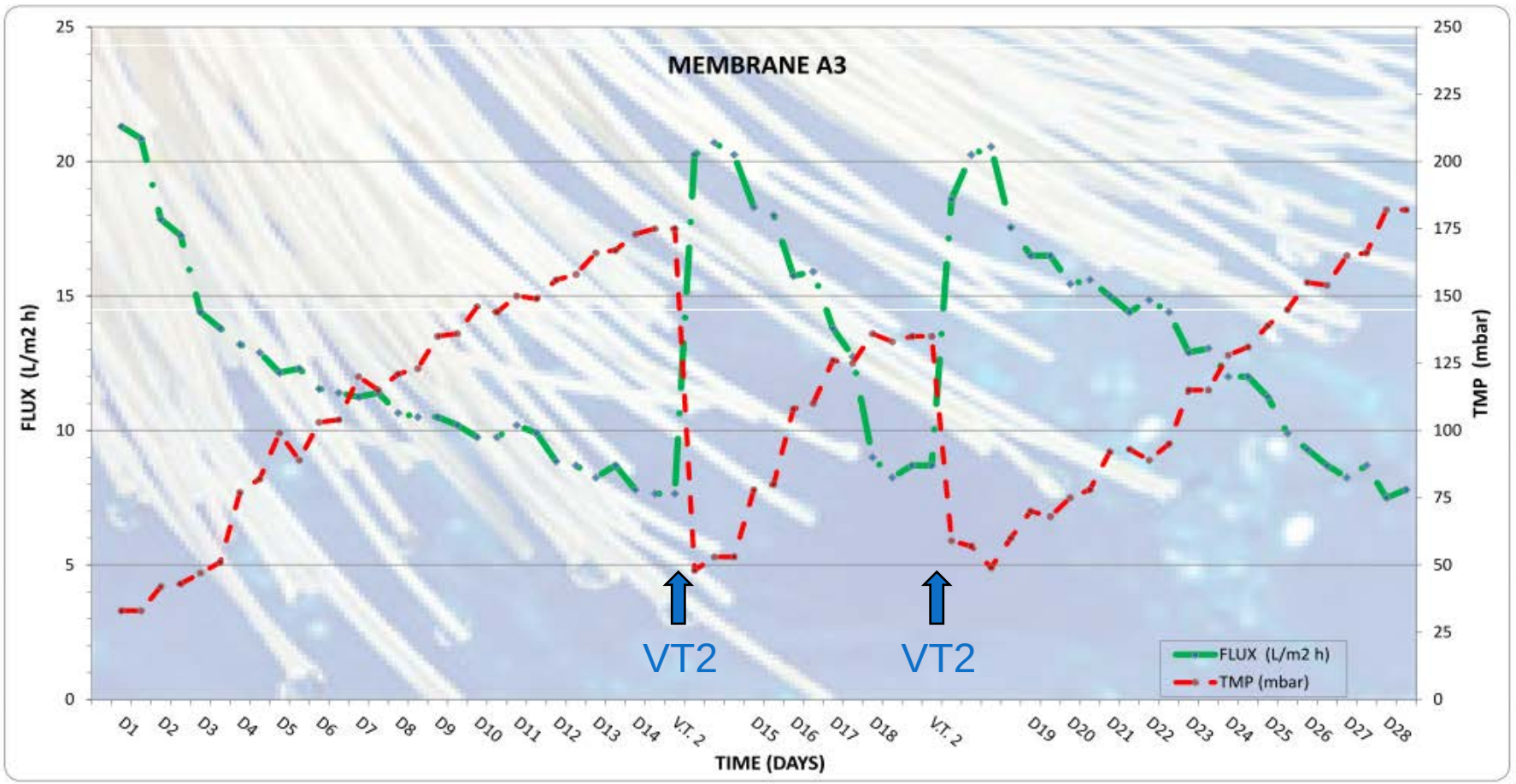
Vibration implementation with K16-K vibrator for 5’ (VT2) on A2 HF membrane



TMP and permeate flux profiles vs. time on A2 HF membrane module

Results and discussion

Vibration implementation with K16-K vibrator for 5’ (VT2) on A3 HF membrane.



TMP and permeate flux profiles vs. time on A3 HF membrane module

Conclusions

- Vibration is presented as a very promising technique when applied in a small pilot-scale SMBR treating SWW.
- Measurements showed clear advantages of this technique over conventional MBR processes in terms of realisable flux and fouling control.
- Repeatability of the vibration application on the membranes showed a homogenous and stable effect on fouling control management over a long period as shown in figures.
- Performance of the vibrated SMBR systems is very high and as presented above, returns almost to the initial TMP and flux measuring values.
- The energy benefit of vibration on fouling limitation will be very high compared with the conventional process of intense air scouring.
- Comparatively less chemical cleaning and removing deposits from strong membranes due to vibration allow the claim of extending the operating life of the components of the membranes
- In addition, this lower aeration should also help to minimize the excess dissolved oxygen (DO) that returns to anoxic tank via the mixed liquor from membrane tank, which typically contains DO at high levels, decreasing significantly the denitrification efficiency.

We have a big target to reach

Thank you!

National Technical University of Athens

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