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ANFA Nonwovens Conference 2019

Innovative Application of Non-woven Textiles on Industrial Wastewater Biological Treatment

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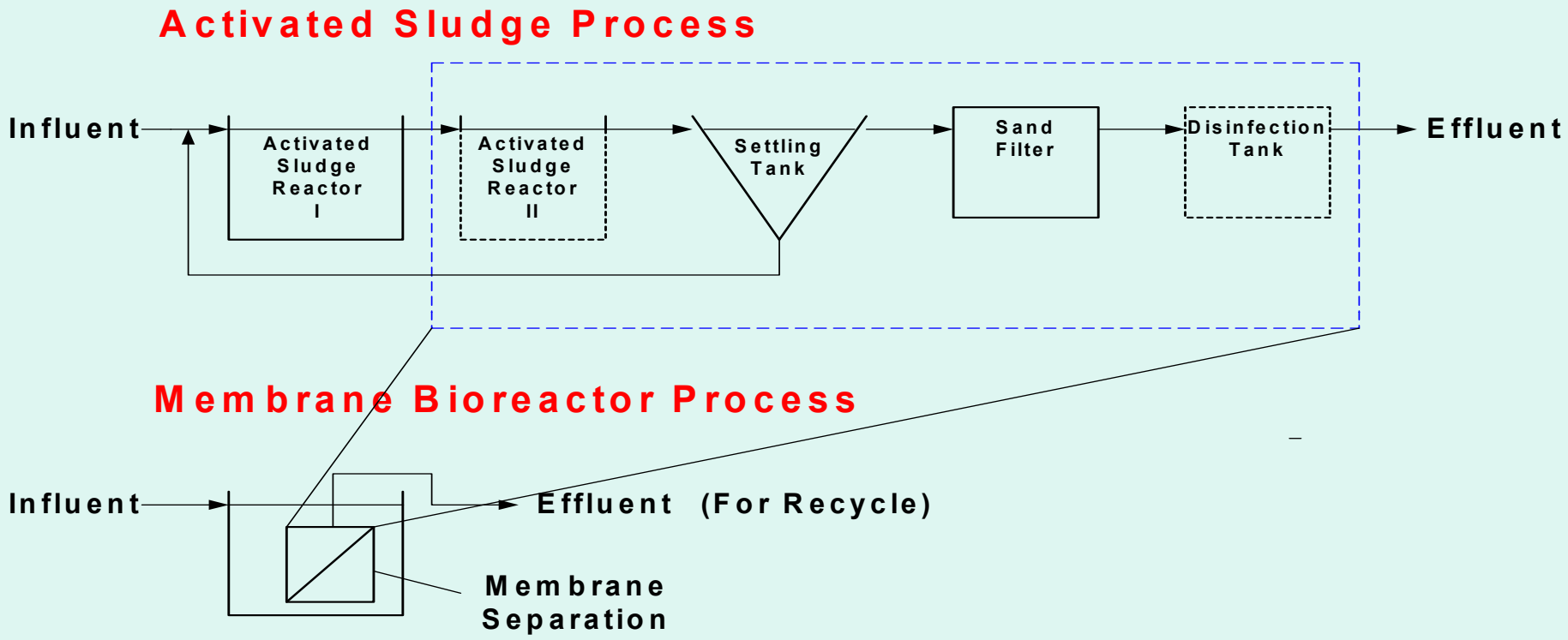
ASP vs. MBR



Note: from Gunder & Krauth, Wat. Sci. tech., 40(4-5), 311-320.

Commercial Membrane Material

- The membrane materials commercially used in MBR process include ceramics and both unmodified and surface modified polymeric materials, called microporous membrane.

- The pore size of these membrane materials are usually in the 0.02μm~0.5μm range.

Filtration Characteristics of Microporous Membrane

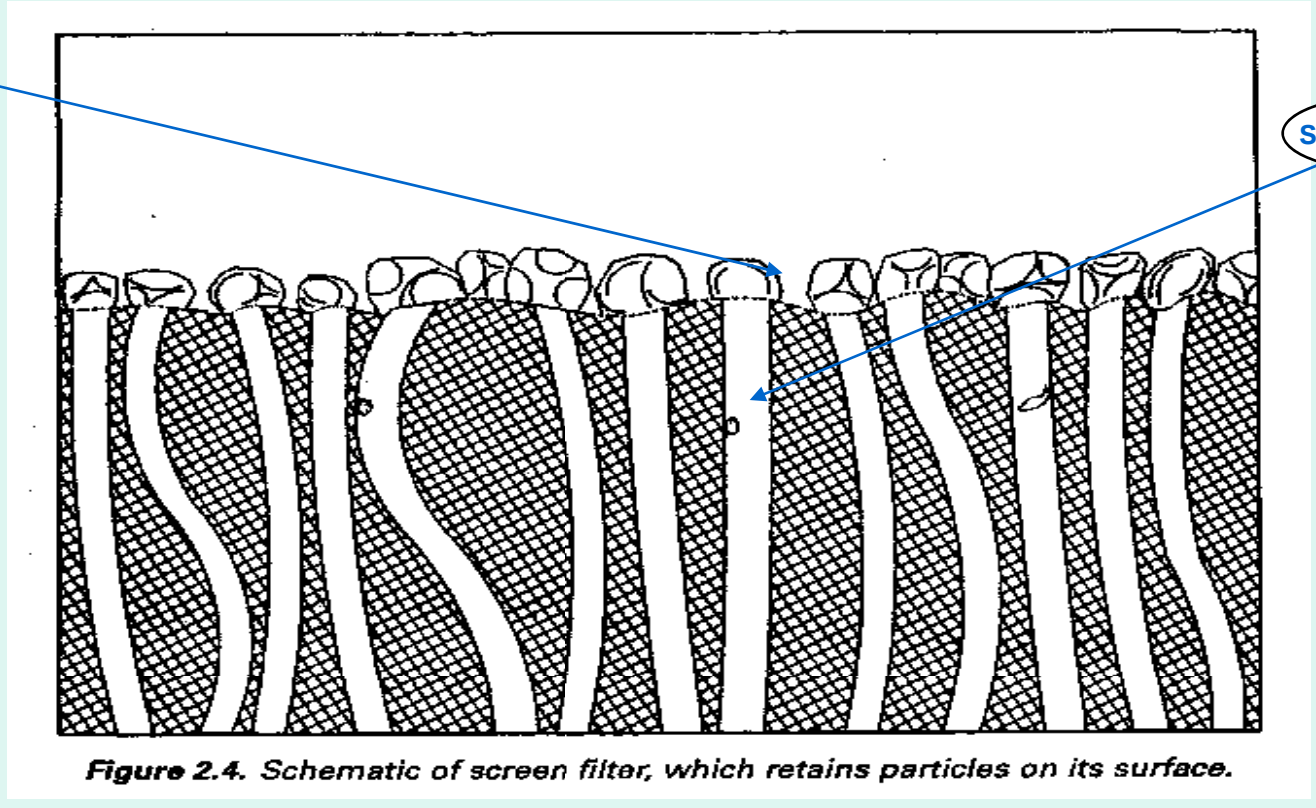


Figure 2.4. Schematic of screen filter, which retains particles on its surface.

Non-woven Fabric Material

- Non-woven fibrous materials are composed of random network of overlapping fibers which create multiply connected pores through which the fluid can flow.

- It is also a less expensive filter material for water treatment.

Filtration Characteristics of Non-woven Membrane

The size of particle small than that of pore can be collected

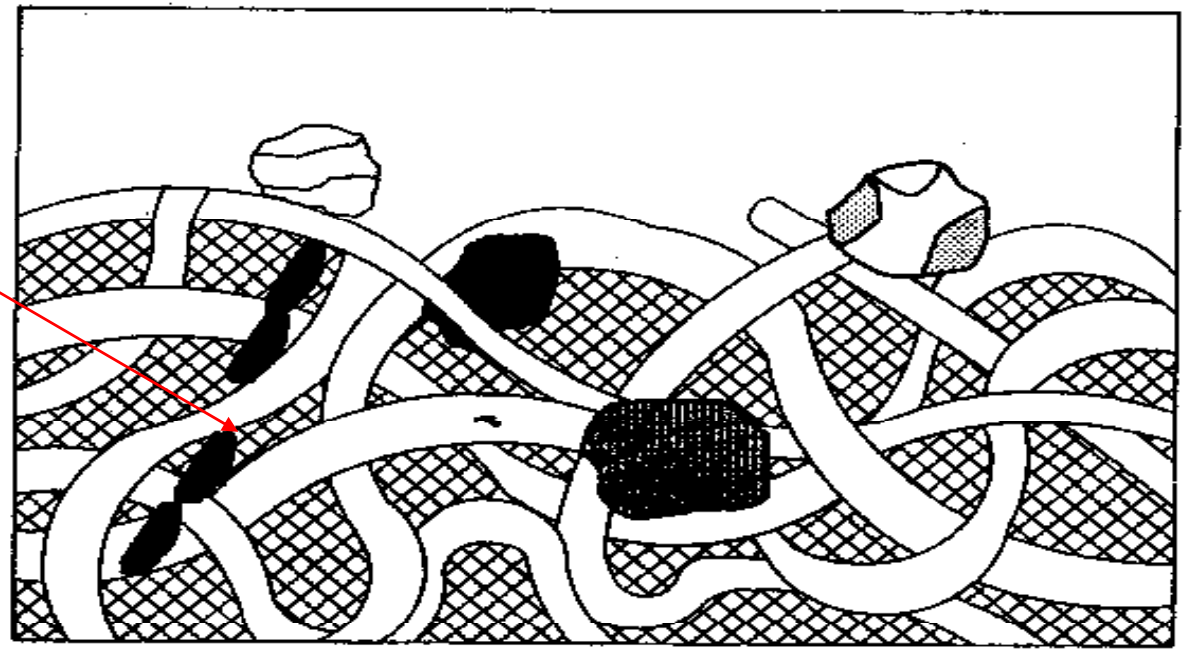
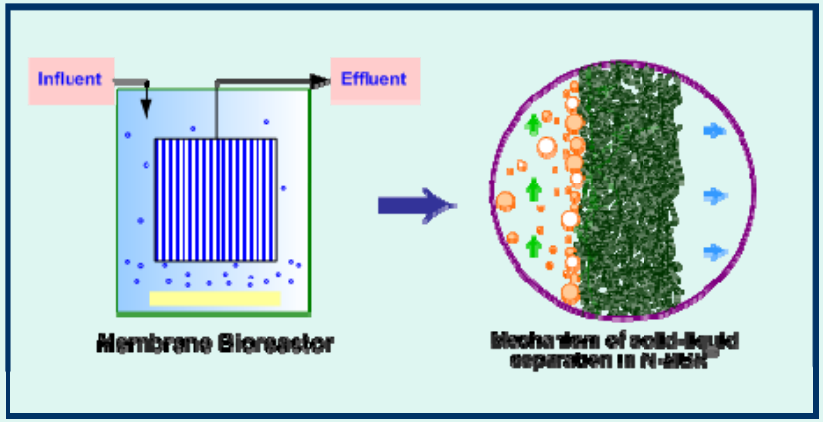


Figure 2.2. *Schematic of depth filter, showing the randomly oriented fibers trapping particles on its surface and within its matrix.*

Filtration Characteristics of Non-woven Fabric Membrane

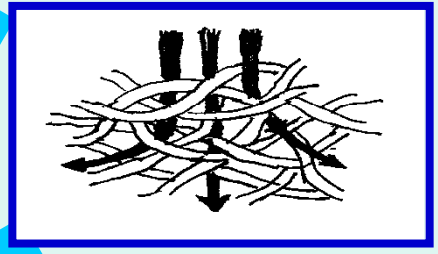
- In non-woven fabric membrane, particle collection mechanisms include inertial impaction, interception and Brownian diffusion etc. Particles with size smaller than the average pore size can also be collected totally or partially due to **Brownian diffusion** which is especially the dominant particle collection mechanism for ultra-fine particles.

Non-woven MBR System



Variable pore size

3D structure



Good chemical stability

High porosity

Contribution to Membrane Fouling in MBR System

- For microporous membrane, the main components of activated sludge system that contributed to membrane fouling are soluble microbial product and small size colloid.
- As for larger pore size non-woven membrane, suspended sludge floc particle may be expected to have a profound influence on membrane fouling.

Advantages of MBRs

- Stable operation and superior effluent quality
- Easy revamping of existing plants
- Easy process control
- Small footprint
- Less sludge production

Serious concerns

➢Energy consumption of scouring aeration of membrane surface

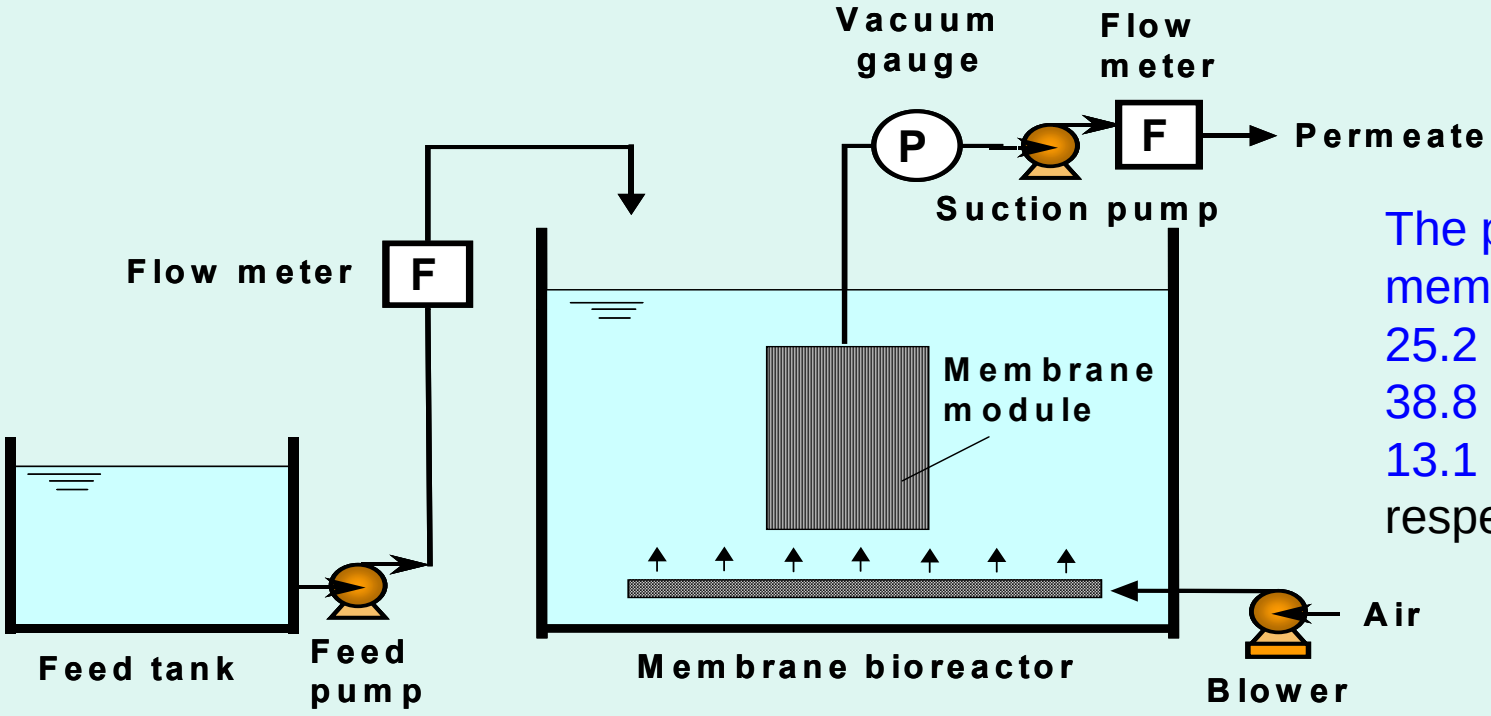
➢Cost of chemical cleaning of membrane to remove fouling

Non-woven MBR System

Unique Features

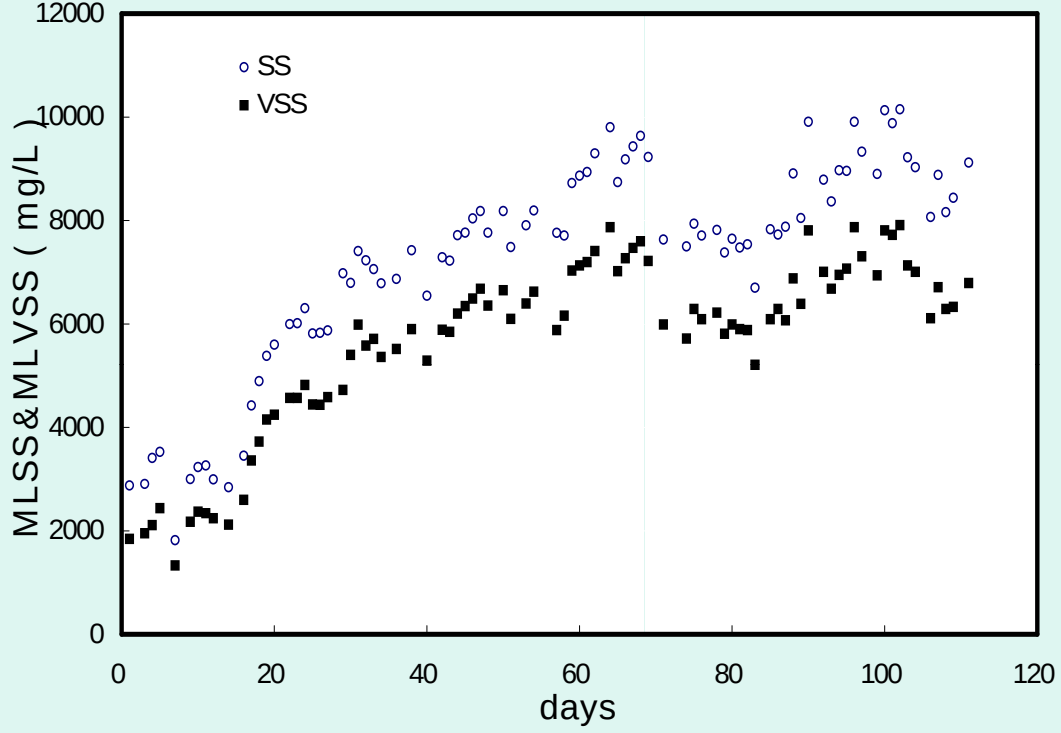
- Controllable pore size distribution
- Easy fabrication of membrane module
- High specific permeate flux at low transmembrane pressure

Non-woven MBR Pilot Test



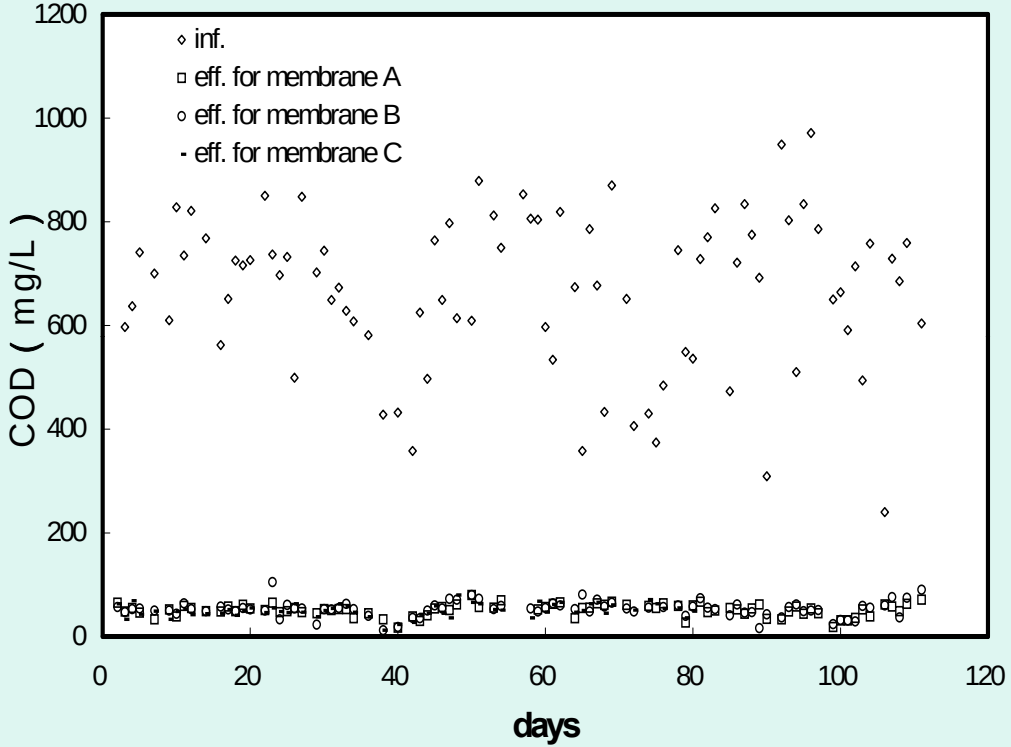
The pore size of non-woven membrane tested was 25.2 µm (membrane A), 38.8 µm (membrane B), and 13.1 µm (membrane C) respectively.

Non-woven MBR Pilot Test



. Change of MLSS and MLVSS concentration in submerged non-woven membrane bioreactor during the operation period. Experimental conditions: membrane type (membrane A), aeration intensity (0.01 m^3/m^2.sec), initial flux (0.2 m^3/m^2.day)

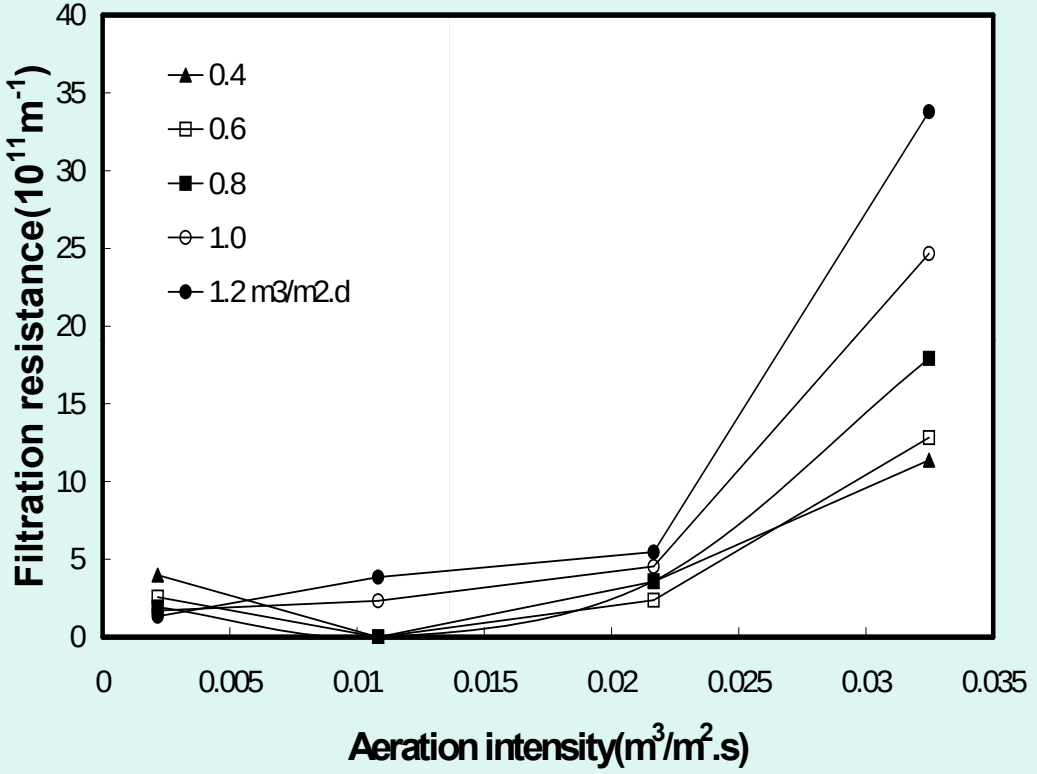
Non-woven MBR Pilot Test



Influent and effluent COD in the submerged non-woven membrane bioreactor during the operation period

Non-woven MBR Pilot Test

Aeration intensity effect



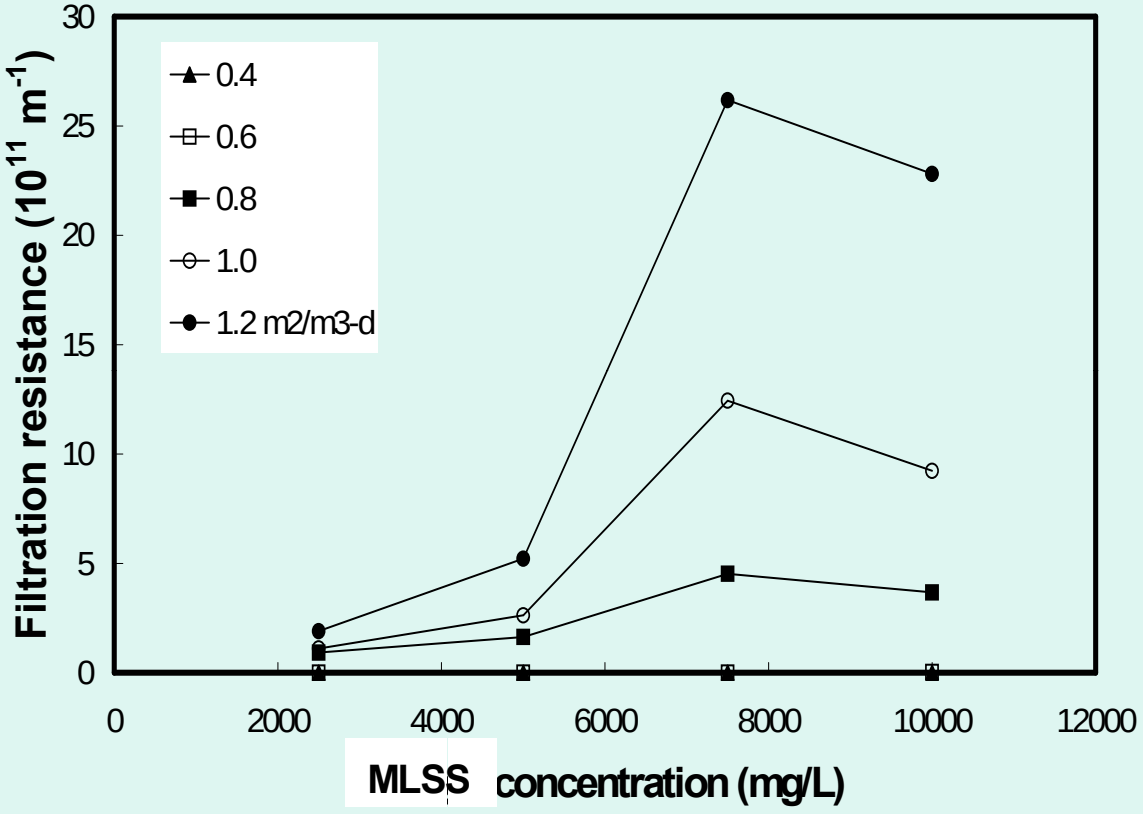
Change of filtration resistance with aeration intensity at different initial flux. Experimental conditions: membrane type (membrane A), MLSS (5,000 mg/L)

Aeration Intensity Effect

- It is shown that the **filtration resistance increased** with increasing aeration intensity when **initial flux** was set at the value **higher than 0.8 m^3/m^2.day** (33 L/m^2.hr)**.** However, there existed a minimum filtration resistance at aeration intensity of 0.01 m^3/m^2.sec when initial flux was lower than 0.8 m^3/m^2.day and filtration resistance was nearly zero.

Non-woven MBR Pilot Test

MLSS effect



Change of filtration resistance with MLSS at different initial flux. Experimental conditions: membrane type (membrane A), aeration intensity (0.01 m^3/m^2.sec)

Non-woven MBR Pilot Test

- The filtration resistance was independent of MLSS at initial flux of 0.4 and 0.6 m^3/m^2.day .

- However, the filtration resistance increased with the increasing of the MLSS, then to a maximum value around 7,600 mg/L at higher initial flux. This trend was more evident when the initial flux was larger than 0.8 m^3/m^2.day (33 L/m^2.hr).

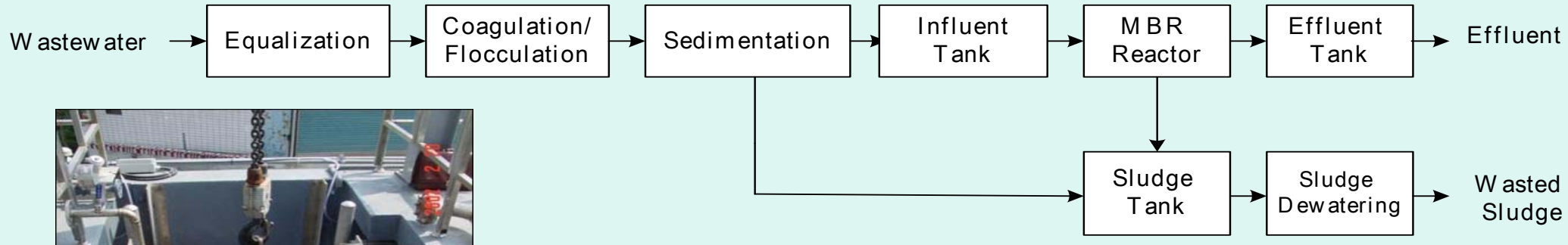
The Difference Between Microporous and Non-woven Membrane System

- In the microporous membrane systems, even with very strong aeration intensity, the aeration intensity has no effect on filtration resistance beyond some critical value.

- However, there exists a minimum and zero filtration resistance at some case in our non-woven membrane bioreactor system.

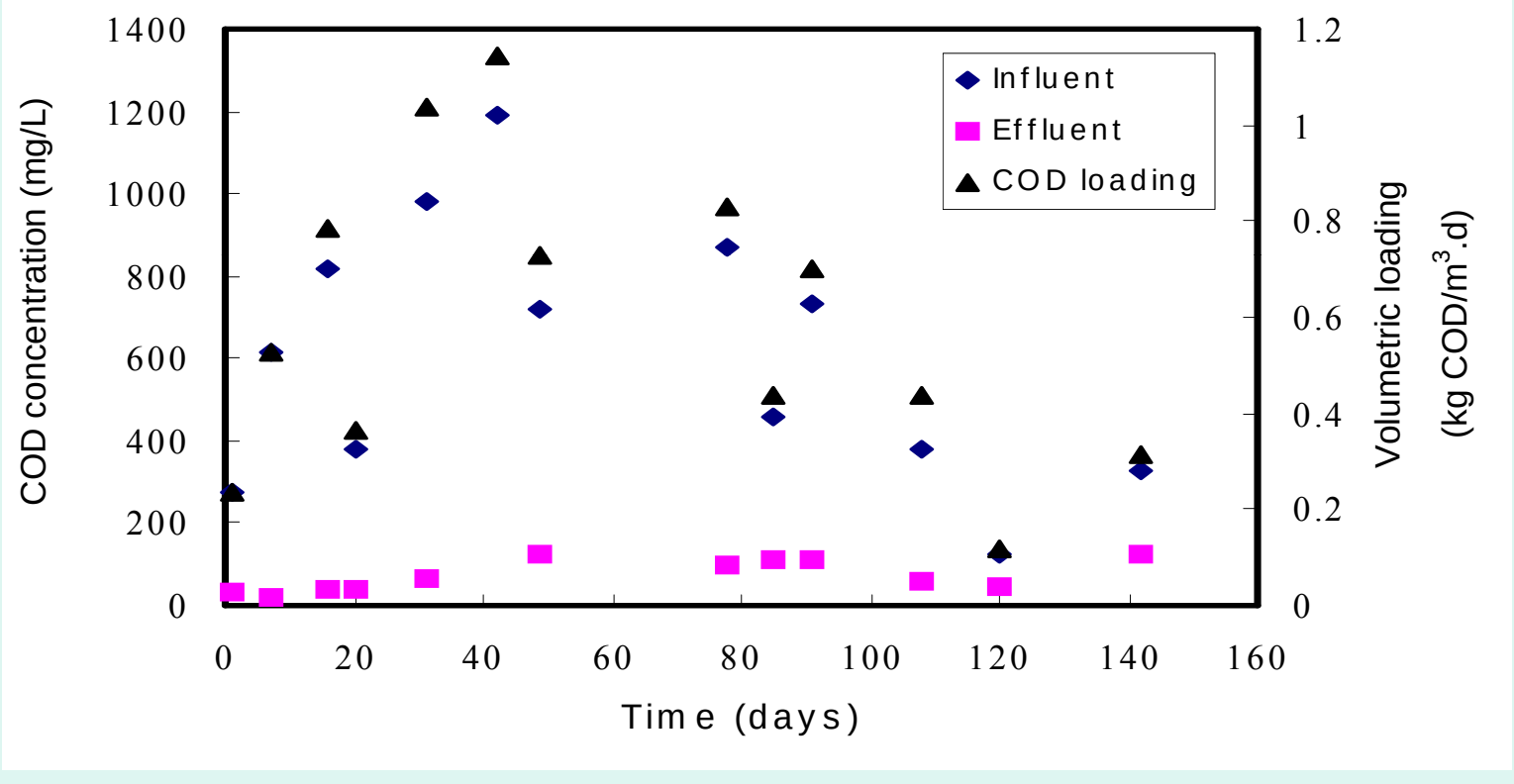
Industrial Wastewater Treatment

Wastewater Treatment Process



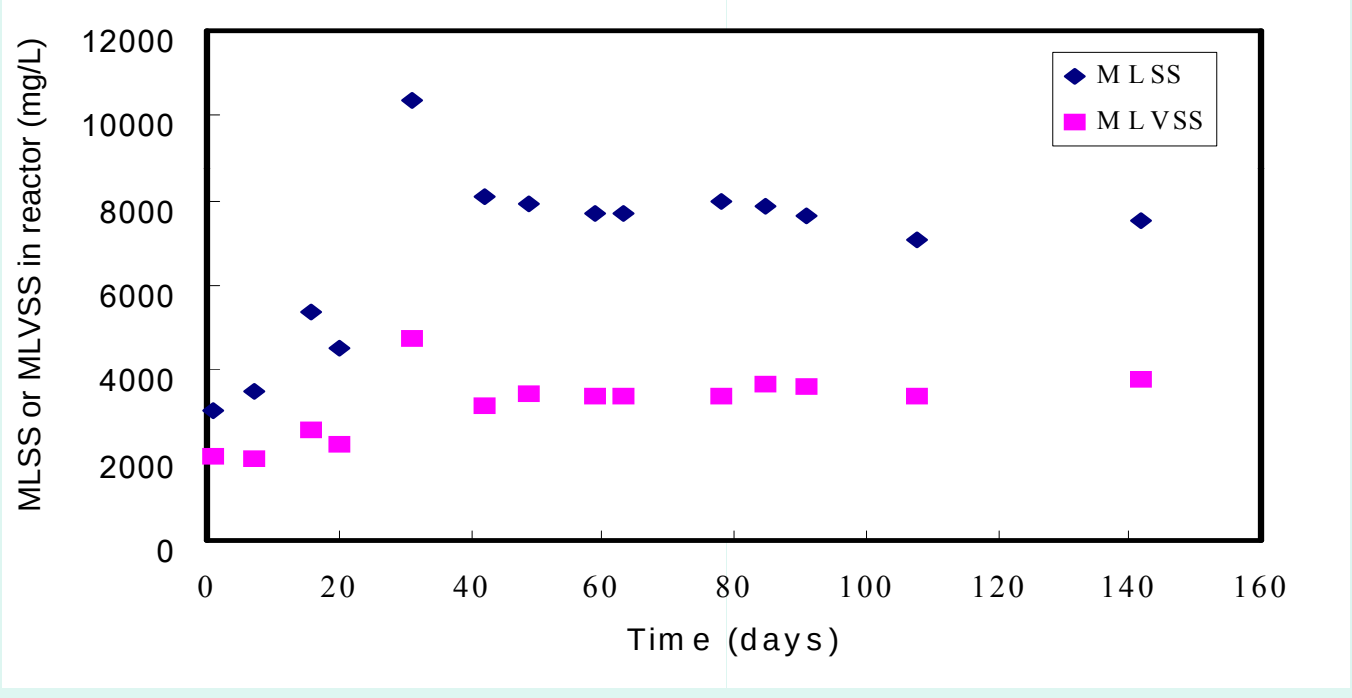
Personal care product wastewater

Influent and Effluent COD of Non-woven MBR



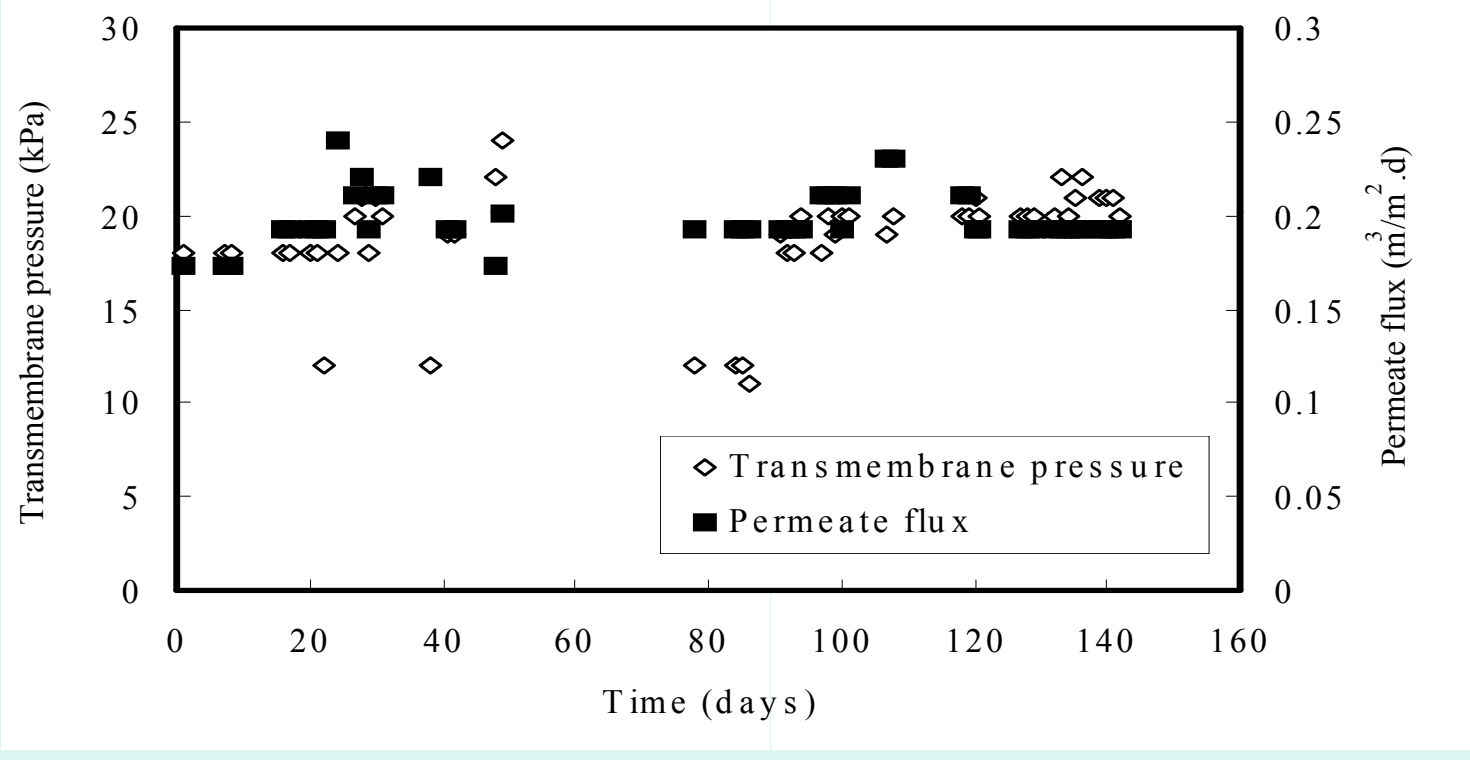
Personal care product wastewater

MLSS Concentration in non-woven MBR Reactor



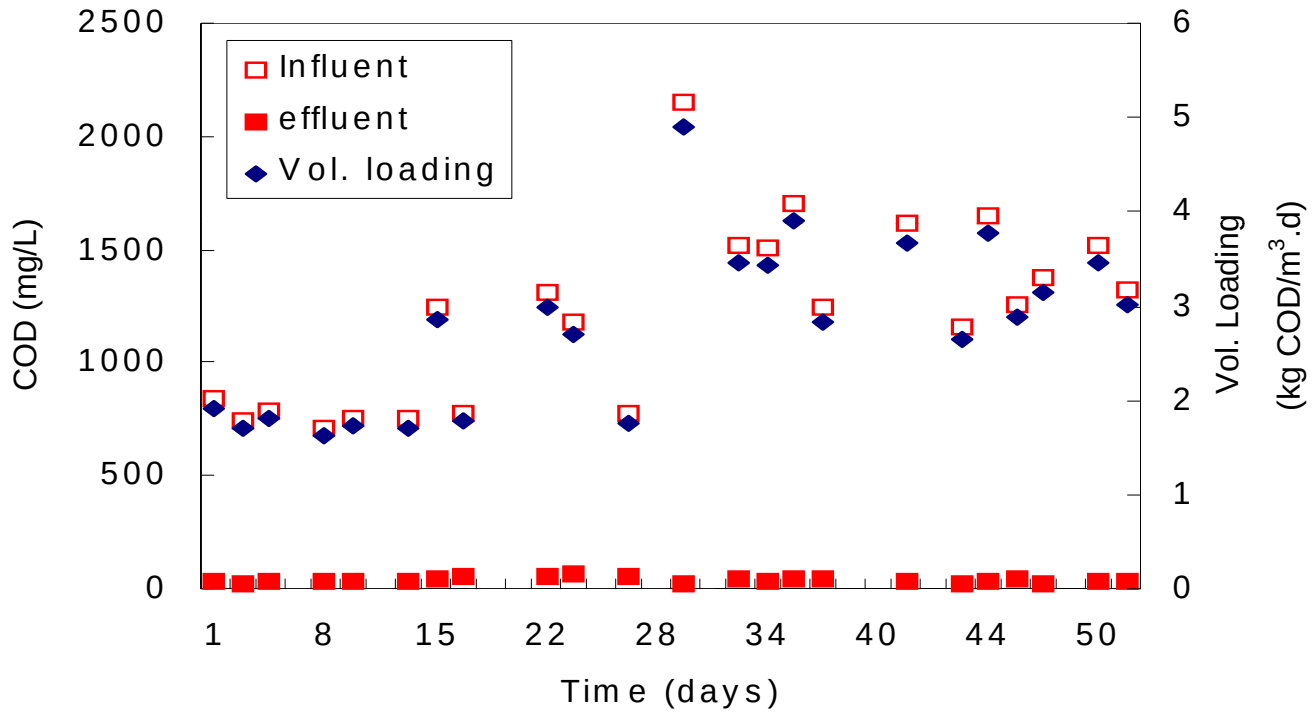
Personal care product wastewater

Operation Pressure and Permeate Flux



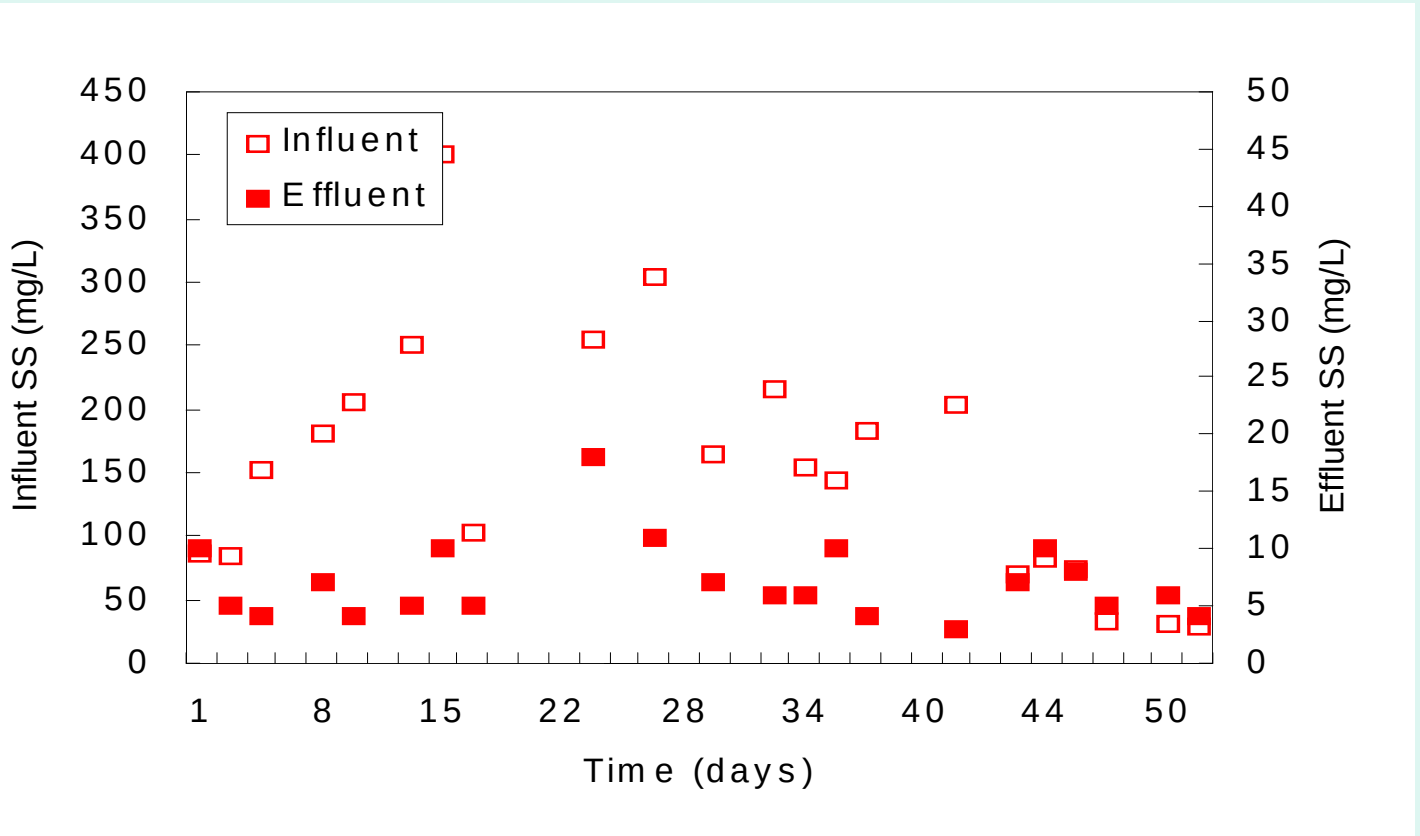
Food Product Wastewater

Influent and Effluent COD of Non-woven MBR



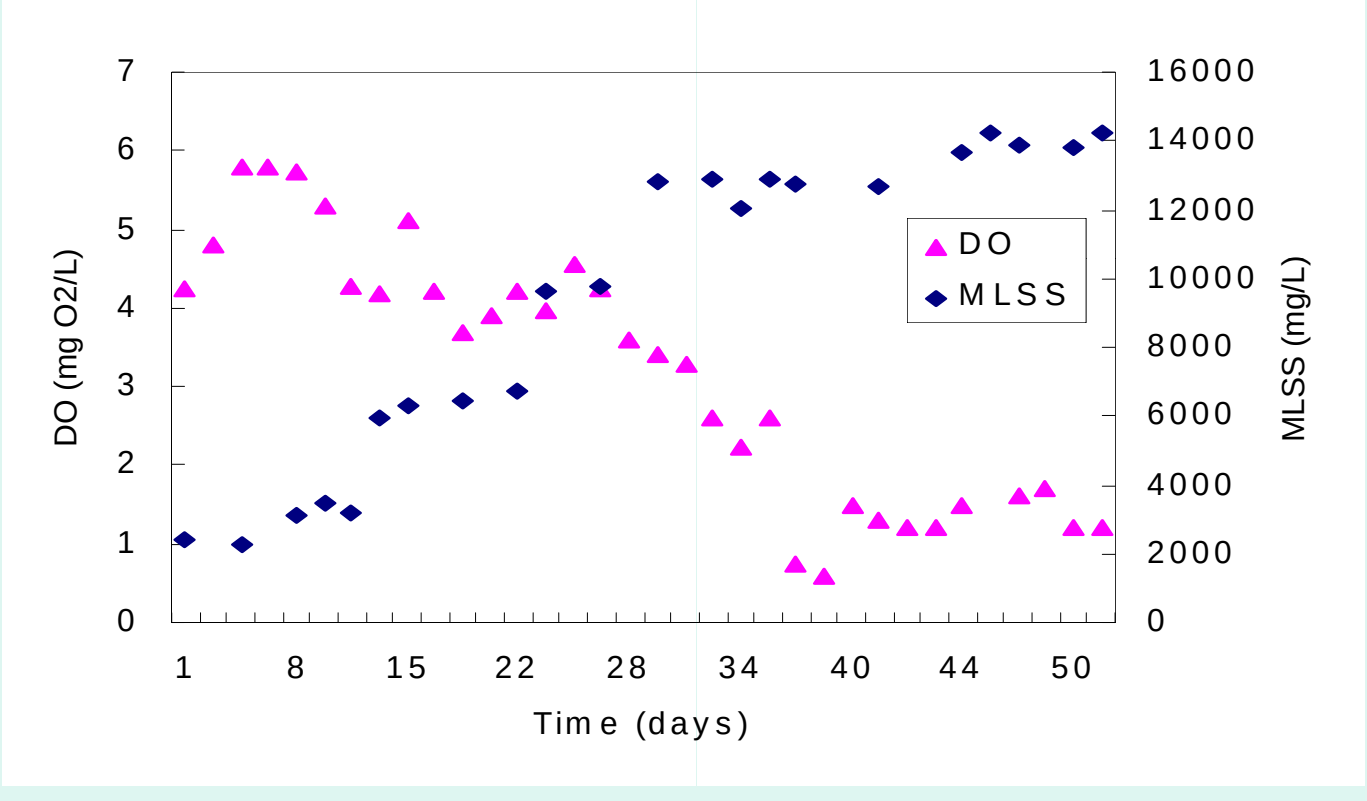
Food Product Wastewater

Influent and Effluent SS of Non-woven MBR



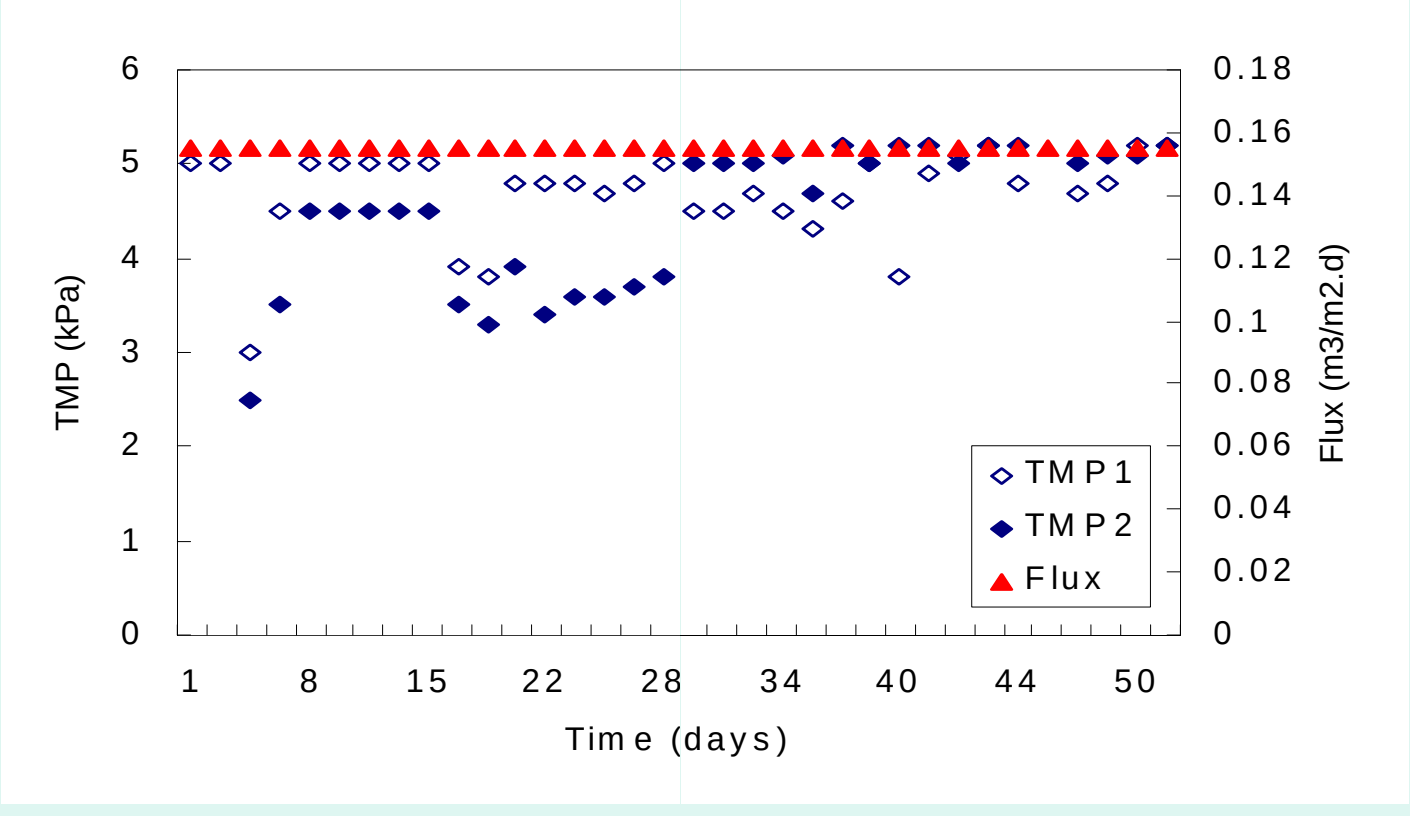
Food Product Wastewater

DO and MLSS of Non-woven MBR



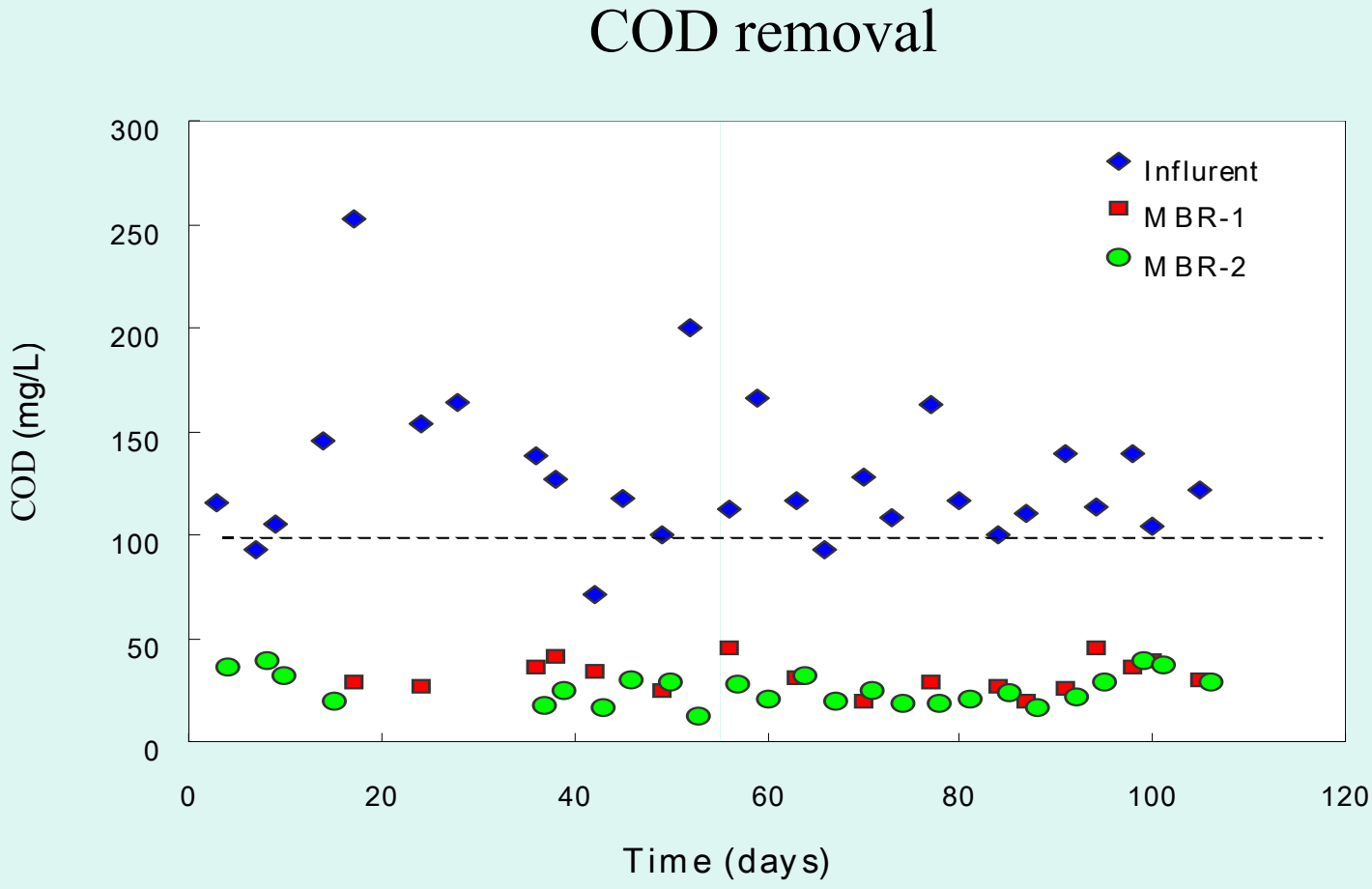
Food Product Wastewater

Transmembrane pressure (TMP) and flux of non-woven MBR

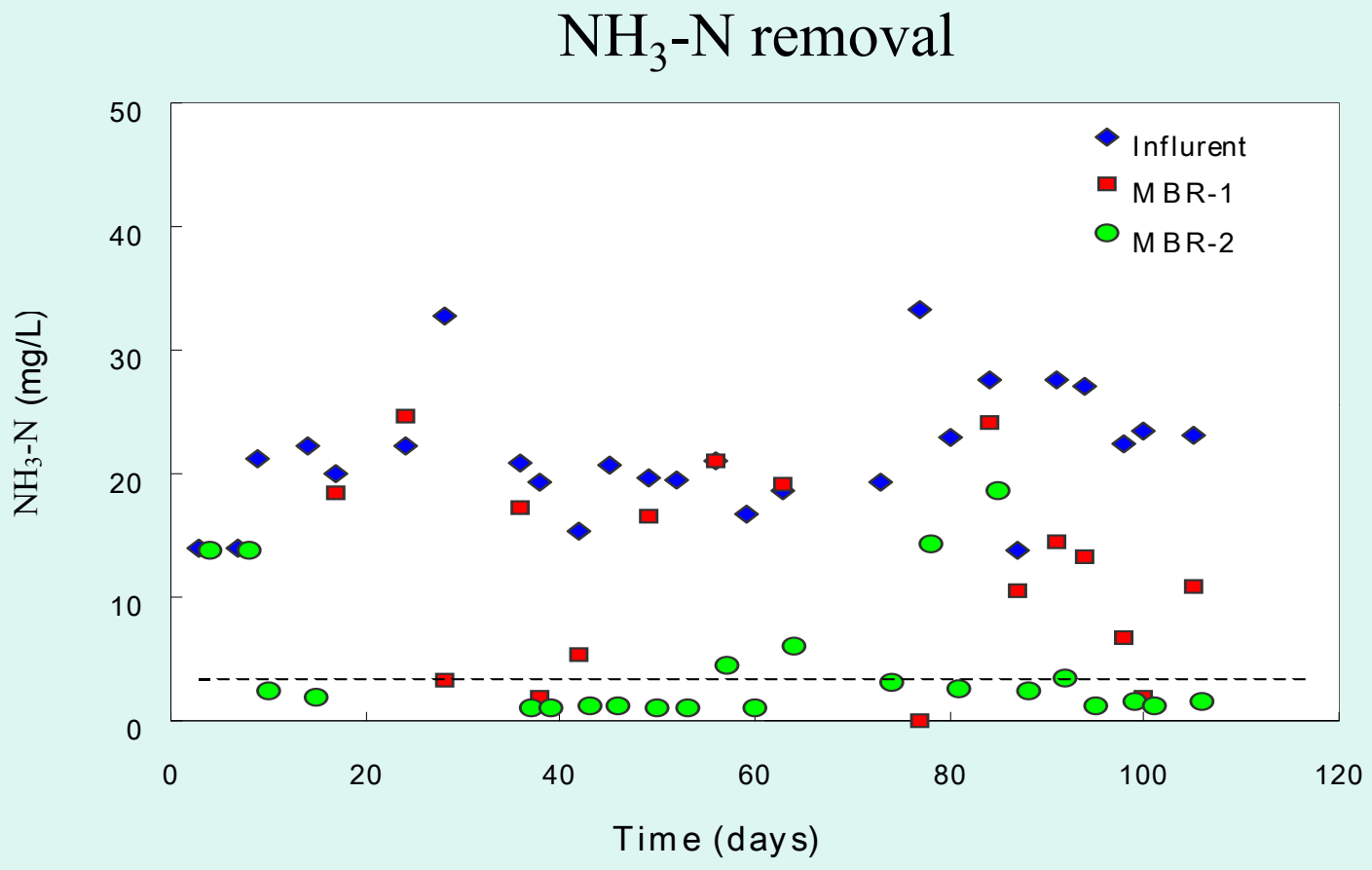


Sewage Non-woven MBR Treatment

Sewage Non-woven MBR Treatment



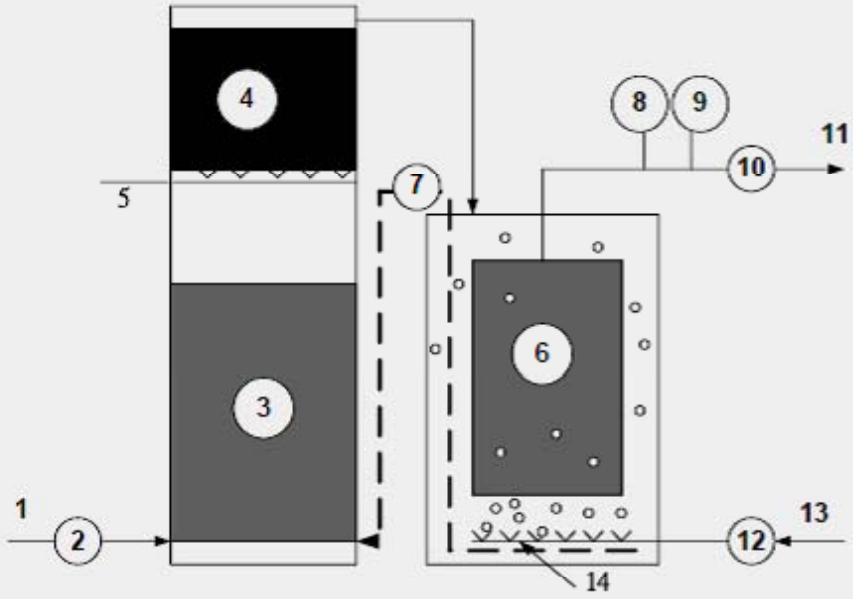
Non-woven MBR Treatment



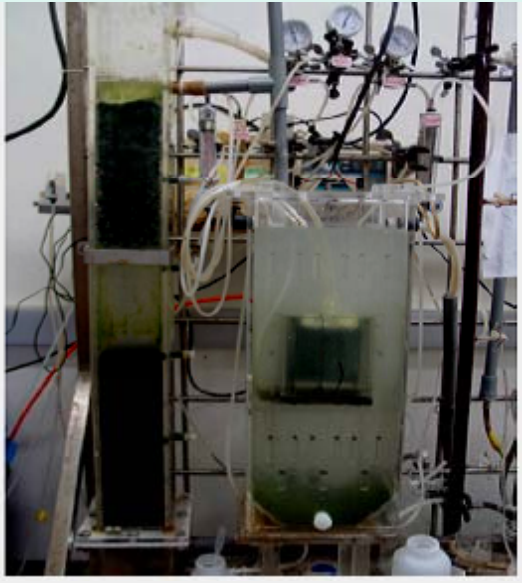
Benefit of Non-woven MBR

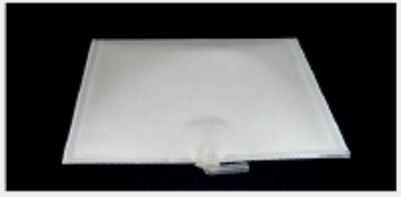
- Low transmembrane pressure
- Advantage in membrane cost
- Low requirement of influent quality and operation

Anaerobic Non-woven MBR process



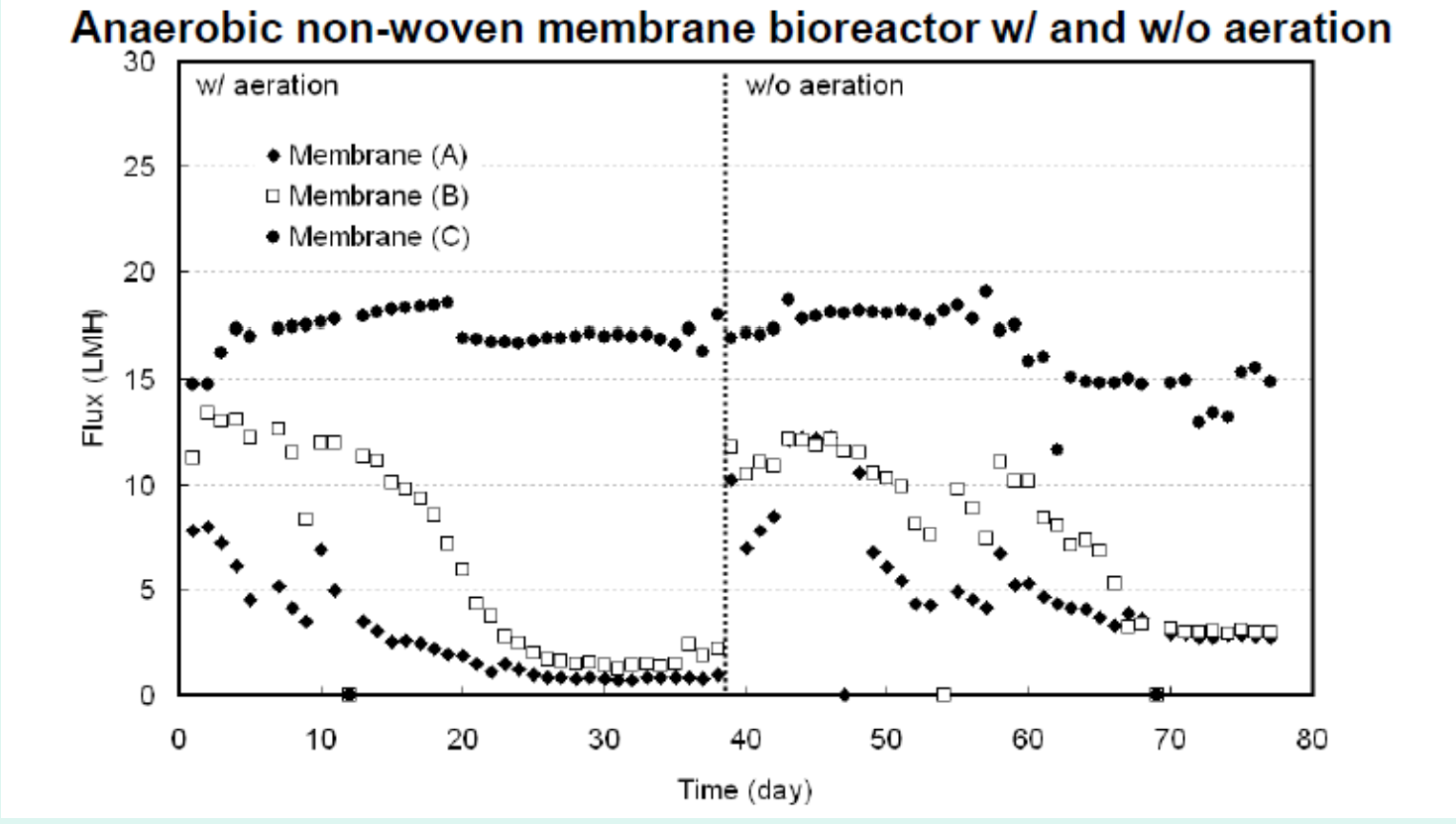
(1:進流水(influent)，2 ：進料幫浦(influent pump)， 3：厭氧生物區(anaerobic zone)，4:不織布擔體區 (non-woven carrier zone)， 5：反沖洗裝置(back-wash)，6:不織布薄膜分離區 (non-woven membrane zone)，7: 污泥回流幫浦 (sludge recycle pump)， 8 壓力表 (pressure gauge)，9:流量計(flow meter)，10: 濾液幫浦 (permeate pump)， 11:濾液(permeate)， 12 :曝氣裝置 (blower)，13：氣體(air)，14 曝氣裝置(aeration device)



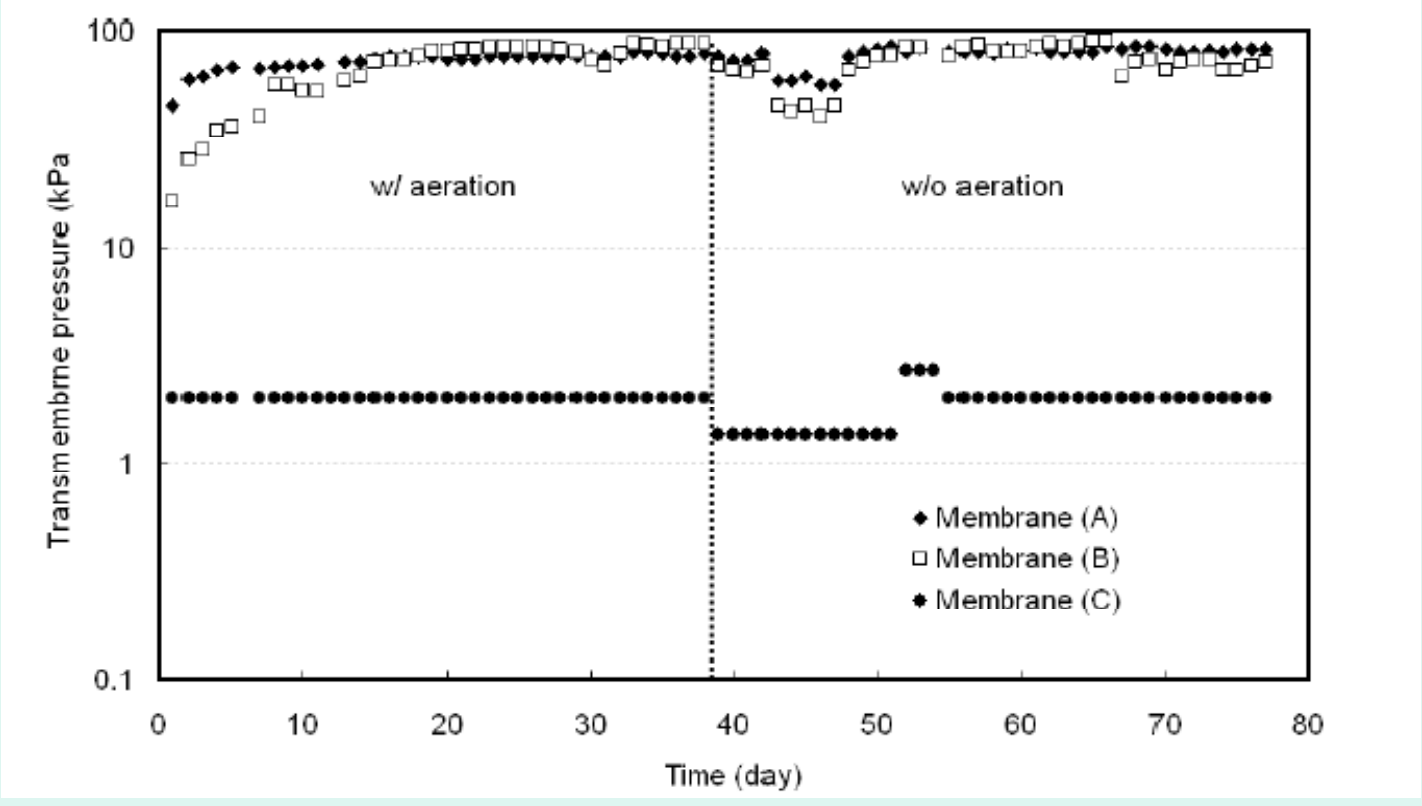


- **Three different pore sizes of non-woven membrane i.e.**
- **0.2μm (membrane A),**
- **2.0μm (membrane B),**
- **20.0μm (membrane c)**

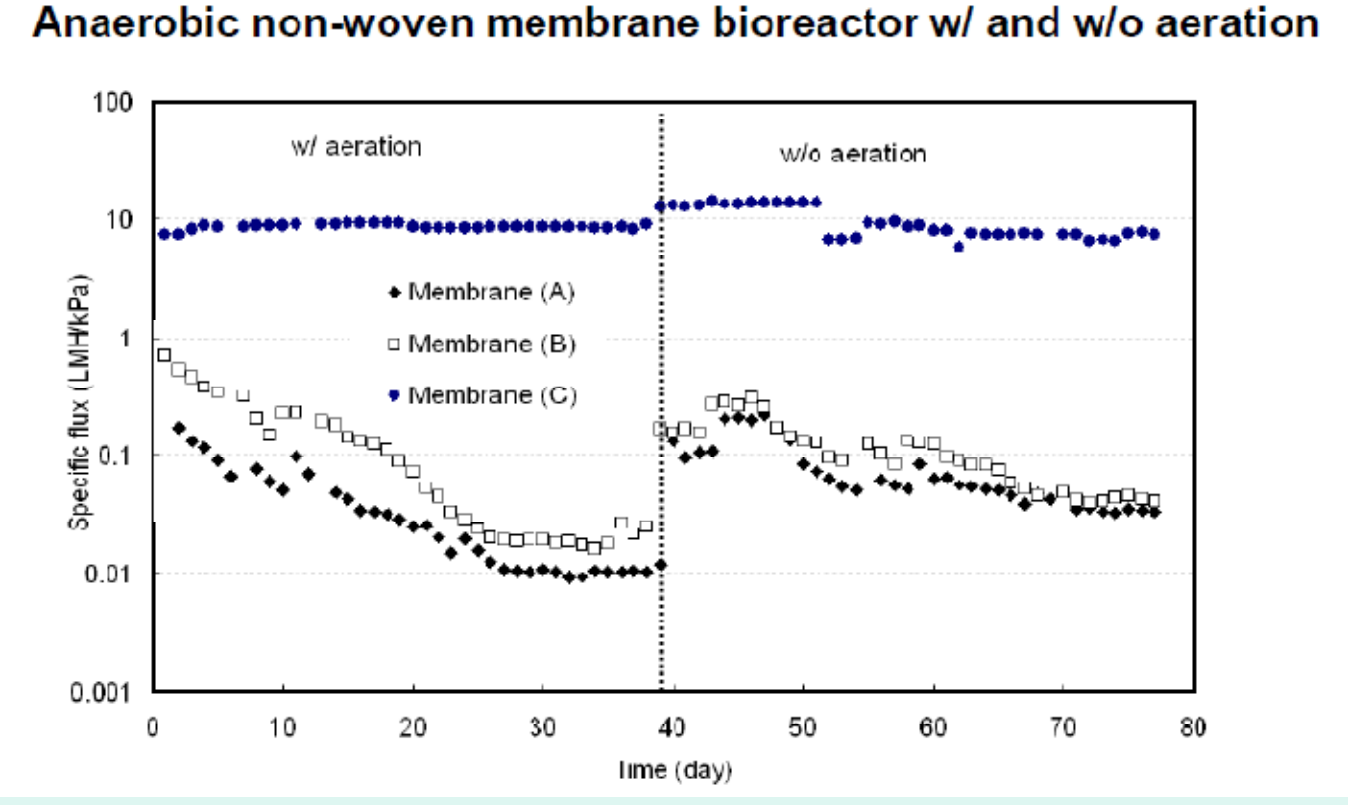
Anaerobic Non-woven MBR process



Anaerobic Non-woven MBR process

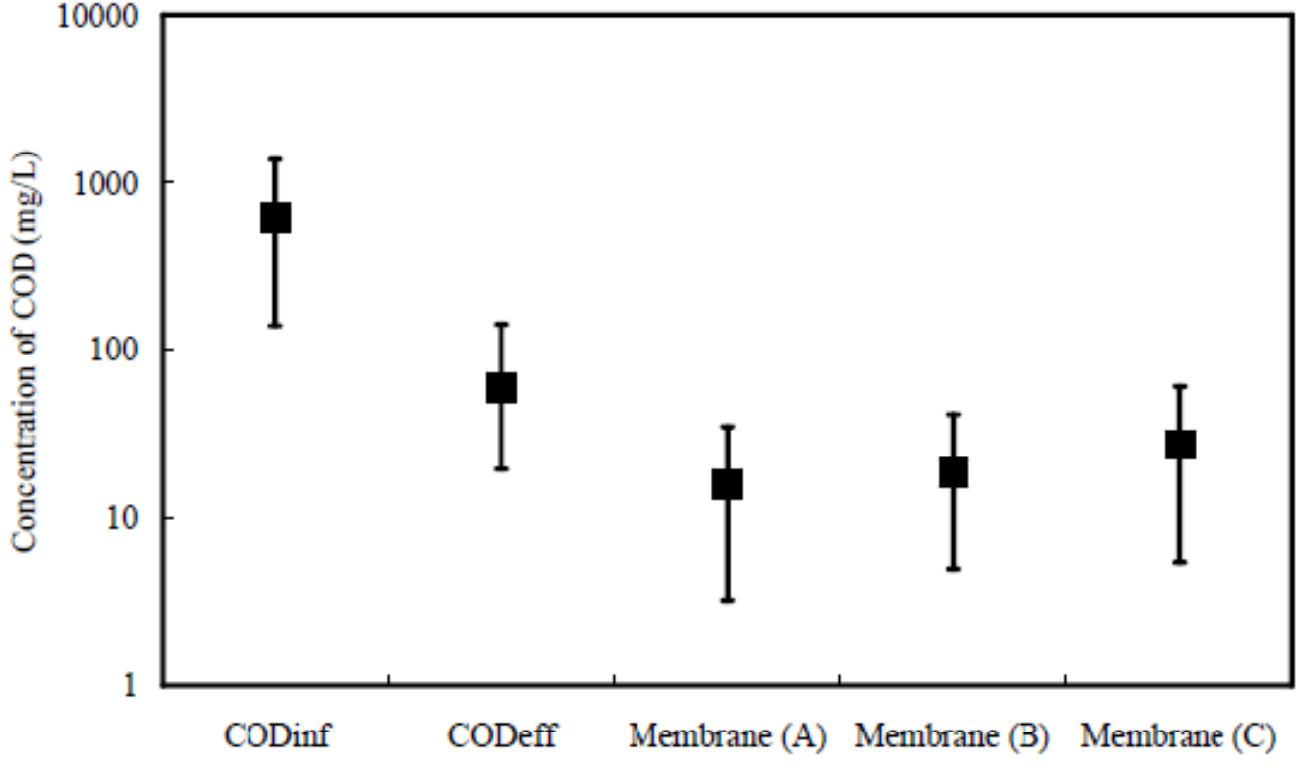


Anaerobic Non-woven MBR process



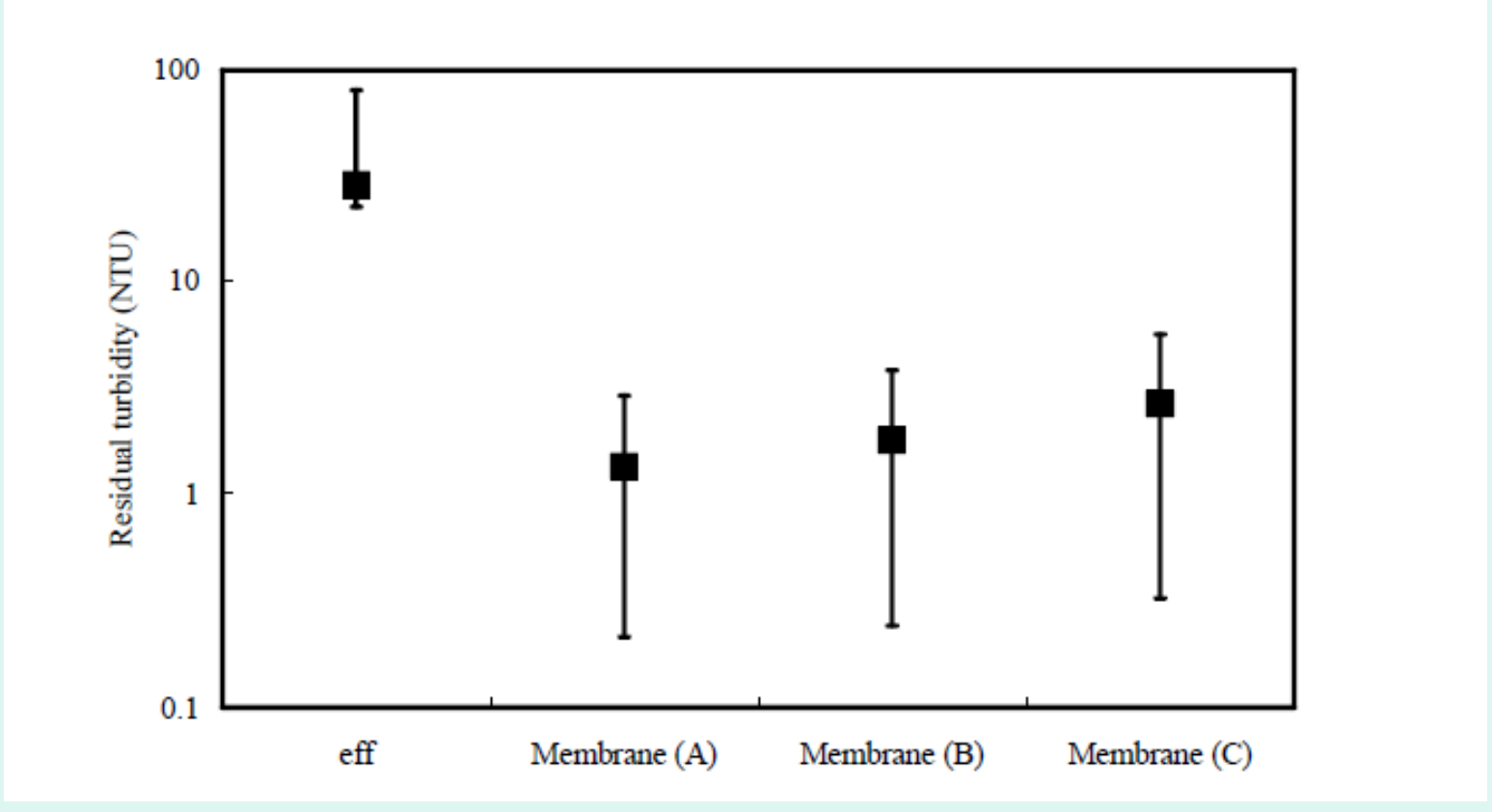
Anaerobic Non-woven MBR process

COD of the effluent from UASB and three membrane modules



Anaerobic Non-woven MBR process

Turbidity of the effluent from UASB and three membrane modules



Anaerobic Non-woven MBR process

Analysis of scale substance on the surface of non-woven membrane

foulants	units	influent	Membrane A (0.2 μm)	Membrane B (2.0 μm)	Membrane C (20.0 μm)
polysaccharide	mg/L	5.9	1.2	3.5	5.7
protein	mg/L	0.21	0.07	0.18	0.20
Bicarbonate alkalinity	mg/L as $CaCO_3$	764	646	707	737
calcium	mg/L	44.8	33.9	37.6	42.8

Conclusions

- Non-woven textiles could be used as the filter material of aerobic and anaerobic MBR by properly selecting its pore size to get low membrane fouling.

- The filtration behavior of the non-woven MBR is different from those of conventional microporous MBR, especially operating at high aeration intensity and high MLSS concentration.

- Anaerobic non-woven MBR, which saving much aeration energy for biodegradation and membrane scouring, shows that will be a promising technology for industrial wastewater treatment.

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Acknowledgements

- ITRI team would like to thank Taiwan KNH Company for a complete cooperation and help on non-woven MBR and relative research and development works.

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