Wastewater Recycle in Microelectronics Industry

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Outline

- General wastewater characteristics
- MBR in Taiwan
- References in Taiwan
- Operation & maintenance
- Concluding remarks

General wastewater characteristics in Microelectronics Industry

Inorganic wastewater

- From UPW system
- From facility operation
- From manufacturing process

Organic waste water

- From manufacturing process

Key objectives in treating the wastewater

- SS removal
- Organic matters removal
- Toxic removal
  - Heavy metal
  - Non-metal, F
- Upcoming challenges in effluent quality requirements
  - COD
  - Ammonium, TN
  - Acute toxicity (combination)
- Others
  - Conductivity
  - TP
  - …

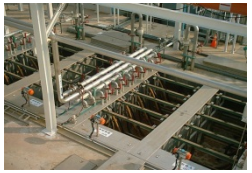
Driven in recycling the wastewater

- Requirements from Government and/or EIA
  - Recovery rate
- Reliability in treatment solutions/ technologies and engineering practice
  - Financial aspect, including CAPEX, OPEX, and ROI
  - BAT, Best Available Technology
- CSR, Corporation Social Responsibility

Possible waste stream to recycle

- Inorganic waste stream
  - ACF/MMF backwash
  - Cooling tower B/D
- Organic waste stream
  - Rinse wastewater
  - General organic wastewater

MBR in Taiwan



1998 2001 2003 2004 2005 2006 2007 2009 2012 2015

First Full scale SMBR plant (1270CMD)

First Integration with RO/ AOP'S for High WW Recovery Flow Rate (22,500CMD)

First Oil Refinery and Chemicals WW Treatment Plant(20,000CMD)

Municipal Industrial Park WW Plant(3000CMD)

Development and Validation (Lab & Pilot)

MBR+RO for WW Reclaim

First Integration with Anaerobic/UASB for High Con. Organic Liquid Waste Treatment (1500CMD)

First Semi-conductor Manufacturing MBR/ RO Reclaim Plant (1200CMD)

Large Scale Municipal Sewage WW Reclaim Plant (>20000CMD)

資料來源：C.H. Ni & J.C-T. Lin, 3rd International Conference on Membrane Bioreactors for Wastewater Treatment, MBR Asia 2013,

Full scale MBR plants for WW application in Taiwan

No.	Industry Types	Capacity (CMD)	Commissioning Date	Applied Processes
1	TFT-LCD(3.5G)	1,270	Dec., 2000	MBR + RO for reclamation
2	PDP	800	Jan., 2002	MBR + RO for reclamation
3	Polarizer	600	Mar., 2004	MBR for discharge
4	TFT-LCD(4.5& 5G)	5,000	Apr., 2004	Anaerobic +MBR + RO + AOP's for reclamation
5	Polarizer	600	Apr., 2005	MBR + RO for reclamation
6	Polarizer	200	Apr., 2005	Anaerobic + MBR for discharge
7	TFT-LCD(6G)	11,250(phase I) 11,250(phase 2)	Jun., 2005 Apr., 2007	MBR + RO + AOP's for reclamation
8	TFT-LCD(6G)	1,500	Jun., 2005	Anaerobic + MBR for discharge
9	TFT-LCD(6G)	6,000	Jul., 2005	MBR + RO + AOP's for reclamation
10	Color Filter(6G)	1,600	Aug., 2005	MBR for discharge
11	Petro-chemical	10,000(phase I) 10,000(phase 2)	Oct., 2005 Jun., 2006	MBR for discharge
12	Microelectronics	600	Apr.,2005	MBR + RO for reclamation
13	TFT-LCD(5G)	2,000	Nov., 2007	MBR + RO for reclamation
		2,800	Mar., 2008	MBR + RO for reclamation
		4,00	Mar., 2009	MBR + RO for reclamation
14	TFT-LCD(6G)	2,000	Jan., 2008	MBR + RO for reclamation
		2,000	Jul., 2009	MBR + RO for reclamation
		2,000	Jan., 2010	MBR + RO for reclamation
		2,600	Sep., 2011	MBR + RO for reclamation
15	TFT-LCD(7.5G)	13,200	Jul., 2009	MBR + RO +AC for reclamation
16	Microelectronics	50	Jul., 2009	MBR for discharge
17	Microelectronics	200	Jul., 2009	MBR for discharge
18	Petro-chemical	5,000	Oct., 2009	MBR for Reclamation
19	Microelectronics	1,200	Dec., 2009	MBR + RO for reclamation
20	TFT-LCD(8.5G)	15,000	Mar., 2011	MBR + RO +AC for reclamation
21	TFT-LCD(4G)	2,500	Dec, 2011	MBR + RO for reclamation
22	TFT-LCD(3.5G)	1920	May., 2011	MBR + RO for reclamation
23	Industrial Park	3000	Jun., 2012	MBR for discharge

資料來源：C.H. Ni & J.C-T. Lin, 3rd International Conference on Membrane Bioreactors for Wastewater Treatment, MBR Asia 2013,

Lab/Bench & Pilot Tests

MBR Lab Test

MBR Bench Test (~1m3/d)

MBR/RO Pilot Unit (~10m3/d)

MBR / RO/ AOP's Pilot Systems

MBR Pilot System (Capacity: ~10m3/day)

Biological aeration

RO Pilot System (Capacity: ~1.5 m3/day)

O3/UV/H2O2 Pilot System

The MBR/RO/AOP's (0.5~10 m3/day) pilot plant established by NCTU in 1998~2000

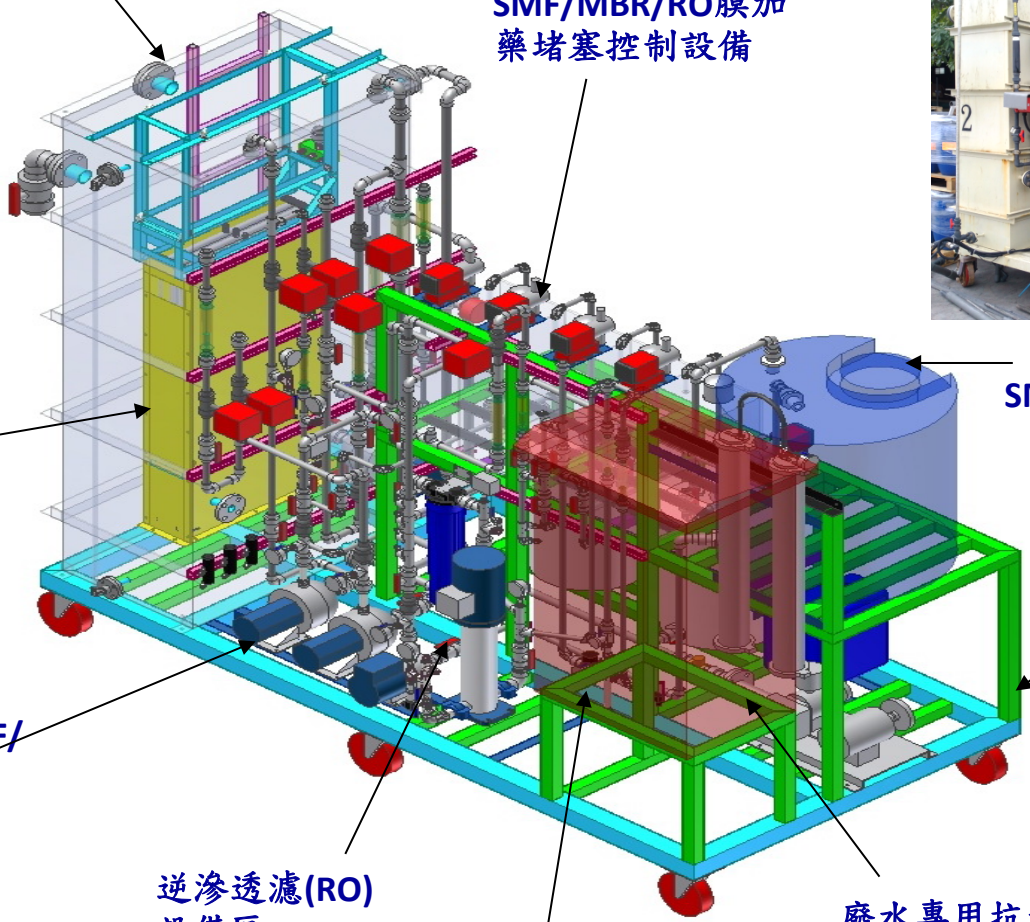
Results of MBR/RO/AOP Pilot Test

Item	Raw water	MBR Treated water		RO	UV/H2O2
	Average	Average	Removal(%)	Average	Average
Temperature ( )	27	28	–	30	29
pH	10.8	7.6	–	7.2	6.5
SS (mg/L)	5	b.d.	–	b.d.	b.d.
COD (mg/L)	1000	27	97.3	b.d.(<5)	b.d.
TOC (mg/L)	650	14.3	97.8	2. 1	<1
BOD (mg/L)	530	3	99.4	b.d.(<5)	b.d.
T-N (mg/L)	160	32.7	80.1	5.5	
NH4-N (mg/L)	2.3	5	–	2.1	
NOx-N (mg/L)	0.1	24.5	–		
Conductivity(us/cm)	550	2000		100	<150
SDI		2.2			

15 CMD MBR/SUF Pilot System

- 1 Train
- Total 3 elements
- UF, 18m2

SuperCycle™ SMF/MBR +RO 模型廠廢水回收處理系統



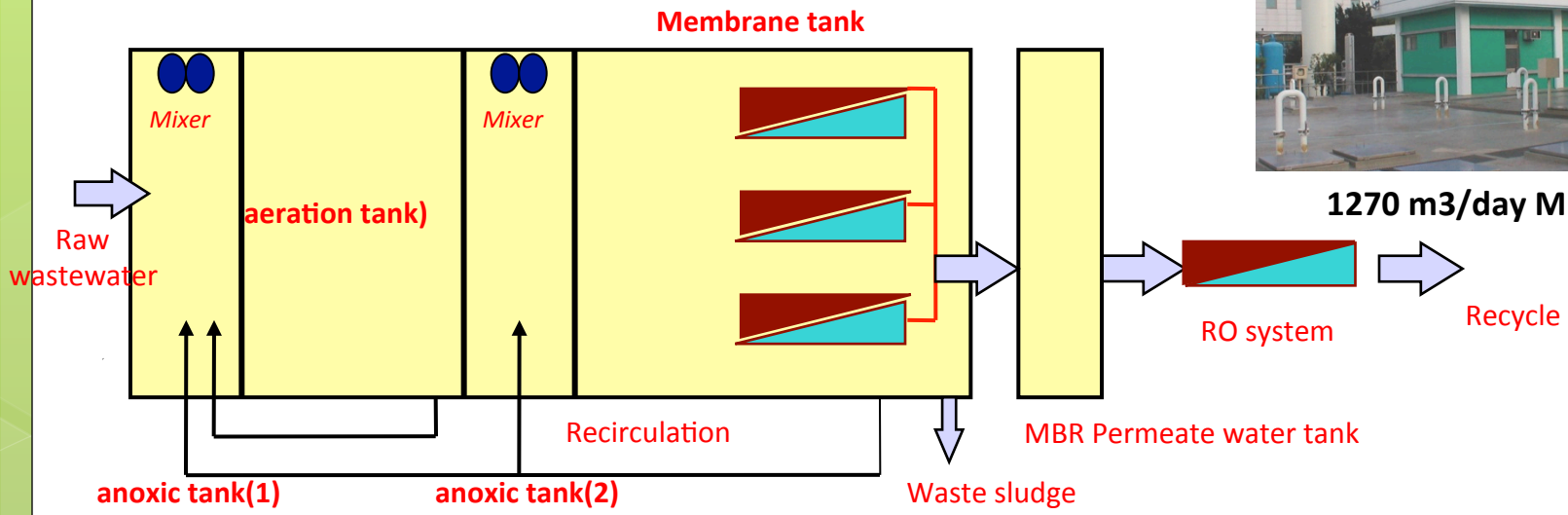
600 CMD MBR System

- **1 Train, 3 cassettes/Train**
- **Total 66 elements**

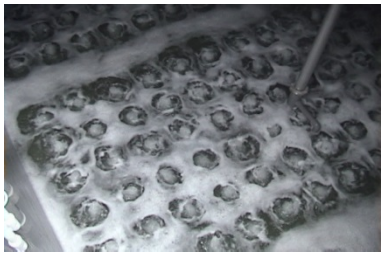
The First Full Scale SMBR/RO Plant(1270 m^3/day)

- MBR Commissioned in Dec. 2000
- RO Commissioned in 2002

1270 m3/day MBR Plant



anoxic tank mixer



Aeration tank diffusers

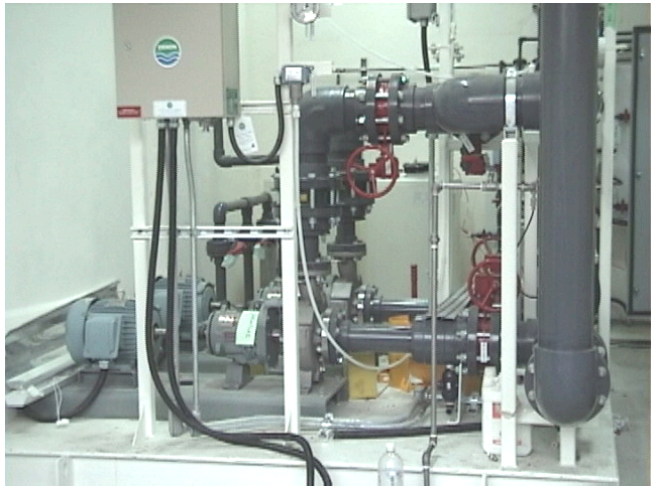
MBR membrane tank

RO system

1,270 CMD MBR System

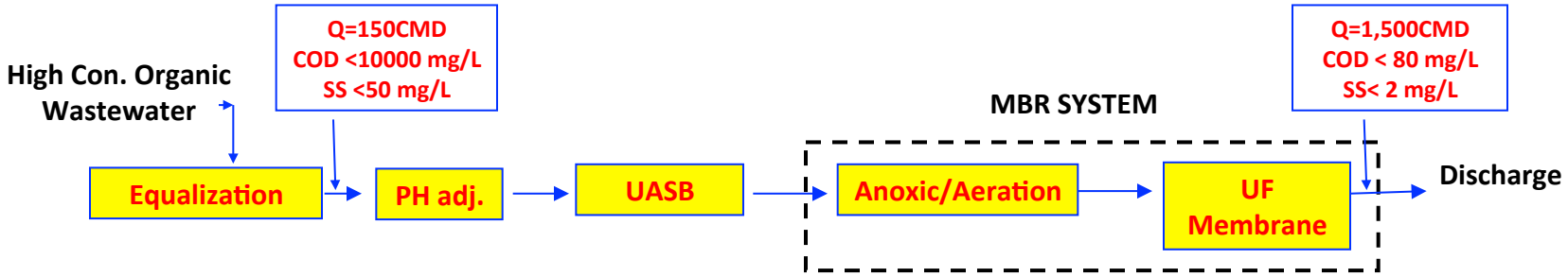
- 1 Train, 6 cassettes/Train
- Total 6 cassettes
- Total 48 elements

Process,Chemical pumps and Blowers for the MBR System



UASB/MBR Wastewater Treatment Plant (1500CMD)

- Highly Concentrated Organic Liquid Waste Treatment



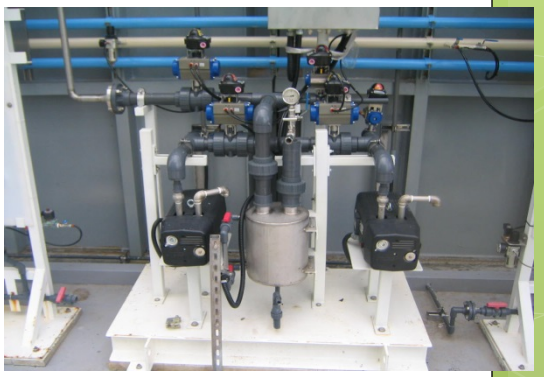
UASB Anaerobic System

MBR membrane System

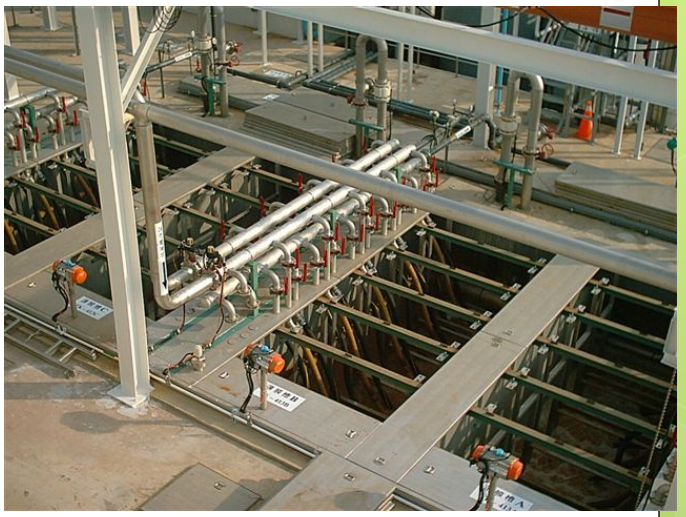
4,000 CMD MBR System

- 2 Trains, 3 cassettes/Train
- Total 6 cassettes
- Total 288 elements

4,000 CMD MBR System



5,000 CMD MBR System



- 4 Trains, 5 cassettes/Train
- Total 20 cassettes
- Total 440 elements

5,000 CMD MBR System

5,000 CMD MBR System

7,000CMD MBR System

- 4 Trains, 3 cassettes/Train
- Total 12 cassettes
- Total 576 elements

20,000 CMD MBR System

- 4 Trains, 8 cassettes/Train
- Total 32 cassettes
- Total 1536 elements

20,000 CMD MBR System

Membrane Blowers

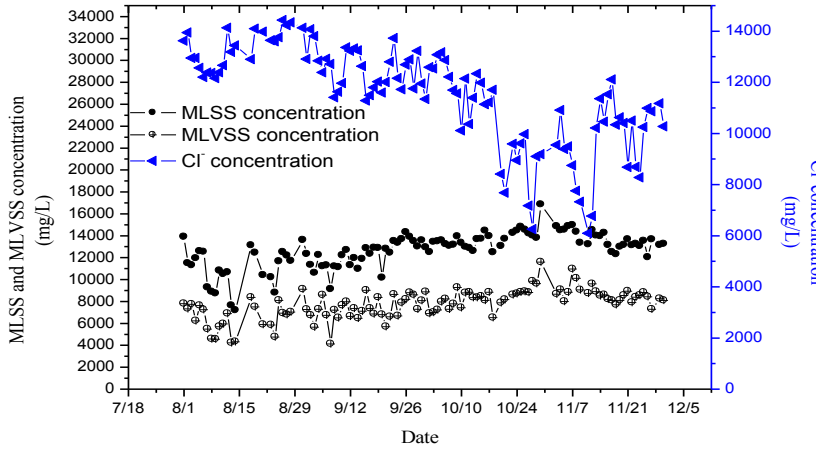
Permeate headers

PLC control panel

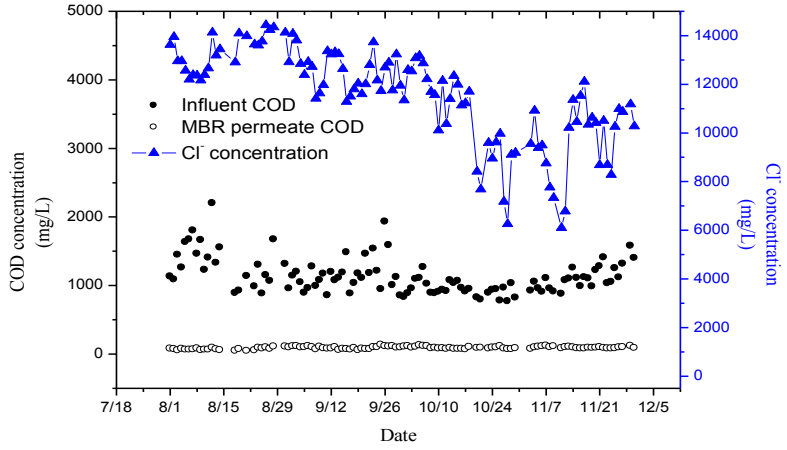
Chemical dosing station

Membrane tanks and pumps

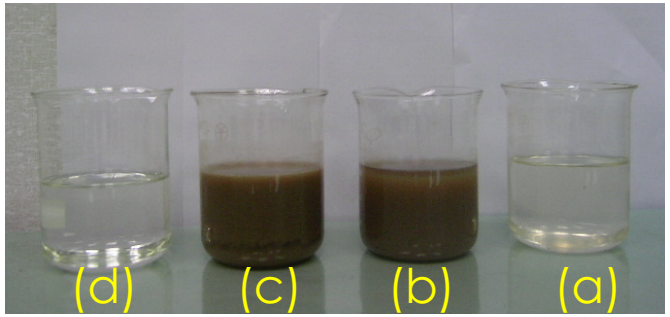
處理水質

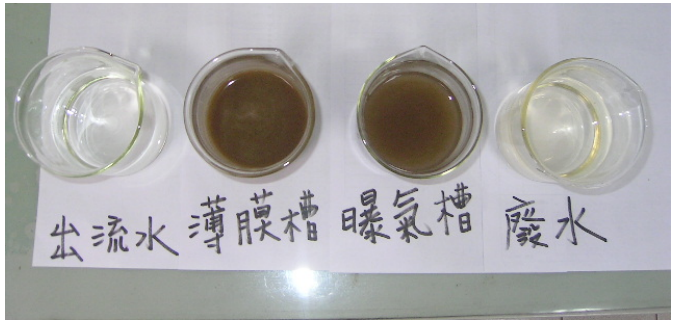


MLSS & Chloride Concentration



COD Removal





(a) Raw wastewater, (b) Aeration Tank, (c) Membrane tank, (d) MBR permeate

22,500CMD MBR System

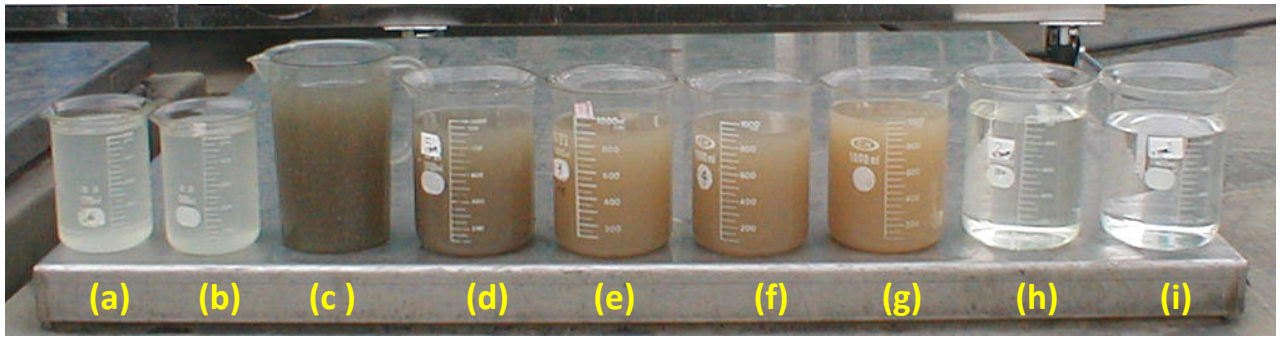
- 4 Trains, 8 cassettes/Train
- Total 32 cassettes
- Total 1536 elements

22,500CMD RO System

- 8 Trains, 3000CMD/train
- One pass, Three stages design
- Operating Pressure: 13~17kg/cm2
- Recovery > 88%
- Pre-filter Replace Freq.> 2 Mon.
- RO CIP Freq: 1.5~ 2 Mon.
- RO membrane life > 4 years

22,5000 CMD MBR/RO Water Quality

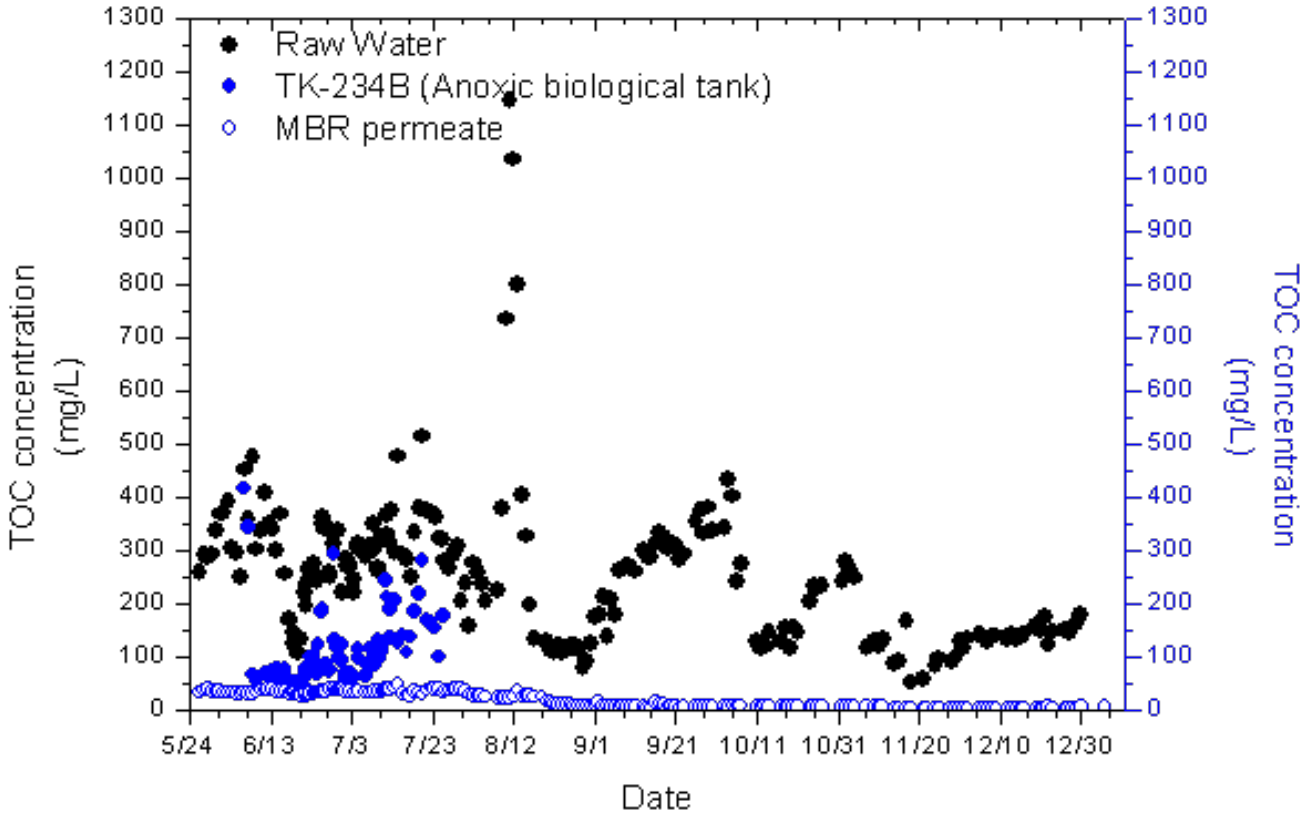
Item	Raw water	UF Treated water		RO permeate
	Average	Average	Removal(%)	Average
Temperature ( )	30	30	–	31
pH	8.7	6.6	–	7.0
SS (mg/L)	10	b.d.(<0)	–	b.d.(<0)
COD (mg/L)	450	20	>96	b.d.(<5)
TOC (mg/L)	150	8	>96	<0.8
BOD (mg/L)	140	3	>98	b.d.(<5)
T-N (mg/L)	15	5	>60	2
Conductivity(us/cm)	1050			<100
SDI		1.9		



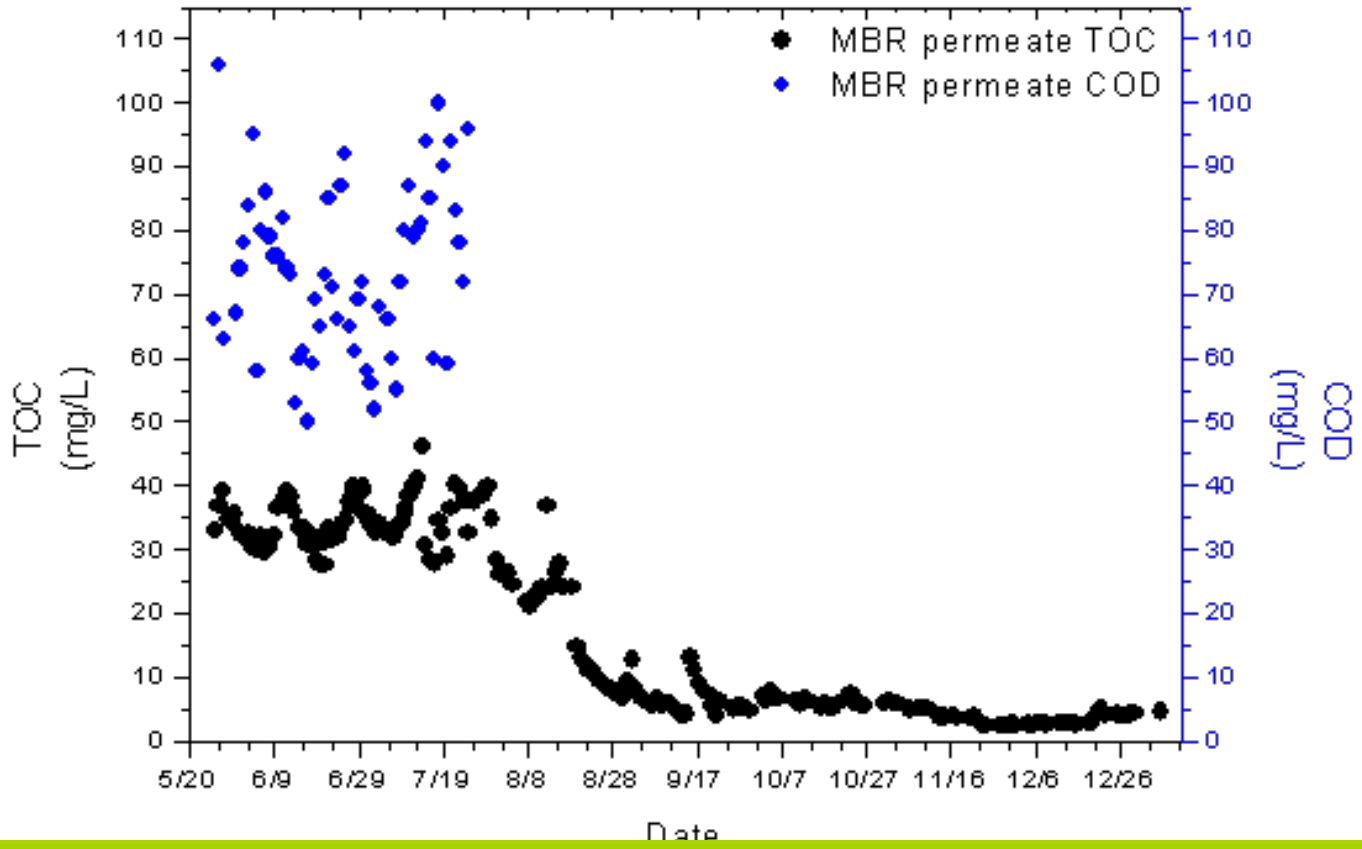
(a):raw wastewater, (b): PH adjustment, (c): anoxic tank, (d~f): aeration tank,
(g): MBR membrane tank, (h): MBR membrane permeate, (i): RO permeate

3,000CMD MBR System - PingJen Industrial Park WWTP

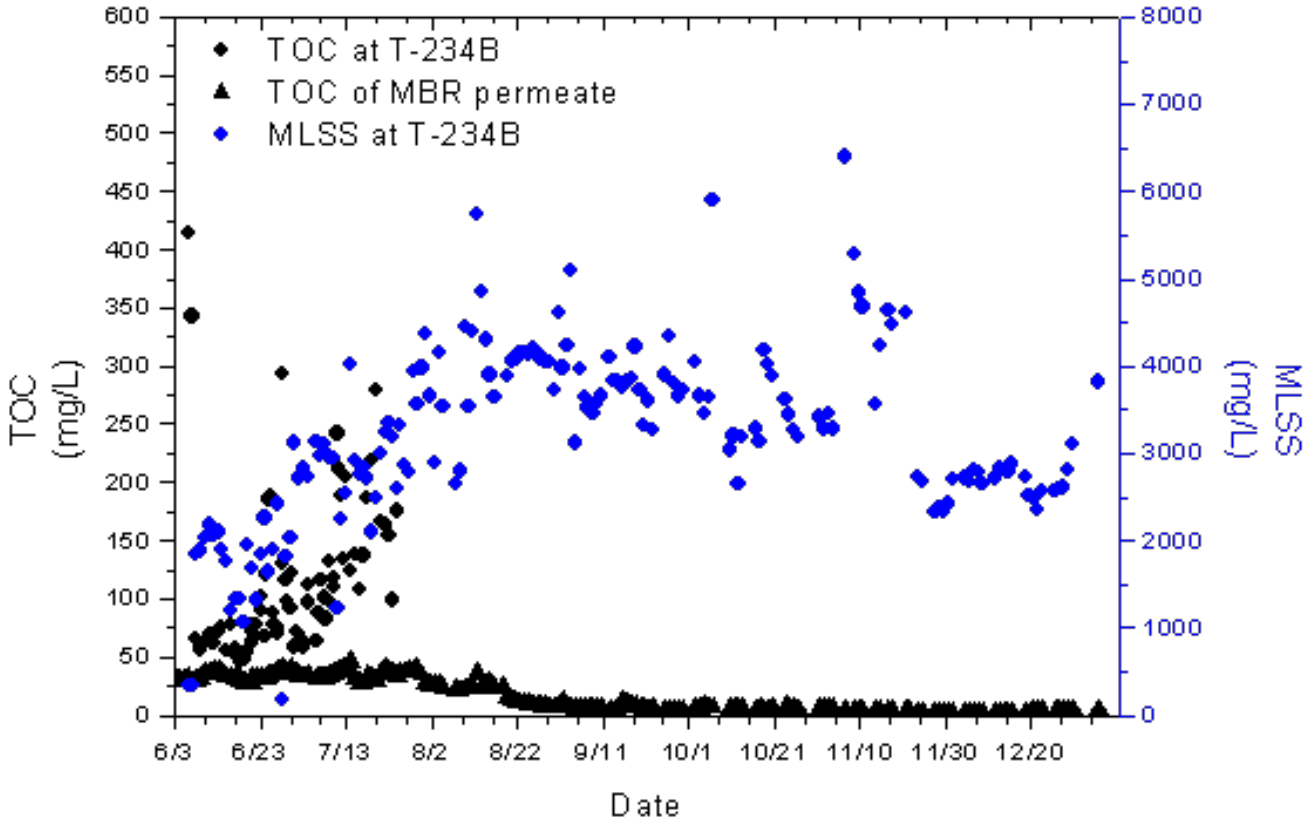
Operation & maintenance



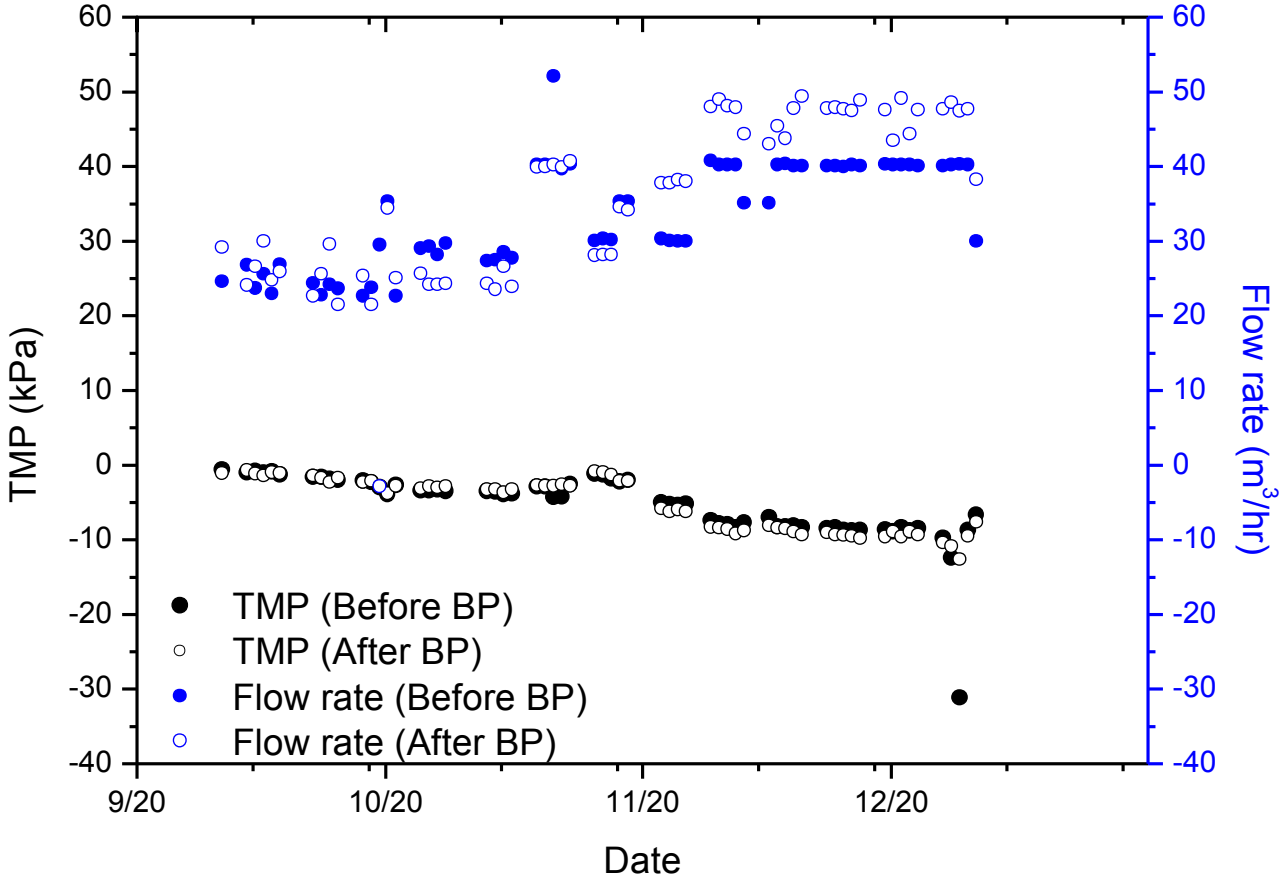
Operation & maintenance



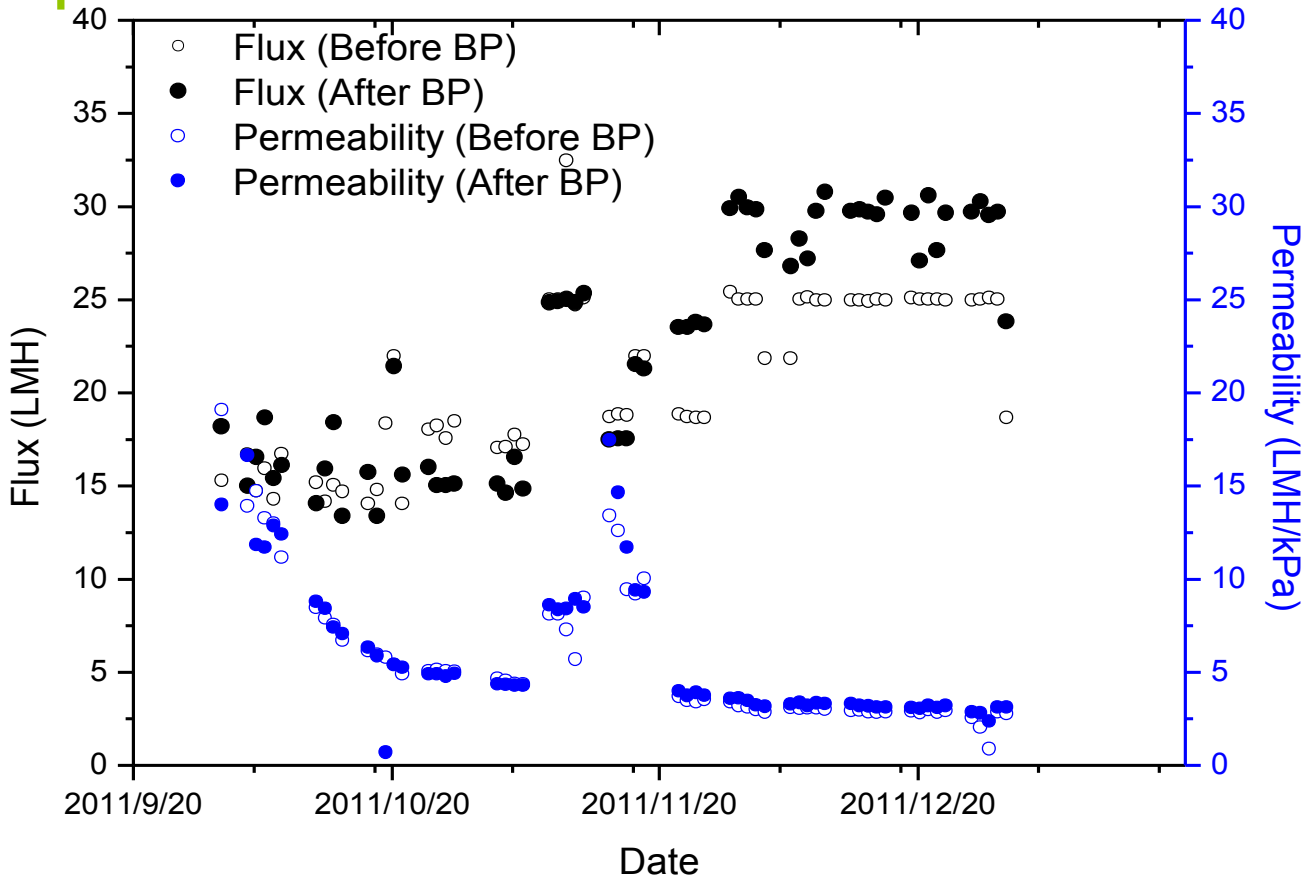
Operation & maintenance



Operation & maintenance



Operation & maintenance



Attentions in MBR operation

- **Trans-membrane Pressure Raising**

Mechanical issues:

- ✓ Sludging
- ✓ Air scour failing/not enough or aerator fouling
- ✓ Flow & pressure hardware failed

Wastewater and biological issues:

- ✓ Inorganic scaling
- ✓ Bio-fouling/ Shock loading
- ✓ Organics fouling

Attentions in MBR operation

- ✓ **Appropriate Membrane Flux Design**
  - ✓ Municipal WW (75~90 % of critical flux)
  - ✓ Industrial WW (60~75 % of critical flux)
- **Membrane or Pipeline Leakage**
  - ✓ Impact for the RO system
  - ✓ SDI test

薄膜長期使用損壞的主要原因

1. 薄膜表面汙泥黏著(Sludging)或異物割傷- 佔 30%

1) 膜絲強度不足，承受不了汙泥載重而斷裂。
2) 封膠處品質不佳或強度不足。
3) 鼓風量設計不足，沖刷效果不佳。
4) 操作不當

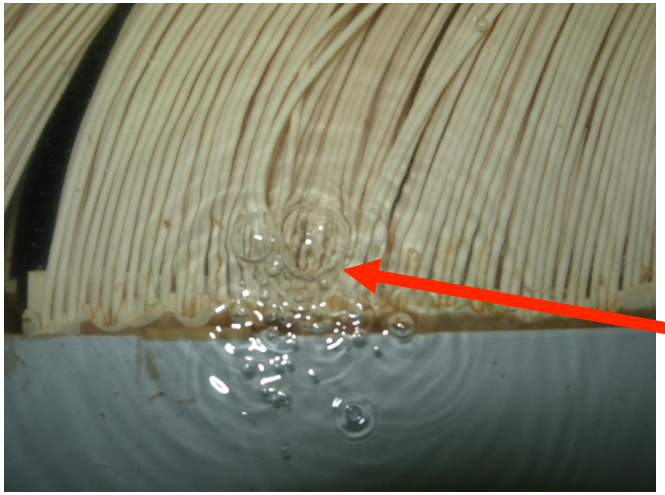
薄膜表面汙泥黏著

薄膜表面汙泥與異物黏著

薄膜長期使用損壞的主要原因

1.膜剝離與洩漏 –佔20%

1) 薄膜品質製作不佳。
2) 膜絲本身強度不足。
3) 藥洗頻率太頻繁
4) 不正確藥洗與操作



膜剝離與洩漏

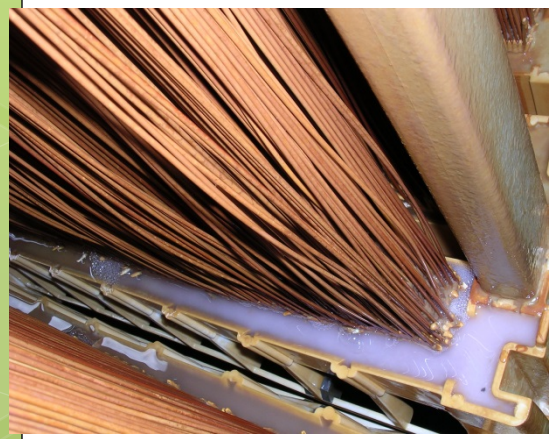
黏著劑: 銨基甲酸鹽，環氧樹酯與抗氧化劑

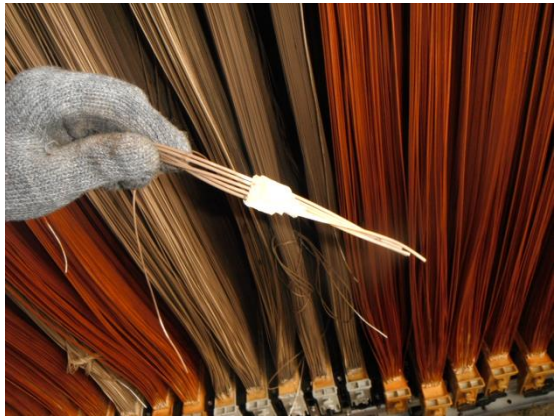
薄膜剝離

薄膜長期使用損壞的主要原因

2. 薄膜封口材料變質，造成薄膜洩漏與脫離- 20%

1) 膜絲與透水收集框黏著封膠處品質不佳或強度不足。
2) 不正確藥洗與操作
3) 藥洗頻率太頻繁



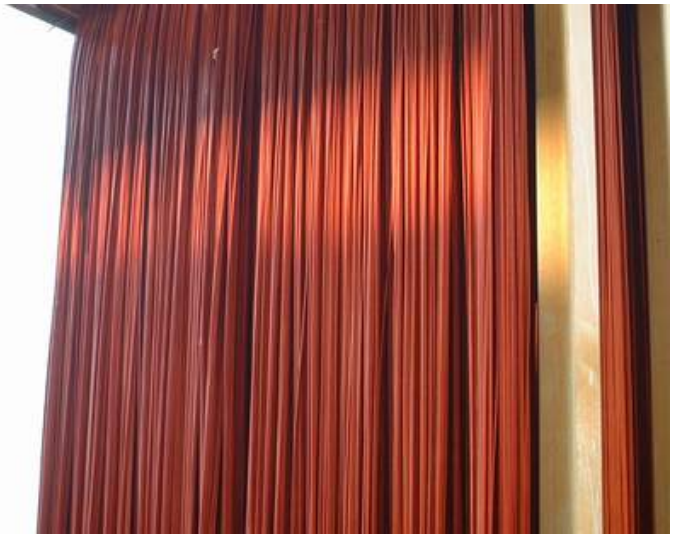


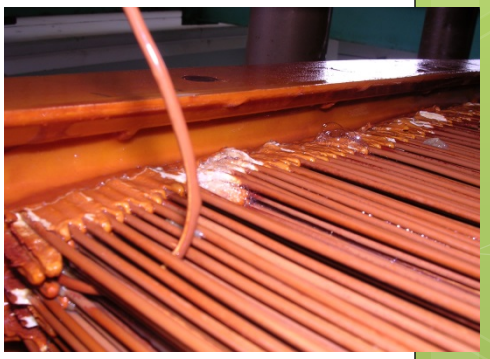
薄膜長期使用損壞的主要原因

4. 薄膜表面堵塞-佔20%

1)無機鹽類堵塞，清洗不易

2)不正確清洗與操作





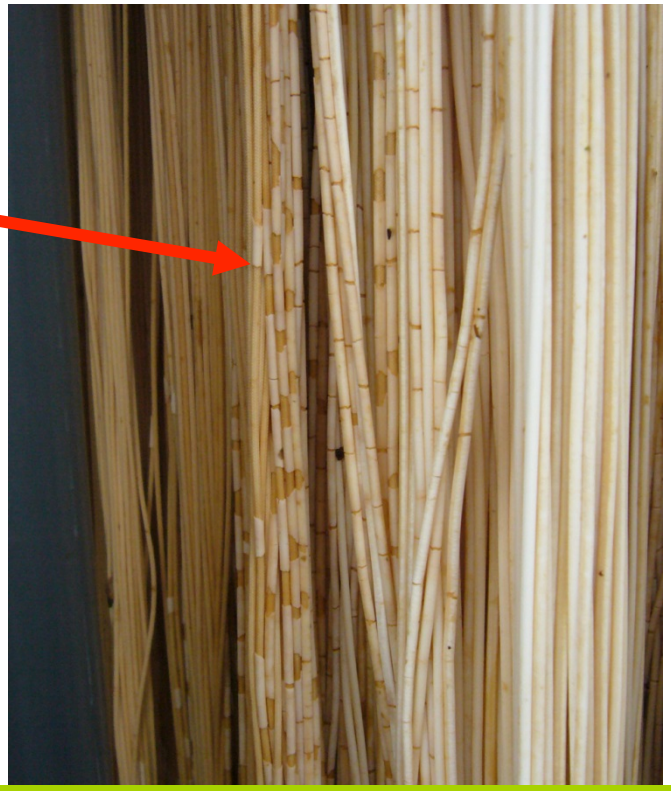
新膜與舊膜外觀比較

薄膜長期使用損壞的主要原因

3. 薄膜變質表面變質劣化破損 -10%

1)膜絲製作品質不佳

表面變質劣化



Concluding remarks

- Keys to recycle wastewater successfully
  - Wastewater streams split
  - BAT
  - Correct design & operation
  - Proper equipment & instruments
  - Comprehensive monitoring and trouble shooting
- Competence bidder

Concluding remarks

- Next trending in wastewater treatment/ recycle solutions
  - Energy saving
  - Green energy production
  - Liquid-liquid separation
  - ZLD
- N & P issues
- Acute toxicity

基於對地球環境保護的責任
我們致力於發展綠能與環境友善的環保技術
對全球環境永續的發展做出貢獻

ECOD
數宇科技顧問有限公司
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Profile
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工作經歷 /

- **數宇科技顧問有限公司(ECOD) 協理 (2013 ~)**
- **台灣威立雅有限公司 (Veolia Water Solutions & Technologies) 業務部經理 (2007 ~ 2013)**
- **綠太環境科技股份有限公司 (GETC) 副理 (2003 ~ 2007)**

專長/

- Wastewater Treatment
  - Chemical and physical treatment solutions, such as advanced oxidation process (AOP) and coagulation and precipitation
  - Biological treatment solutions, such as Membrane Bioreactor Technology (MBR) and Moving Bed Bio-Reactor (MBBR)
  - Evaporation and crystallization
  - ZLD design
- Ground water
  - Groundwater Flow and Contaminant Transport
  - Groundwater Remediation
  - Containment source identification

Profile
Experience

廢水處理與回收工作經歷:

- 中華映管龍潭廠 L1&L2 (2003)
- 中華映管楊梅廠 (2004)
- 廣輝(QDI) TFT-LCD 6G (AUO L6B) (2004)
- 力特光電 (Optimax) (2005)
- 台塑化 (FPCC Refinery) (2006)
- 和喬科技 (SHDT (Showa Denko HD Trace)) AOP reclaim BOT project (2006)

Profile
Experience

- 友達光電 L8B 廢水處理系統規劃 AUO L8B project (2008)
- 奇美光電T3廠 Chimei T3 MBR/RO reclaim project (2011)
- 友達光電L6B 銅蝕刻廢液 AUO L6B Spent Cu-etching chemical treatment /蒸發器 (2011)
- 友達光電L7A 銅蝕刻廢液 AUO L7A Spent Cu-etching chemical treatment /蒸發器 (2011)
- 友達光電L7A 銅蝕刻清洗廢水 AUO L7A Cu-etching rinse wastewater treatment / ACF + IEX (2011)
- 友達光電龍潭廠 廢水全回收專案 AUO LT ZLD project (2012)
- 中華映管龍潭廠 廢水全回收專案 CPT LT ZLD project (2013)
- 台塑化麥寮廢水系統改善案 (2012/2013)

Profile
Publication

Journal:

- Lin, Y.C., and H.D. Yeh (2005), THM Species Forecast Using Optimization Method: Genetic Algorithm and Simulated Annealing, *Journal of Computing in Civil Engineering*, ASCE, Vol. 19, No. 3, 248-257. (SCI)
- Lin, Y.C., and H.D. Yeh (2006), Identifying Groundwater Contaminant Source Characteristics Using Simulated Annealing, *Journal of the Chinese Institute of Environmental Engineering*, Vol.16, No.3, 183-188.
- Chang, T.H., Y.C. Lin, and H.D. Yeh (2006), Develop a Three-dimensional Model to Determine a Constant Release Contaminant Source in Groundwater, *Journal of the Chinese Institute of Environmental Engineering*, Vol.16, No.3, 189-194.
- Yeh, H.D., Y.C. Lin, and Y.C. Huang (2007), Parameter Identification for Leaky Aquifers Using Global Optimization Methods, *Hydrological Processes*. Vol. 21, No. 7, 862-872. (SCI, IF: 1.798)

Profile
Publication

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- Huang, Y.C., H.D. Yeh, and Y.C. Lin (2007), A Novel Approach Based on Simulated Annealing and Genetic Algorithm to Identify the Aquifer Parameters, *International Journal for Numerical and Analytical Methods in Geomechanics*. Vol. 32, No. 3, 235-249, doi: 10.1002/nag.623. (SCI, IF: 0.797)
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