초청강연 II

Membrane Technology for Waste Water Recovery

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1. Introduction

With the experience of the 1994 drought, and the shortage of water resources in Japan, it has been re-informed upon us ensure and maintain the stability of water resources. Accordingly, with each plant, a serious appraisal has begun looking at the re-use of waste water.

Membrane technology is an important process for waste water recovery.

Effluent from waste water facilities changes the quality of water significantly. The conventional pre-treatment of RO is hard to supply good quality feed water to RO in the waste water recovery system.

The microfiltration system as a pre-treatment of RO in the paper overcomes the fouling with the air backwash and is operated in direct flow mode at a low pressure producing a high flux.

The paper will focus the waste water recovery using membrane technology and many examples will be given.

2. Required Performance of membrane technology

The world largest 3000m3/day RO plant installed in 1971 at Sumitomo Metal Ind. Ltd., Kashima Iron & Steel Mill has been operating satisfactorily and has demonstrated excellent performance. This successful operation prompted the widespread application of RO plant. The RO plant at Smitomo Metal Ind. Ltd. has since been expanded to a capacity of 13,400m ^{3} /day Figure 1 shows the increase in the maximum capacity of the largest RO plant in the world. The RO plant at Sumitomo was surpassed by the 19,000m ^{3} /day Water Factory 21 plant in Orange County, Calif. to desalt sewage water by RO. Both two plants use the conventional pretreatment processes. (Figure2-1)

In conventional water treatment, the coagulation-sedimentation-filtration process is inevitable, which needs a large installation space.

The objective we hope to realize is to replace the coagulation-sedimentation-filtration by membrane in all water and wastewater treatment processes. The most important requirement for this purpose is development of an anti-fouling membrane modules suitable for treating heavily contaminated water. A membrane module suitable for wastewater must maintain a high flax at a low pressure without accumulating solids even when treating high solids wastewater, at a cost competitive with the conventional process.

Also it is reported on the global microbiology decline of drinking water quality.

The membrane technology is very effective to remove Giardia, Cryptosporidium and total coliform bacteria.

As a conclusion, the membrane technology pre requisites are as follows.

* Less Fouling and Higher Resistant Membrane
* Working at a Lower Pressure
* Higher Flux
* Lower Energy Consumption
* Lower Cost
* Higher Volume Treatment Capacity
* Longer Menbrane Life

3. Membrane Microfiltration with Air Backwash (Figure 3)

Membrane used in the systems are hollow fibre polypropylene membrane with a mean pore size of 0.2 micron. The membrane module consists of more than several thousand hollow fibres of 320 micron in inside diameter and 620 micron in outside diameter. The high porosity of the membrane (70% porosity) allows operation at a very low pressure. As well, this unique membrane has enough elasticity.

The membrane microfiltration system uses a gas backwash to clean the hollow fibre membranes. Gas at high pressure (600kpa) is injected into the center of the hollow fibres and bursts through the membranes, removing the foulants which have accumulated on the membrane surface.

As the gas passes through the membrane, it expands the membrane and shakes loose any built-up impurities.

Then, then contaminants are forcibly carried away into the feed stream. The operation takes about one minutes to complete, depending on feed water quality.

4. Reuse of Industrial Waste Water

1) Sony Mizunami factory

In Sony Mizunami factory, producing TV brown tube, total consumption of city water is at 2,200m^3 per day, then 1,100t/day of the organic waste water from the factory is treated with activated sludge process and discharged. For the purpose of re-use of this waste water due to 1994 drought,the test run of pilot plant was enforced for approximately 4,000 hours. As a result of this test, it was confirmed that the operation of the plant was well and hollow fibre type RO which was sensitive to feed water quality was easily applied using air backwash type MF. Therefore a re-μse plant shown in Figure-4 has installed. Table-1 shows the specification of membrane module used in the system and Table-2 shows the system's design condition.

The quality of treated water is quite good as shown in Table–3. Since the operation started in 1995 the system has been operated well.

Table–4 shows the running cost. Cost of city water is 250 yen/m^3, therefore the system takes the cost down.

2) Reuse of waste water in LCD manufacturing

A–factory (Figure 5)

Equipment : Two (2) only 420M10 MEMCOR standard microfiltation units
Two (2) only 500micron pre–screen
One (1) each Backwash tank and CIP Tank.

Pre–treatment : Biological treatment (fixed bed)

Installed : August 1994

Process :

Waste water is pumped directly from a waste water tank, then passed directly to the continuous microfiltration plant where the filtrate is stored in a holding tank to be processed through a carbon filter, then onto the RO system.

The RO permeate is stored in a holding tank to be processed through a mixed bed ion exchange unit then on to the process line to be used in the rinsing stage of the manufacture of electronic components.

Operational data :

The MEMCOR system produces 30,000 LPH continuously to meet the needs of production by 6 hours alternative operations. The backwash is directed to their waste water system to be repreprocessed. Chemical cleaning is carried out on a yearly basis using NaOH. This is done in conjunction with there annual maintenance shut down period.

Advantages :

The MEMCOR allows the RO system to work higher stable performance. Small footprint (restricted space). Minimum operator impute. Reliable and cost effective

B–factory (Figure 6)

Equipment : One (1) only 300M10 MEMCOR standard microfiltation units
One (1) only 500 micron pre–screen
One (1) each Backwash tank and CIP Tank.

Pre–treatment : Biological treatment (fixed bed)

Installed : October 1994

The MEMCOR system produces 25,000 LPH continuously to meet the needs of production.

3) Reuse of waste water in Electronics Co. in Malaysia (Figure 7)

Application : To treat their process water for re–use in the manufacturing area or directly to drain

Equipment : One (1) only 200M10 MEMCOR standard microfiltration units
One (1) CIP Tank.

Installed : 1994

Pre-treatment : Conventional plus Biological treatment (fixed bed)

Process :

Waste water is pumped directly from a waste water tank to the conventional treatment plant where the appropriate chemicals are added to floc out the solids and oils/greases.

It is then passed directly to the biological treatment for the removal of BOD/COD. Then to the continuous microfiltration plant where the filtrate is either reused or to the drain.

Operational data :

The MEMCOR system produces 18,000 LPH continuously to meet the needs of production.

The backwash is directed to their waste water system to be reprocessed to their cooling water system. Chemical cleaning is carried out on a 3 day basis using EXA2 or acid.

This is done in conjunction with their maintenance shut down period.

Advantages :

Due to the clean water act in Malaysia, ALL companies must treat their waste water before going to the common drainage system. In some cases they can re-use the filtrate for cooling water in their plant.

5. Sewage Treatment

Table-5 shows the typical result of MF membrane filtration for sewage secondary effluent

1) Water Factory 21 (Figure 2-1, 2-2)

Since the early 1970s Water Factory 21 of Orange County Water District has been treating secondary effluent to a potable standard for recharging a fresh water aquifer. The aquifer, which is a major source of potable water for the Los Angeles area, has dropped significantly over the years and is subject to salt water ingress.

The existing plant includes a six-step lime based pretreatment process to remove fine solids, bacteria and viruses ahead of reverse osmosis. Since April 1992, as part of a strategy to double the plant's capacity, Water Factory 21 has been trialling one-step microfiltration to replace the existing expensive and operationally troublesome pretreatment. The work has produced such favorable results that the district has installed a 2.7MLPD microfiltration system as part of its scale-up strategy.

2) Pacific Power Corporation NSW Australia-Eraring Power Station (Figure 8)

Application : Treatment of secondary sewage for use as feed to the high pressure boiler feed

: Demineralizer plant and for other process water applications

Equipment : Two 90 module M10C Continuous Microfiltration Machines and two CA Reverse Osmosis trains,with associated ancillary equipment, each capable of handling 40% of the CMF filtrate.

Capacity : 3.5 MLPD of feed with peak flow of 5.2MLPD

3) Aberporth and Tresaith sewage treatment works (Figure 9 and Table 6)

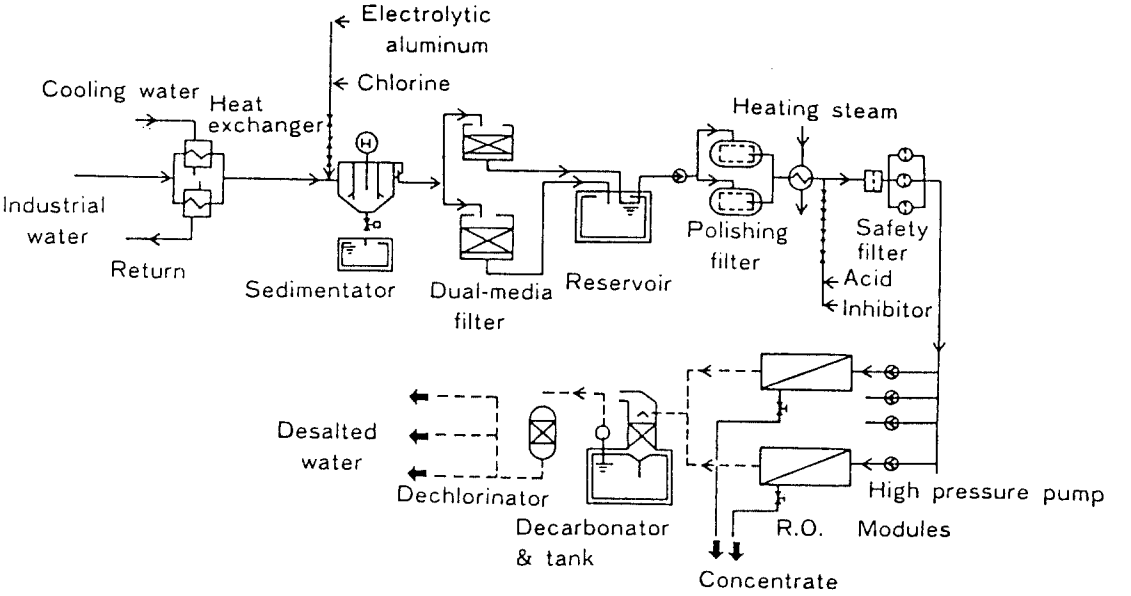
Application :

Sewage treatment works for coastal discharge, incorporating disinfection by continuous microfiltration.

6. Conclusion

Research on membranes has been active in many countries in the world. As a result, high-flux/high-rejection membranes at a low pressure are emerging.

The membrane application to wastewater treatment will be promoted under these circumstances. We hope mutual cooperation will develop among various countries in this field of technology.



FLOW DIAGRAM OF THE RO UNIT AT SUMITOMO METAL IND.LTD.,AT KASHIMA

Figure 1

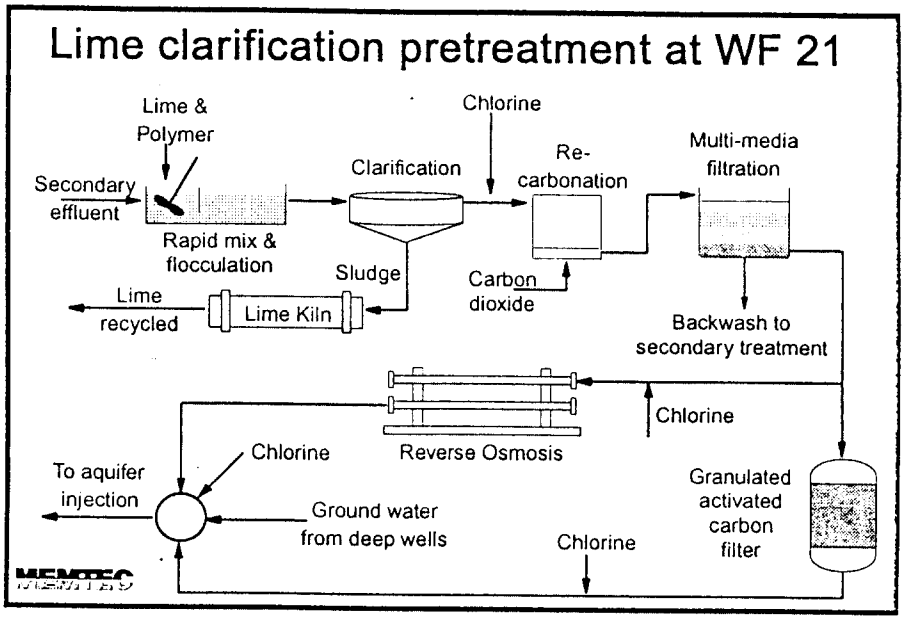


Figure 2-1

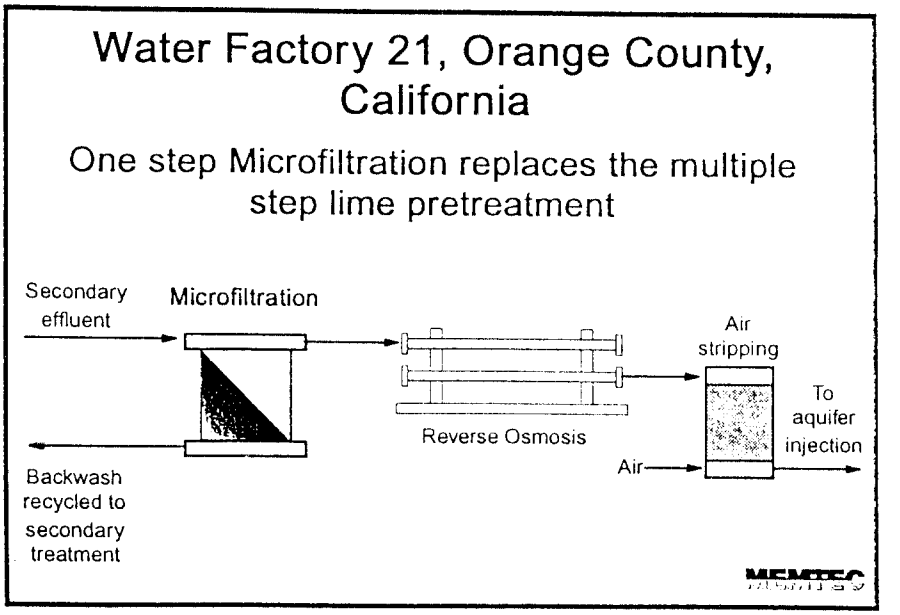


Figure 2-2

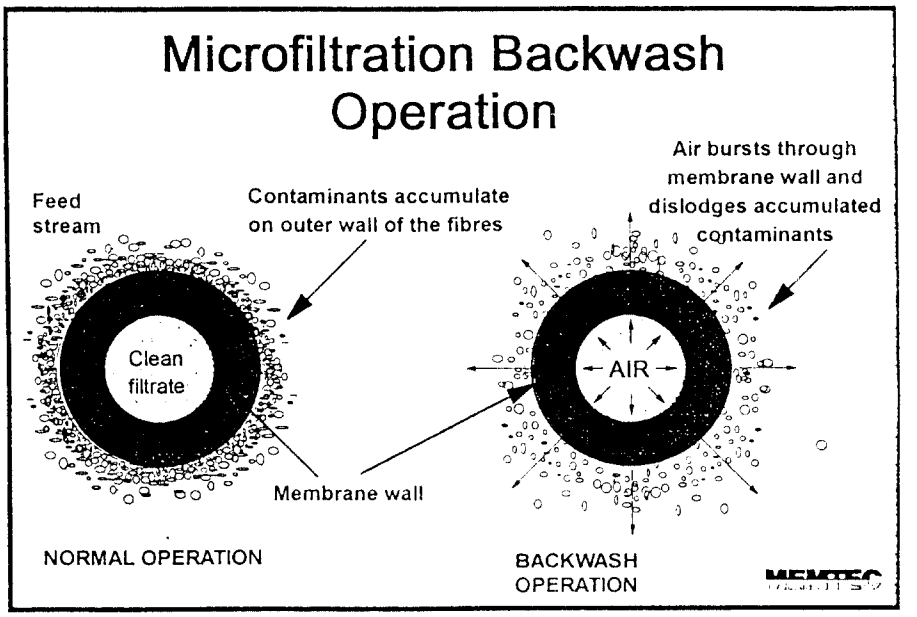
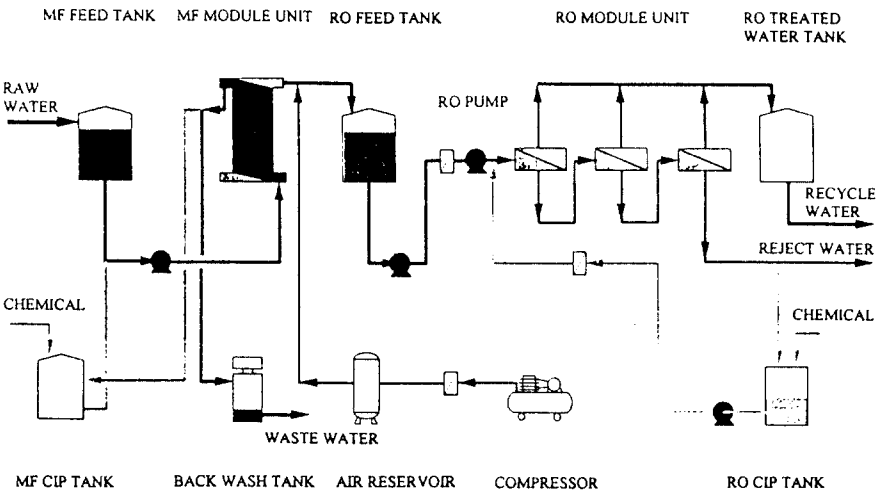


Figure 3



Schematic flow diagram of the industrial waste water recycle system
Capacity:720m3/day Recovery ratio:75%

Figure 4

Table-1 Specification of Membrane module

	MF Membrane module	RO Membrane module
· Manufacturer	MEMTEC LTD.	TOYOBO CO.,Ltd.
· Model	MEMCOR M10C	HOLLOSEP HA8130
· Filtration mode	External pressure Dead end	–
· Material	Polypropylene	Tri-Cellulose acetate
· Pore size	0.2 μ m	–
· Membrane area	15m2/module	–
· Permeate flow rate	–	60m3/day/module
· NaCl rejection	–	94% as 1500mg/l
· Dimention	118mm ϕ × 1156mmL	295mm ϕ × 1320mmL

Table-2 Design condition

	MF Unit	RO Unit
· Permeate flow	720m3/day	540m3/day
· Module No.	48 No. off	12 No. off
· Stage No.	1	3
· Applied pressure	20～150kPa	2～4mPa
· Water recovery	87%	75%
· Net water flux	1.2m3/m2/day	—

Table-3 Water analysis data (Sampling date 1995.9.25)

Substance	Raw water	MF treated water	Ro treated water
· Temperrature(℃)	27	—	—
· Conductivity(μ S/cm)	—	365	5.6
· Suspended solid(mg/l)	19	< 1	—
· pH	—	7.3	—
· TDS(mg/l)	—	254	3
· Calcium(mg/l)	—	31.9	—
· magneisum(mg/l)	—	0.9	—
· Sodium(mg/l)	—	25.1	—
· Bicarbonate(mg/l)	—	12.5	—
· Sulfate(mg/l)	—	113	—
· Nitrate(mg/l)	—	13.3	—
· Clorite(mg/l)	—	4.6	—
· Silica(mg/l)	—	10.5	—
· SDI	—	1.9	—
· COD(mg/l as O)	16	6.8	—

Table-4 Running cost

(unit:¥/m3)

	MF unit	RO unit	Total
· Electrical	6.41	25.98	32.39
· Membrane module	19.71	17.28	37.03
· Chemicals	4.16	11.00	15.16
· Maintenance	5.00	5.00	10.00
Total	30.32	54.26	94.58

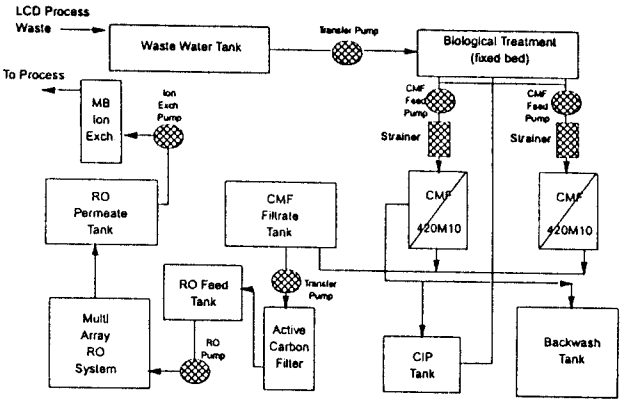


Figure 5

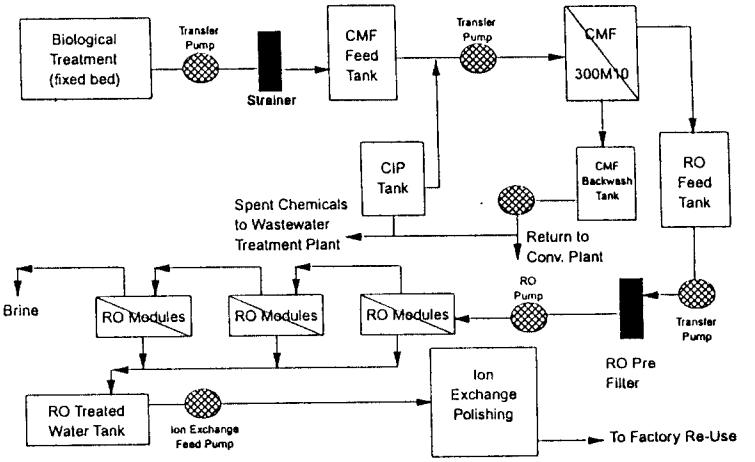


Figure 6

Malaysian plants

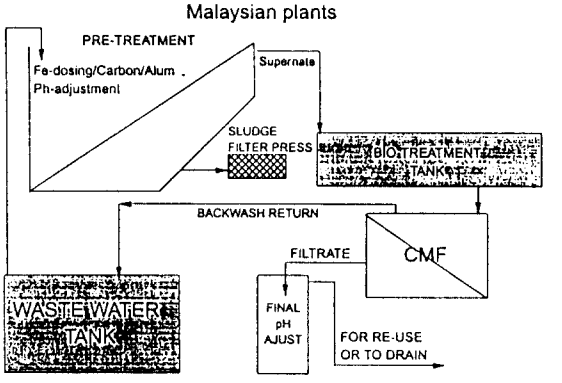


Figure 7

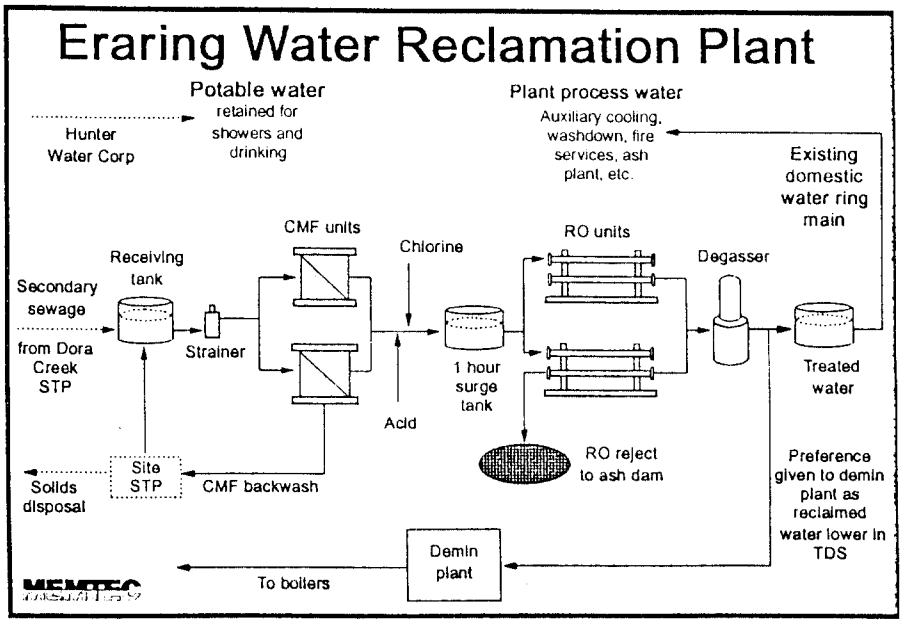


Figure 8

Table 5 GENERAL OPERATING CONDITIONS OF MEMCOR® CMF SYSTEMS

CONTAMINANTS	FEED	FILTRATE	REMOVAL EFFICIENCY
Suspended Solids	Mean 200 mg/l	<1 mg/l	99.5%
Colloidal Particles	Similar to above	Similar to above	99.5%
Turbidity	500 ntu	<0.2 ntu	99.96%
Silt Density Index	Over 5	2.0 to 1.0	N/A
Total Coliforms	10^6 cfu/100ml	<1 cfu/100 ml	5 log
Fecal Bacteria	10^6 cfu/100ml	<1 cfu/100 ml	6 log
Giardia Lamblia	10^6 cysts/100ml	non detected	6 log
Cryptosporidium	10^6 cysts/100ml	non detected	6 log
Viruses	10^3 pfu/100ml	non detected	3 log
Phosphorus	2 mg/l	0.04 mg/l	98%
Heavy Metals	Refer Note	Refer Note	

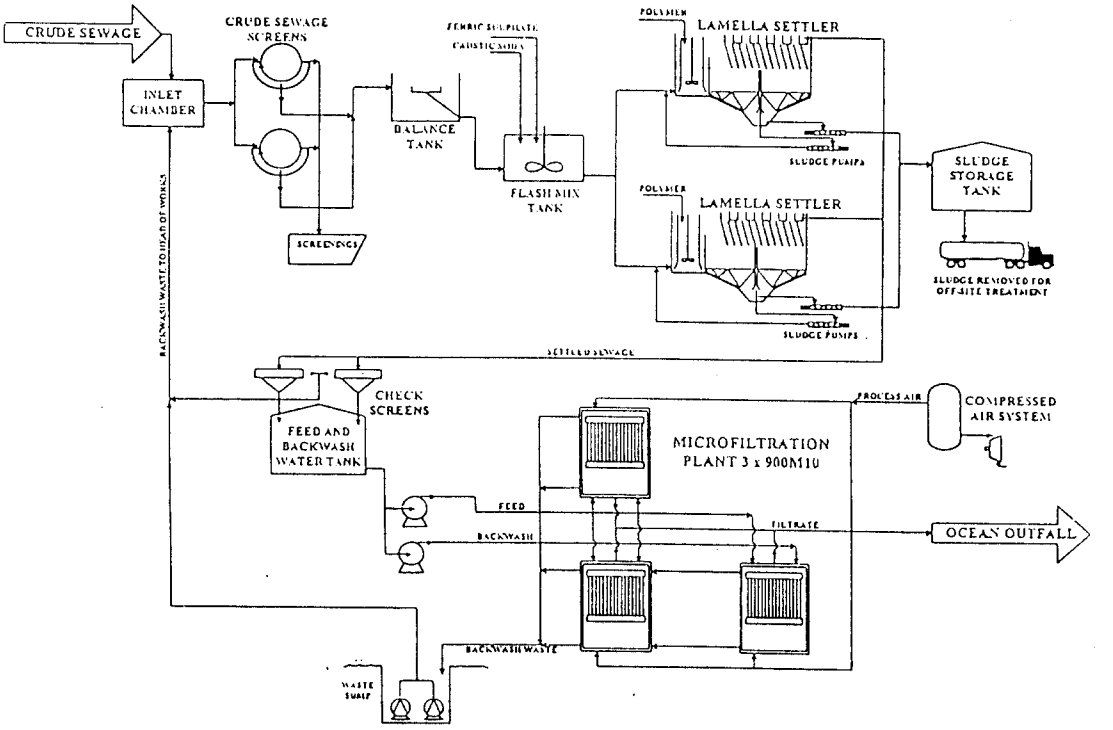


Figure 9 Process Flow Diagram - Aberporth / Tresaith STW

Table 6 TECHNICAL DATA:

Capacity:	Winter	Summer
Population	3150 ep	4530 ep
ADWF (m3/day)	1165	1676
FFT (m3/day)	2330	3352

Effluent Quality:

BOD	<80 mg/l
TSS	<2 mg/l
Total Coliforms	$>10^6$ barrier across the works

CMF Operating Parameters:

Feed pressure	150 kPa
Backwash interval	18 mins
Backwash duration	160 secs
Backwash volume	12% feed
Power consumption	0.3 kWh/m3