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FIELD EXPERIENCE WITH TREATING MUNICIPAL EFFLUENTS USING RO MEMBRANES.

The municipal effluent after being treated with mechanical treatment (separation) and biological treatment (activated sludge process) is treated again and becomes a tertiary (treated three times) effluent. The third treatment step could consist of conventional treatment only, or it can be supplement by a membrane treatment process.

Conventional pretreatment.

The conventional pretreatment process applied to treat secondary effluent could be similar to one used in Water Factory 21, Orange County, California, which is shown in Fig 1. It consists of lime clarification, recarbonation (pH adjustment with CO2), chlorination and media filtration. Such a treatment process produces feed water which still has a very high fouling potential. The 15-min SDI of the treated feed water is too high to measure. The TOC values are in the range of 10 —20 ppm. The experienced membrane fouling is mainly a result of adsorption of dissolved organics and deposition of colloidal matter on the membrane surface. In a properly operated treatment system there is a continuos presence of chloramine at the level of 4 —8 ppm. Due to presence of choramines, bacterial activity is minimal and usually no bacterial growth associated with slime formation is observed in the membrane system. The pressure drop increase across the RO elements is small.
Membrane type most suitable to be operated with a conventional pretreatment is cellulose acetate membrane. The examples of performance of cellulose acetate membranes at

Water Factory 21 are demonstrated in figure 2, 3 and 4. The WF 21 RO system operates at 85% recovery. Permeate flux is set at 10 gfd (16.5 l/m2-hr). Figure 2 shows that the salt rejection was very stable, at the level of 96 —94% for the operating period of over two years. Figure 3 shows the feed pressure required to maintain a constant permeate flow. Immediately after the startup, within few days, the feed pressure increased from the initial level of 200 psi (13.8 bar) to a level of about 260 psi (17.9 bar). After this initial increase, the feed pressure continued to increase at a lower rate, modulated by the feed temperature fluctuation. Membrane elements were cleaned frequently, in two to four week intervals. After about two years of operation the feed pressure has reached the maximum pressure, the feed pump can develop —330 psi (22.8 bar). Afterwards, the permeate flow started to decrease, due to lack of sufficient feed pressure (Fig. 4).

There were continuos attempts to operate composite membrane on tertiary effluent, which was treated with a conventional pretreatment. Both low pressure (CPA2) and ultra low pressure (ESPA) membranes were tested at Water Factory 21. The results of operation of CPA2 and ESPA membranes for the period of about 2.5 years are shown in Figure 5, 6, 7, 8, 9 and 10. The results indicate that in spite of the presence of chloramine in the feed water, salt rejection of composite polyamide membranes remained stable (Fig 5 and 8). The feed pressure, however, had to be increased at a rapid rate to maintain constant permeate flow (Fig 6 and 9). Frequent cleaning did not result in restoration of permeate flux. Fig 7 and 10 shows results of pressure drop of CPA2 and ESPA membranes during the operating period. It is evident that fouling which would result in blockage of feed channels is negligible in this type of application. This is a result of maintaining biostatic conditions due to presence of chloramine in the feed water.

Membrane pretreatment.

Membrane pretreatment of municipal effluent usually consists of treating secondary effluent with flocculation, chlorination, settling, media filtration and ultrafiltration or microfiltration, using the backwashable capillary technology. The feed water obtained after membrane pretreatment has similar concentration of TOC as feed water obtained after a conventional pretreatment. However, concentration of colloidal and suspended particles is significantly lower. After conventional pretreatment the SDI of feed water is still too high to measure. After capillary pretreatment the ‘15 min SDI of feed water is in the range of 1.5 — 3.5.

Examples of such operation are the pilot tests conducted at the Water Factory 21 and at San Pasqual Water Treatment Plant, California.

The results of operation of ESPA membranes at San Pasqual, CA, on a capillary membrane pretreated water, for a period of about 18 months are shown on Fig. 11 and 12 The results of permeate conductivity shown on Fig. 11 indicate stable salt rejection of about 99%. The feed pressure data shown on Fig. 12 indicate rapid pressure increase from 80 psi (5.5 bar) to 105 psi (7.2 bar) within few days of initial operation. Afterwards, there was a more moderate pressure increase to about 145 psi (10 bar) followed by slow pressure increase modulated by the feed water temperature fluctuation.

A new membrane technology introduced recently by Hydranautics is the low fouling composite membrane, designated as LFC1. The LFC1 membrane is made of a fully aromatic polyamide polymer. The membrane surface has been modified to make it hydrophilic and reduce its affinity to dissolved organics. The LFC1 membrane elements have been in test operation at San Pasqual, on a feed water pretreated with capillary membranes for a period of about two months, since the beginning of April 1998. The results are included in Fig. 13 and 14. The results of Fig. 13 indicate stable salt rejection of over 99%. The feed pressure fluctuates with feed temperature in the range of 80 —100 psi (5.5 —6.9 bar).

Summary

Well designed and operated conventional tertiary treatment of municipal effluent still produces RO feed water having a strong fouling potential.

Cellulose acetate membrane, operating on a feed water after conventional pretreatment will experienced a rapid rate of fouling during the initial operating period. Afterwards, flux rate will decline at slower rate. Membrane life of 2 —3 years can be expected.

Composite polyamide membranes will experience very high fouling rate when operating on a conventionally treated tertiary effluent. Fouling rate will be much faster than experienced with cellulose acetate. After a period of about one year of operation, the feed pressure could be similar to required for the cellulose acetate membranes.

The composite membranes can operate on municipal wastewater in presence of chloramines. The salt rejection remains stable. Pressure drop does not increase, regardless of thickness of the feed spacer.

The capillary pretreatment produces feed water of significantly better quality than the conventional pretreatment. The 15-min SDI values in the range of 1.5 —4 can be obtained.

The composite membranes operating on feed water treated with capillary pretreatment, demonstrate lower degree of fouling than in operation with the conventional pretreatment.

LFC1- low fouling membrane provides the most stable performance and the lowest feed pressure requirement for the municipal wastewater treatment applications . Hydrophilic nature of membrane surface results in low fouling rate, probably due to low adsorption rate of dissolved organics.

It can be expected that in RO systems, where biological activity results in slime formations, membrane fouling conditions will develop regardless of membrane material type or spacer thickness used. This type of fouling process will result in a decrease of permeate flux and increase of pressure drop. Excessive pressure drop may result in mechanical damage of the membrane elements.

Constituent	Influent OCSD	Treated RO Feed	RO Product Water	WF-21 Blended Product	Regulatory Limits
Tot. Nitrogen, ppm	31	21	2.7	3	10
Boron, pp,	0.85	0.6	0.52	0.4	0.5
Chloride, ppm	256	256	29	57	120
Conductivity, uS/cm	1,848	1,800	150	419	None
Fluoride, ppm	1.4	0.8	0.16	0.4	1.0
pH	7.5	5.5	6.9	7.2	6.5 —8.5
Sodium, ppm	231	231	21	65	115
Sulfate, ppm	300	300	1.4	37	125
Tot. hardness., ppm	298	205	4.7	34	180
Cyanide, ppb	33.4		2.3	6.3	
TDS, ppm	1067	934	82	232	500
Color, color units	34.6		<5	11	None
Turbidity, JTU	6.2	0.9	<0.01	0.27	None
Coliform, MPN	7.2E5	0.9	2.5	0.00	None
Arsenic, ppb	<5.0	<0.5	<5.0	<5.0	50
Barium, ppb	93.5	36.4	1.1	6.6	1000
Cadmium, ppb	9.3	2.4	0.07	0.2	100
Chromium, ppb	33	9.6	0.82	0.5	50
Copper, ppb	49.3	7.8	3.9	4.9	1000
Iron, ppb	113.8	19.3	2.8	22.2	300
Lead, ppb	4.7	0.1	0.6	0.1	50
Manganese, ppb	56	1.7	0.1	2.1	50
Mercury, ppb	0.3	0.1	0.3	0.4	2
Selenium,, ppb	<0.5	<0.5	<0.5	<0.5	10
Silver, ppb	1.6	0.2	0.1	0.2	50
COD, ppm	53.4	20.3	0.8	3.5	30
TOC, ppm	14.7	11	0.7	1.4	None
THM s, ppb	6.0	6.0	2.7		100