Appendix 7.1.2-5

Results of Observation on Membrane Surface Foulants

Membrane Foulant Analysis

1. Objective

A sample of fouled membrane was received from SWCC Umm Lujj SWRO plants through the Japan–Saudi Arabia Technical Cooperation Group on Seawater Desalination. The samples were analyzed as reported below. This report presents the method and analysis results.

RO seawater desalination plants are affected by the quality of the feed seawater. In the previous period, fouled membrane from the RO seawater desalination plant in Umm Lujj on the Red Sea was obtained and analyzed. As the turbidity of Arabian Gulf seawater is estimated to be higher than Red Sea seawater, it is necessary to analyze fouled membrane from the Arabian Gulf to ascertain the causes of the fouling, and to establish a foulant control measures. As SWCC has promised to obtain a fouled membrane from the Arabian Gulf Region, JICA instructed the SWCC's staff in the SWCC RD Center on how to sample, analyze fouled membranes, and the method of analyzing pollutants. The structure of foulant was also explained.

2. Experimental Method

For the analysis of fouled membranes, the following steps were followed:

A. Sampling and Sample Selection
B. Performance Evaluation of Fouled Membranes
C. General Appearance of Disassembled RO Elements (Autopsy Test)
D. Determination of Structure and Composition of Deposits
E. Membrane Surface Analysis
  1. Scanning Electron Microscope (SEM)
  2. Energy Dispersive X-ray Spectroscopy (EDS)
  3. Structure Identification of Organic Matter by Fourier Transform Infra-Red (FT-IR)
F. Determination of Physical & Chemical Properties of the Membrane
  1. Strength and Elongation
  2. Molecular Weight Determination
  3. Viscosity Measurement
  4. Degree of Polymer Acetylation

It is possible to carry out the above analysis procedures with the analytical instruments already equipped at SWCC's RDTC (APPENDIX 7.1.2-1). Training to acquire skills in the above procedures A through E will be held in the center.

APPENDIX7.1.2-2 shows manual for operation of SEM and EDX analysis, and APPENDIX7.1.2-3 for FT-IR analysis.

Details of experiments are given hereunder.

2.1 Seawater Turbidity Content Removed by Micro-filtration Membrane

Location: Pre-treatment equipment to remove turbidity content from the seawater feed exists at SWCC Research Development&Training Center, Al Jubail, Saudi Arabia.

Method: Samples were collected using a Millipore HA Type 0.45 micron membrane filter at the sampling points and under current conditions corresponding to the SDI measurements noted below.

General properties of seawater:

Location:	Al Jubail, Arabian Gulf
Date:	October, 1993
Sea Temperature:	33°C
pH:	8.1
Electrical conductivity:	63000 μS/cm

Sampling points:

Sample 1: Seawater feed to entry port of pretreatment equipment before the intake pipe
SDI value: 5.3
Volume of filtered seawater: 10 liter

Sample 2: Seawater feed Sample 1 sampled on another day
SDI value : 5.6

Sample 3: Seawater treated by coagulation and filtration (DMF)
SDI value : 3.6

Sample 4: Seawater at sand filter polisher outlet
SDI value : 3.1

Sample 5: Seawater at 10 micron cartridge filter outlet
SDI value : 3.4

Sample 6: Foulants from pretreatment section of desalination plant in the sea near Japan
——fouling comparison sample

2.2 RO Membrane Foulant, Sample A

Location: Membrane surface observations were made on a sample of Polyamide Composite RO membrane which had been used for Seawater tests in connection with the pretreatment equipment on the experimental desalination plant at the SWCC Research, Development&Training Center.

Sample 7: Nitto Denko Polyamide Composite RO Membrane NTR-759SW, Part A-1
(Hydranautics product assembled as a Mini RO element, sized 2" x 40")

Sample 8: Polyamide Composite RO Membrane NTR-759SW as above, Part A-2

2.3 RO Membrane Foulant Sample B

Location: Membrane surface observations were made on a sample of Polyamide Composite RO membrane which had been used on a different desalination plant in Saudi Arabia.

Sample 9: Desalination Corp. Polyamide Composite RO Membrane Part B-1, product serial number unknown.
Sample 10: Desalination Polyamide Composite RO Membrane as above, Part B-2
Sample 11: Desalination Corp. Polyamide Composite RO Membrane as above, Part B-3
Sample 12: Desalination Corp. Polyamide Composite RO Membrane as above, Part B-4

2.4 Analysis Equipment

The following equipment is normally used for membrane surface observations previously reported:

* Observation of foulants
SEM : Scanning electron microscope
* Identification of inorganic foulants
EDX : Energy dispersion X-ray microanalyzer
* Identification of organic foulants
FT-IR : Fourier transform - infra-red spectrometer

3. Results

3.1 MF membrane captured foulant samples

* Results of observations made by SEM, EDX and FT-IR on membrane surface foulants

Sample (1): Seawater feed samples are shown in Photo 1-1 to 1-5.
The FT-IR chart in Figure 1 shows calcium salts an absorption peak at 1450 cm^{-1}, and absorption peaks at 1650 cm^{-1}(-NHCO-), 1050 cm^{-1} and 3300 cm^{-1} (-OH) derived from marine organisms. Another peak at 450 cm^{-1} is possibly caused by iron rust.

Sample (2): Another sample of Seawater feed, similar to the above, is shown in Photos 2-1 to 2-5. Crystals of NaCl, $MgCl_2$, etc. are present as well as marine organisms. The FT-IR chart in Figure 2 shows calcium salts an absorption peak at 1450 cm^{-1}, and absorption peaks at 1650 cm^{-1} (-NHCO-), 1050 cm^{-1} and 3300 cm^{-1} (-OH) derived from marine organisms. Another peak at 450 cm^{-1} is possibly caused by iron rust.

Sample (3): The DMF outlet sample is shown in Photos 4-1 to 4-5. The cubic crystals from the SE,M and EDX are assumed to be NaCl. Other peaks due to Ca, K, Mg and S from sulphate ions are seen in the EDX spectrum. Crystals of NaCl and $MgCl_2$ are present as well as marine organisms. The FT–IR chart in Figure 4 does not show the characteristic absorption peaks reported above. Another peak at 450 cm^{-1} is possibly caused by a little iron rust.

Sample (4): The sand filter polisher outlet sample is shown in Photos 5–1 to 5–5. The cubic crystals from the SEM and EDX are assumed to be NaCl. Other peaks due to Ca, K, Mg and S from sulphate ions are seen in the EDX spectrum. Crystals of NaCl and $MgCl_2$ are present as well as marine organisms. The FT–IR chart in Figure 5 does not show the characteristic absorption peaks reported above. Another peak at 450 cm^{-1} is possibly caused by a little iron rust. The chain of spherical globules, about 0.8 micron in size, seen in Photo 5–3 are a type of fungous mold.

Sample (5): The cartridge filter outlet sample is shown in Photos 3–1 to 3–6. From the SEM and EDX the presence of $FeCl_3$ and $MgCl_2$ is assumed. Other peaks due to Ca, K and S from sulphate ions are seen in the EDX spectrum. The FT–IR chart in Figure 3 suggests Fe and hydroxides at 300–400 cm^{-1} and shows (–OH) absorption peaks at 3300 and 1600 cm^{-1}.

Sample (6): The MF recovery sample of foulants on the pre–filter cartridge from the desalination RO operation in the sea near Japan is shown in Photos 6–1 to 6–4. The EDX shows strong Fe and Cl peaks and from the SEM observations, it can assumed that the $FeCl_3$ coagulant used in pre–treatment is present in the form of a colloid. The FT–IR chart in Figure 6 suggests Fe and hydroxides at 800–400 cm^{-1} and shows (–OH) absorption peak at 1000 cm^{-1}. Organic material absorption is slight.

3.2 RO Membrane Foulant Sample A

Sample (7): Nitto Denko Polyamide Composite RO Membrane Part A1 is shown in Photos 7–1 and 7–2. Fe, Cl and inorganic Si salts are assumed from the SEM and EDX and the presence of foulants is shown by peaks in the EDX spectrum. The FT–IR chart in Figure 7 suggests Fe and hydroxides at 800–400 cm^{-1} and shows (–OH) absorption peak at 1000 cm^{-1}.

Sample (8): As above Part A2

As shown in Photos 8–1 and 8–2 and in Figure 8, Part A2 exhibits the same results for SEM and EDX spectrum as Part A1 above. In particular, the fuzzy image which can be seen in the SEM 4000X observation in Photo 8 indicates the presence of bacterial slime on the surface of the membrane.

3.3 RO Membrane Foulant Sample B

Sample (9): Desalination RO Membrane Part B1

SEM observations and EDX spectral analysis results for Part B1 are shown in Plate 9. This EDX spectrum confirms the presence of Ca and Si salts. However, since none of the characteristic SO_4 absorption peaks at 1150, 600–700 or 3400–3600 cm^{-1} are present in the FT–IR chart in Figure 9, the presence of S which is observed in the EDX spectrum is considered to be derived not from SO_4 salts but from sulfon ($-SO_2-$) in the high polymer polysulfon which comprises the supporting layer for the RO membrane.

Samples (10)–(12): RO Membrane as above, Parts B2–4

SEM observations and EDX spectral analysis results for samples B2, B3 and B4 are shown in Photos 10, 11 & 12. Photos 10, 11 and 12 confirm the presence of Fe in addition to Ca salts. With respect to the FT–IR differential spectra, no significant differences could be detected in the results for the four parts, B1 to B4. Characteristic absorption peaks can be observed for –NHCO– (at 1600 cm^{-1}) and for Ca (at 1450 cm^{-1}) which are due to bacteria, and for –OH (at 3400, 1000 and 400–500 cm^{-1}) which are due to either $Ca(OH)_2$ or bacteria.

4. Conclusion

On this occasion, the main purpose of analyzing the membrane foulant content analysis in seawater feed to the pretreatment process of the desalination plant was to analyze the minute particles of solid matter causing turbidity in raw seawater which are captured by the MF membrane.

Nevertheless, whether they are in the moist state or later stored in an air–dried state, the samples contain ions such as Na, Ca, Mg, Cl, etc. which are in the seawater. Therefore we can see that, as analytical samples, they are greatly influenced by the crystal content of these soluble ions because these dissolved ions have been precipitated on the membrane as solids.

Consequently, in membrane sample analysis using feed water with a high TDS such as seawater, contamination by the precipitation of soluble ions must be considered. In future analyses of membrane foulants in seawater, a preliminary wash with distilled water at the sample preparation stage to remove the soluble ion salt content is a matter which still needs to be developed.

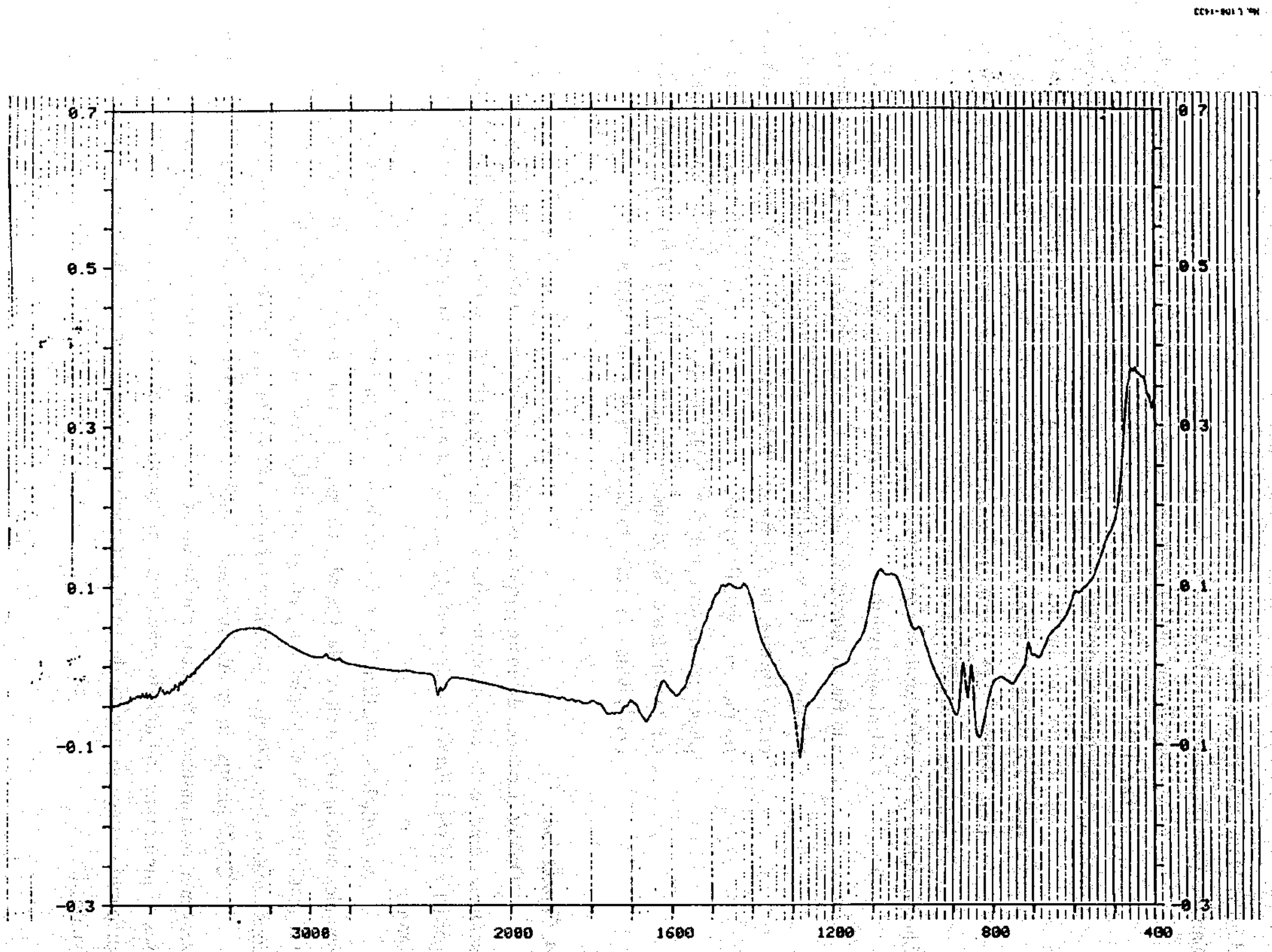


Figure 1. IR Chart of Fouling Material on MF Membrane Surface (sample 1)

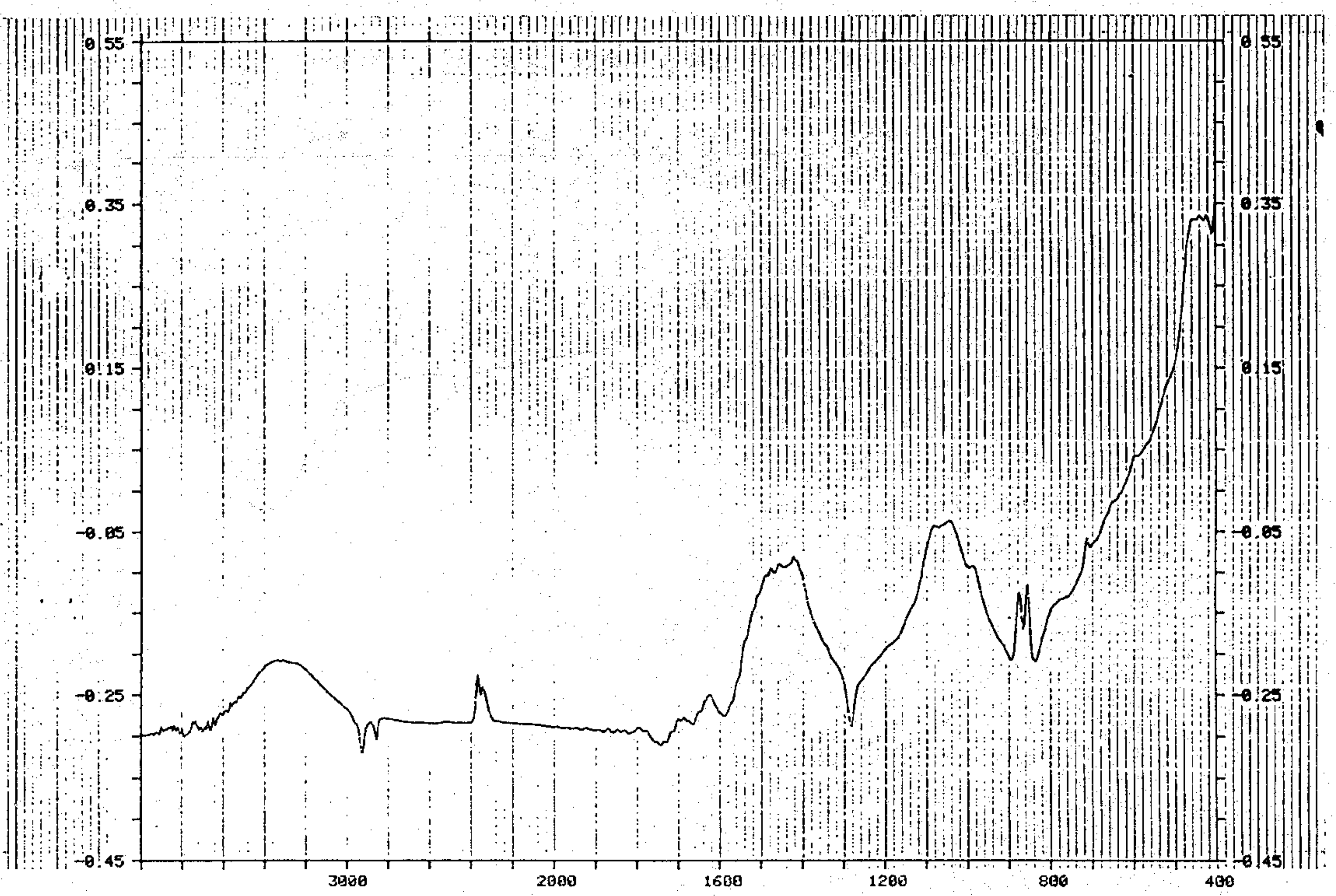


Figure 2. IR Chart of Fouling Material on MF Membrane Surface (sample 2)

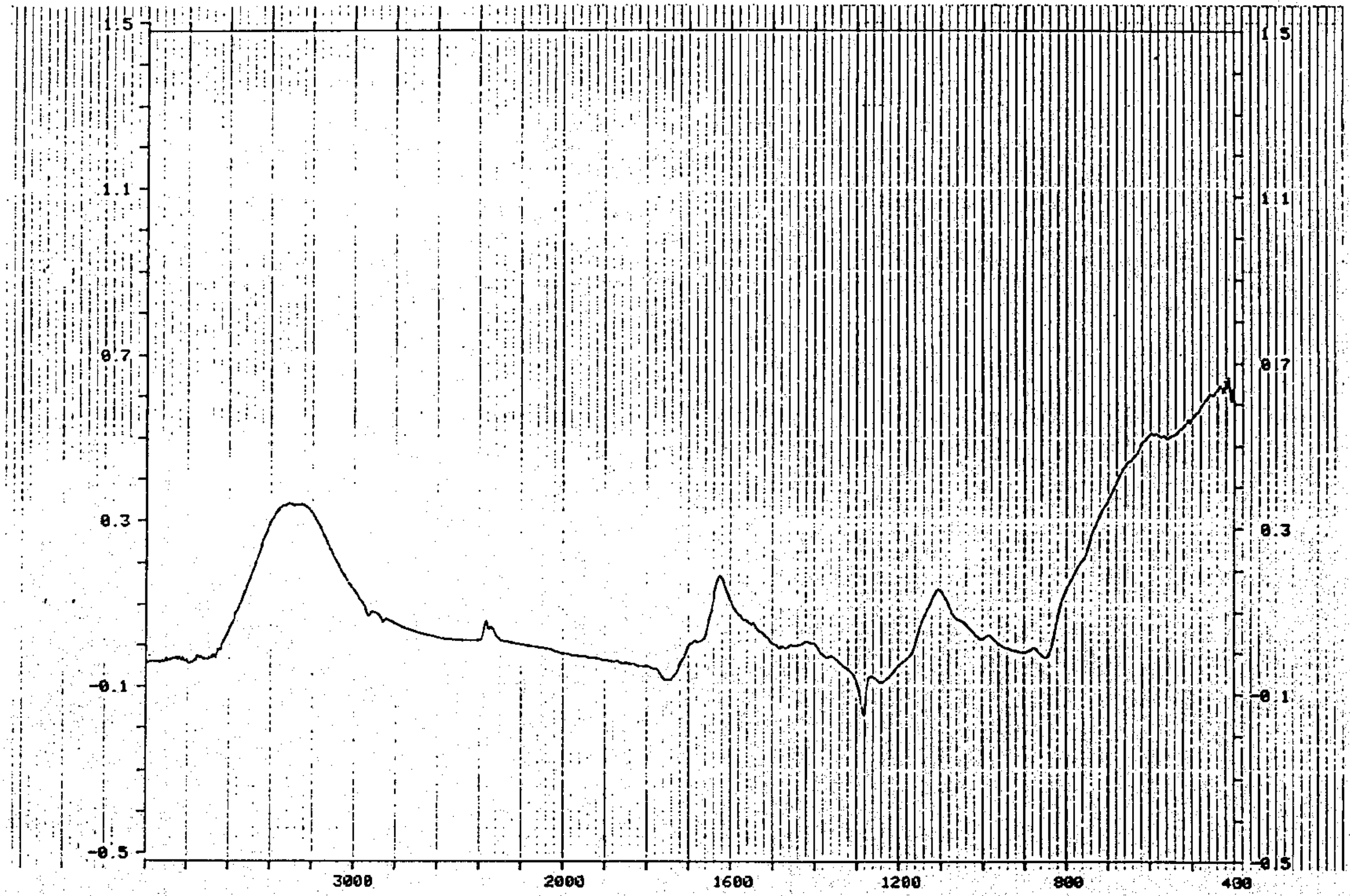


Figure 3. IR Chart of Fouling Material on MF Membrane Surface (sample 5)

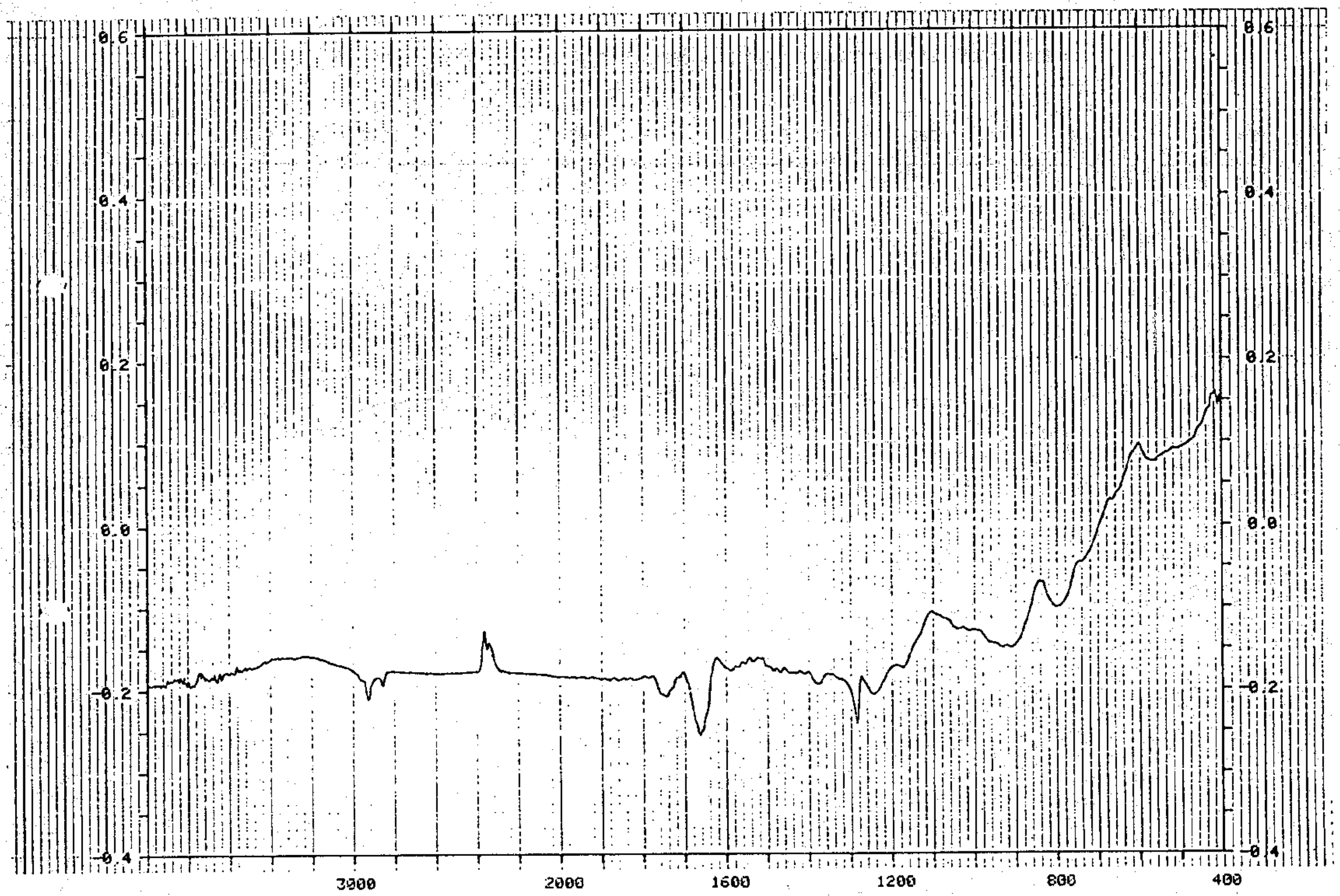


Figure 4. IR Chart of Fouling Material on MF Membrane Surface(sample 3)

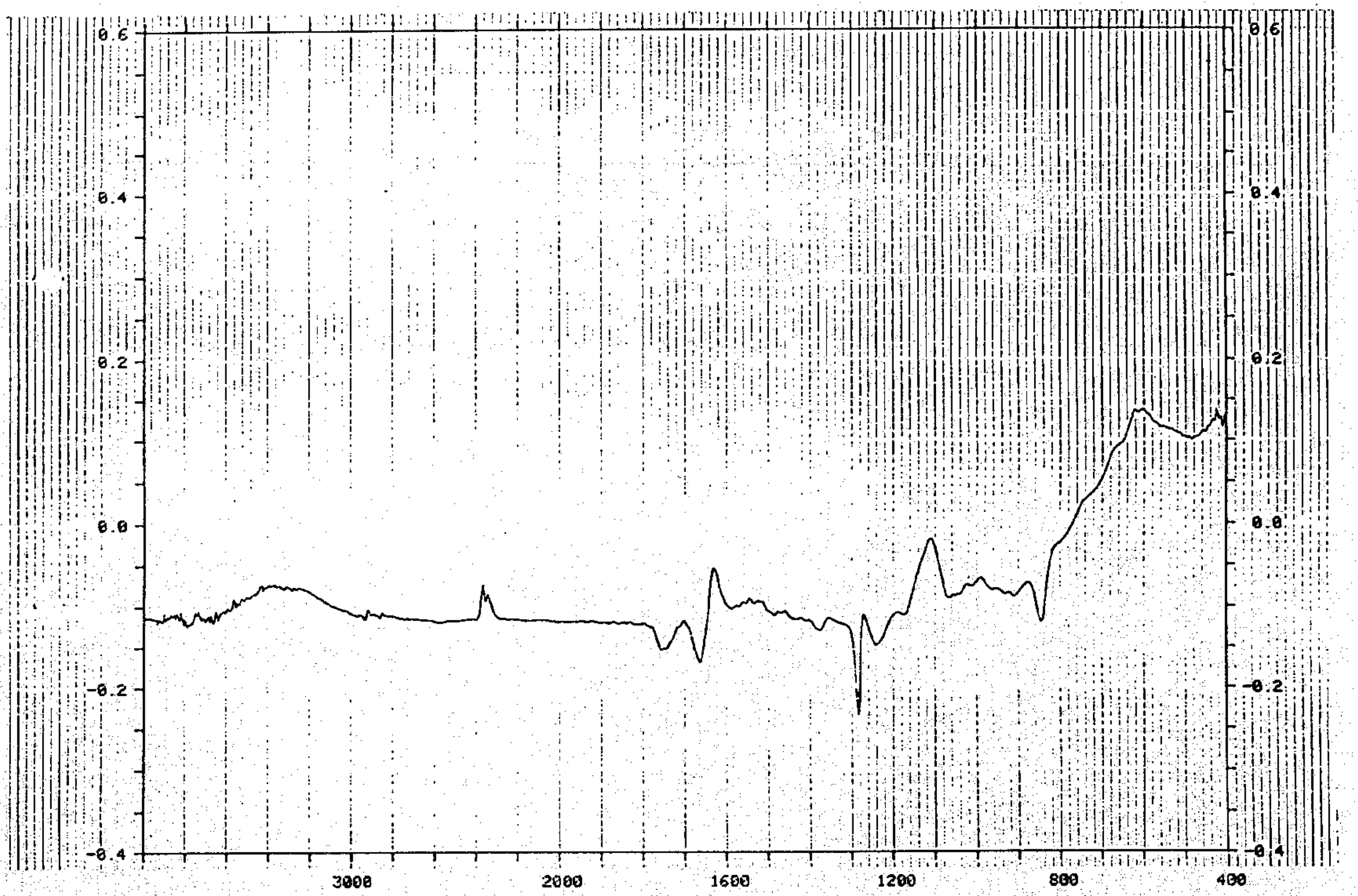


Figure 5. IR Chart of Fouling Material on MF Membrane Surface(sample 4)

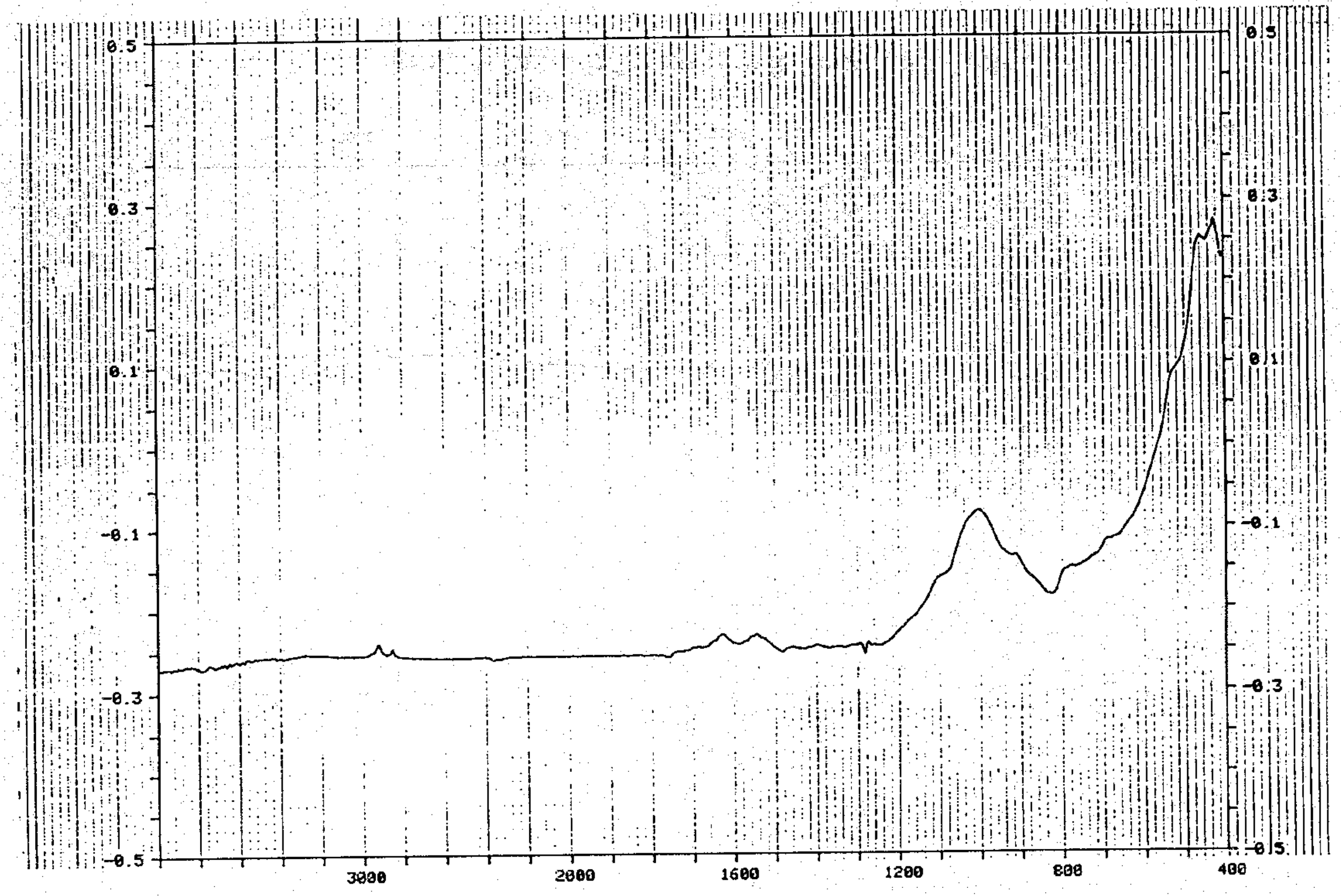


Figure 6. IR Chart of Fouling Material on MF Membrane Surface(sample 6)

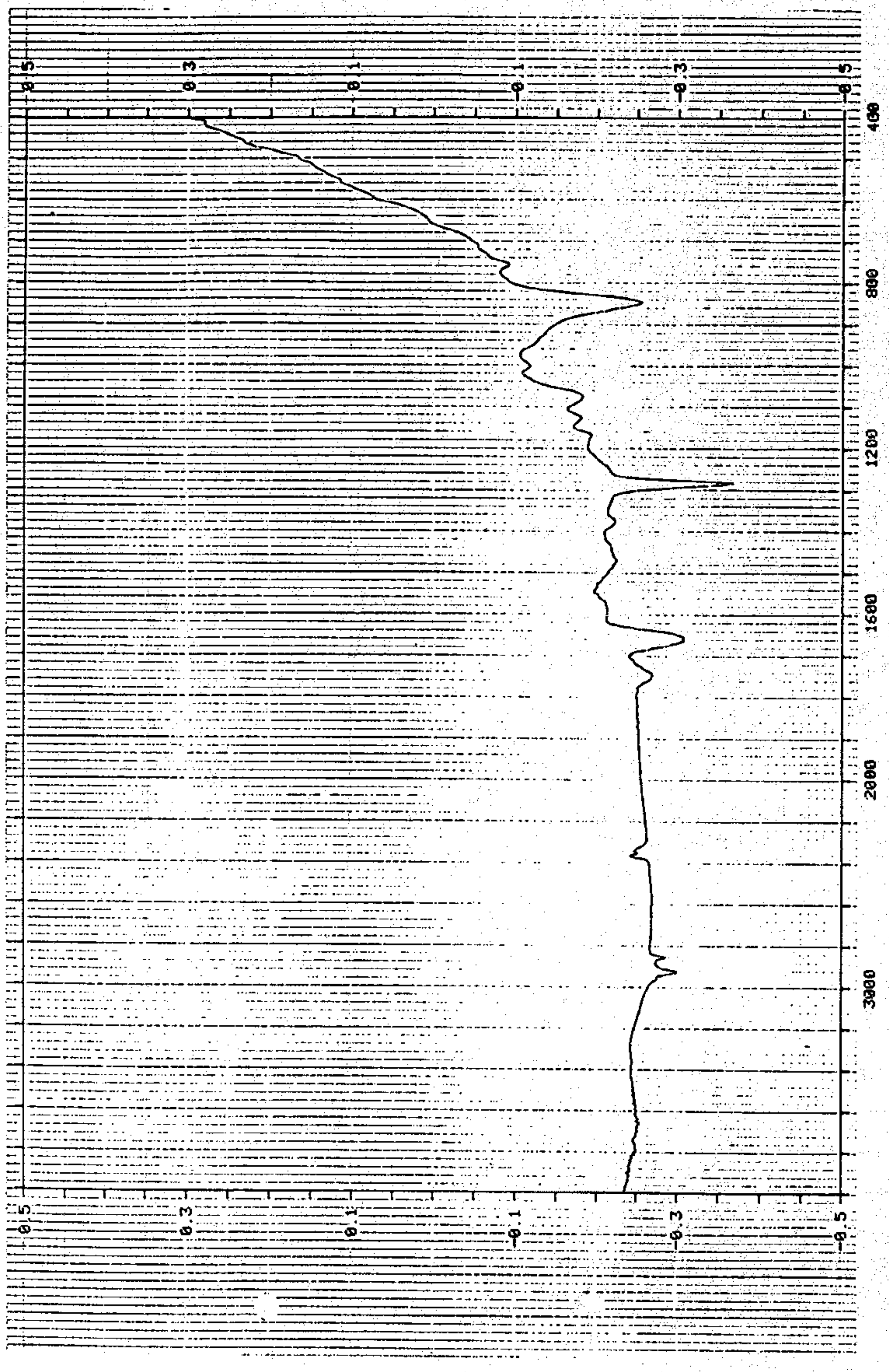


Figure 7. IR Chart of Fouling Material on RO Membrane Surface(sample 7)

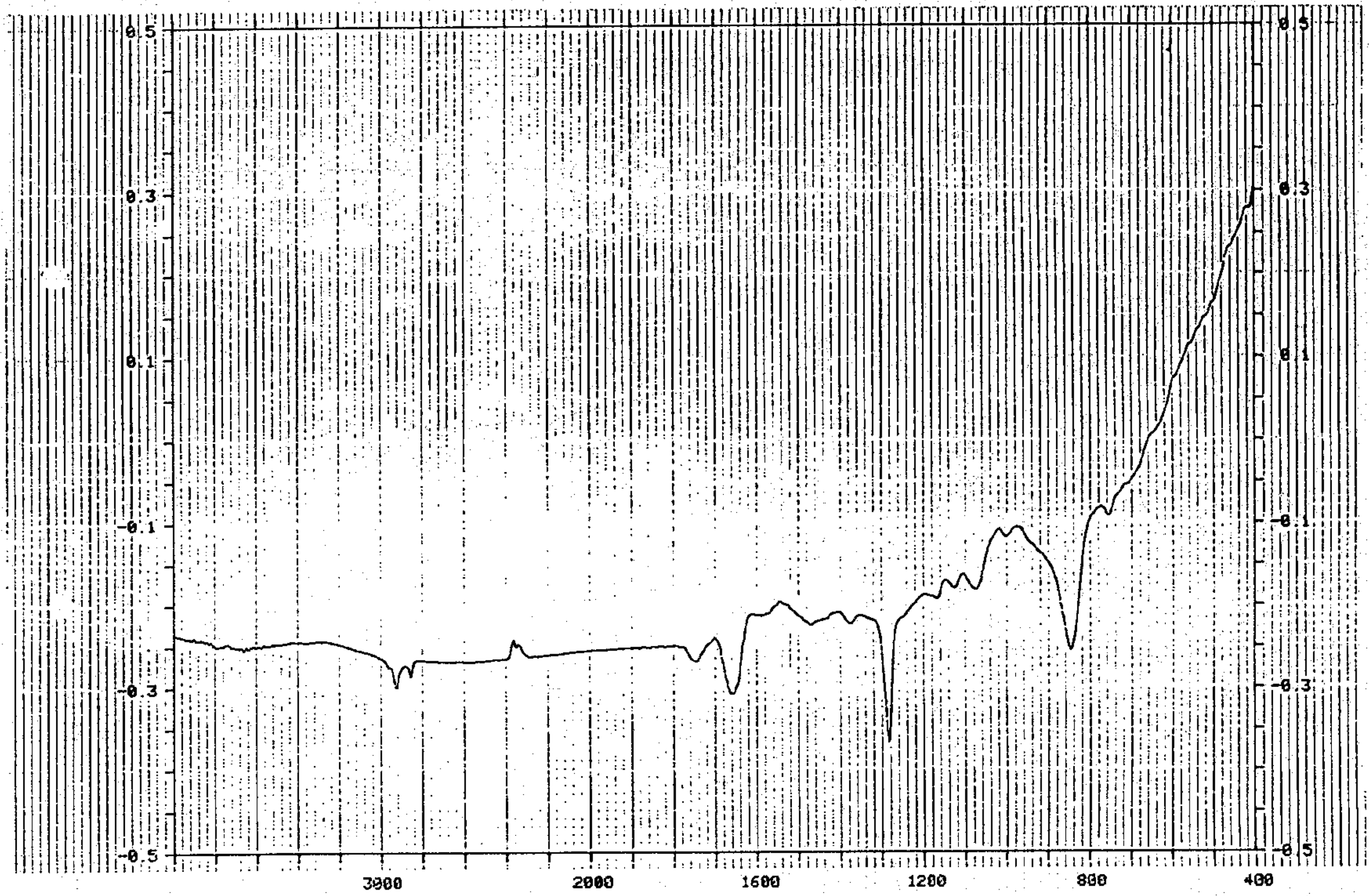


Figure 8. IR Chart of Fouling Material on RO Membrane Surface(sample 8)

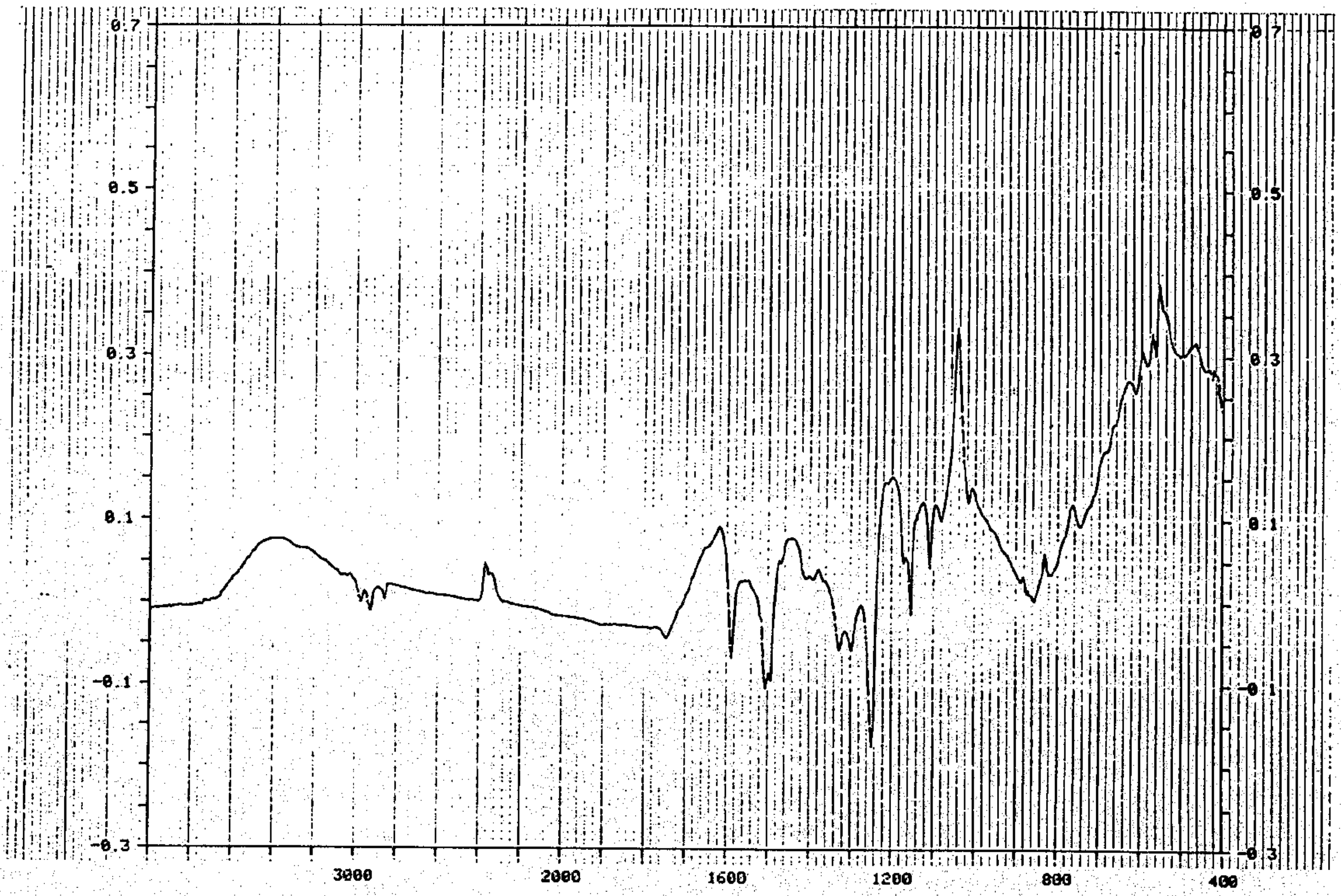
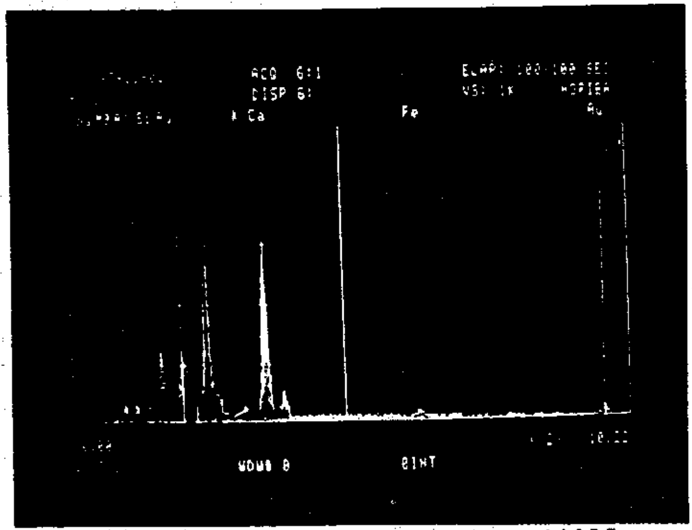


Figure 9. IR Chart of Fouling Material on RO Membrane Surface(sample 9)

SEM (X 800)



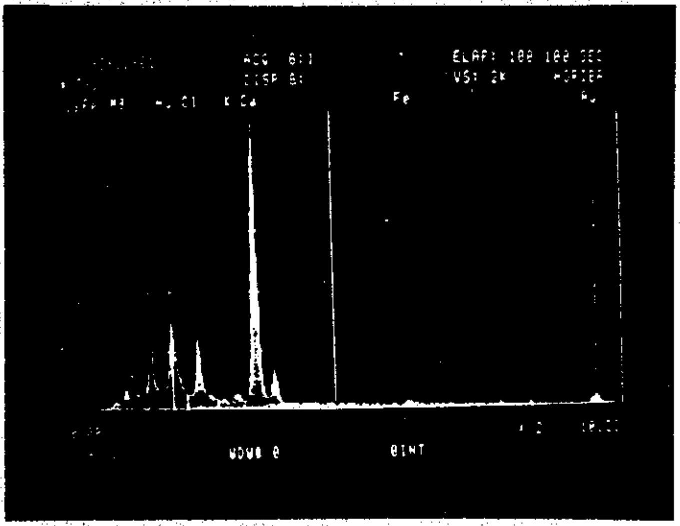
EDX SPECTRUM OVER THE ABOVE SCOPE

PHOTO 1-1 SEM AND EDX OF THE FOULED MEMBRANE SAMPLE (1)

SEM (X 800)

PHOTO 1-2 SEM AND EDX OF THE FOULED MEMBRANE SAMPLE (1)

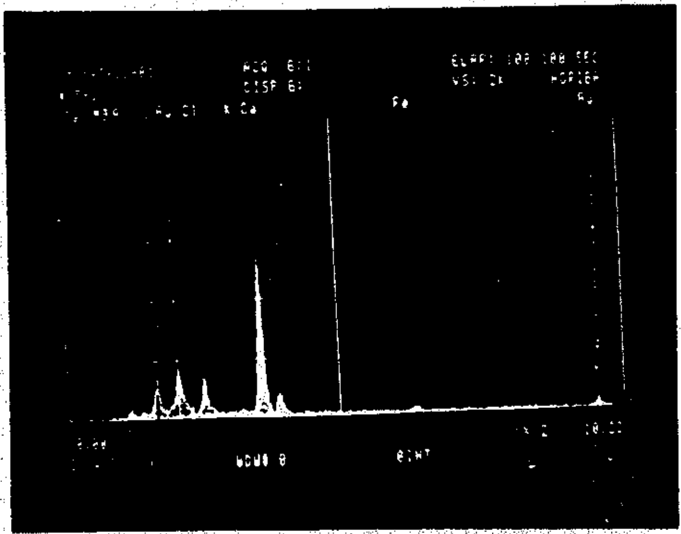
SEM (X 4000)



EDX SPECTRUM OVER THE ABOVE SCOPE

PHOTO 1-3 SEM AND EDX OF THE FOULED MEMBRANE SAMPLE (1)

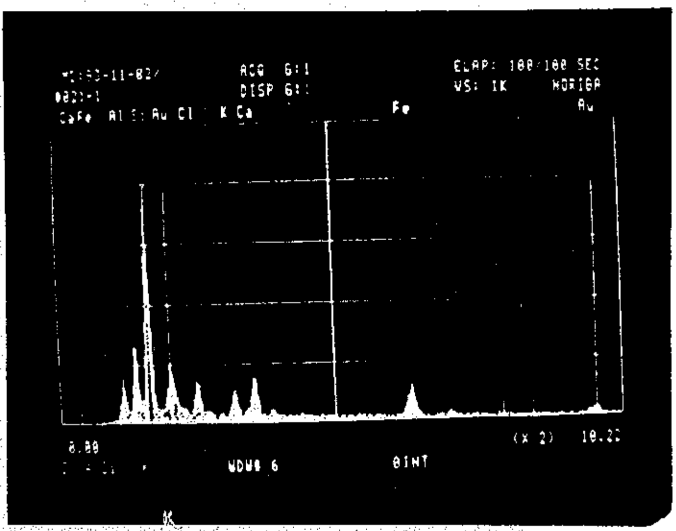
SEM (X 4000)



EDX SPECTRUM OVER THE ABOVE SCOPE

PHOTO 1-4 SEM AND EDX OF THE FOULED MEMBRANE SAMPLE (1)

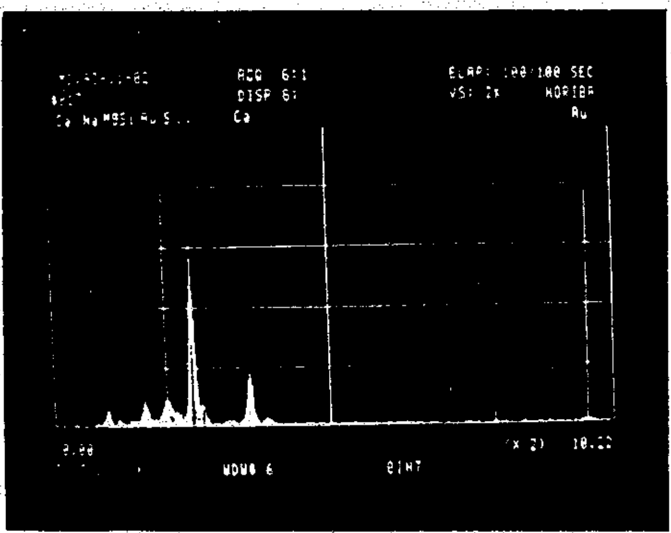
SEM (X 4000)



EDX SPECTRUM OVER THE ABOVE SCOPE

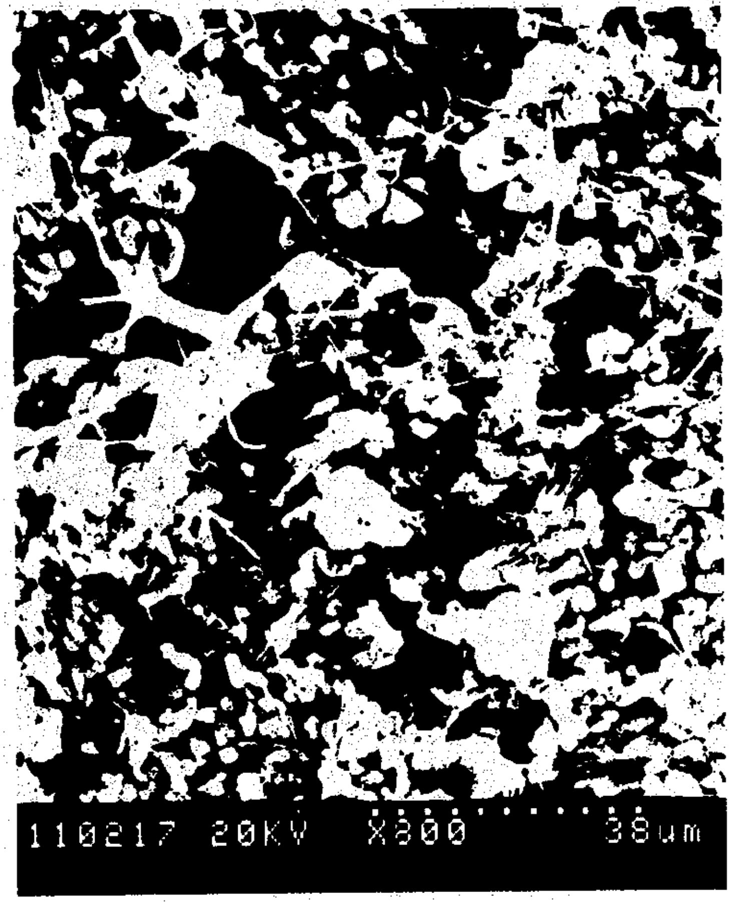
PHOTO 2-1 SEM AND EDX OF THE FOULED MEMBRANE SAMPLE (2)

SEM (X 800)



EDX SPECTRUM OVER THE ABOVE SCOPE

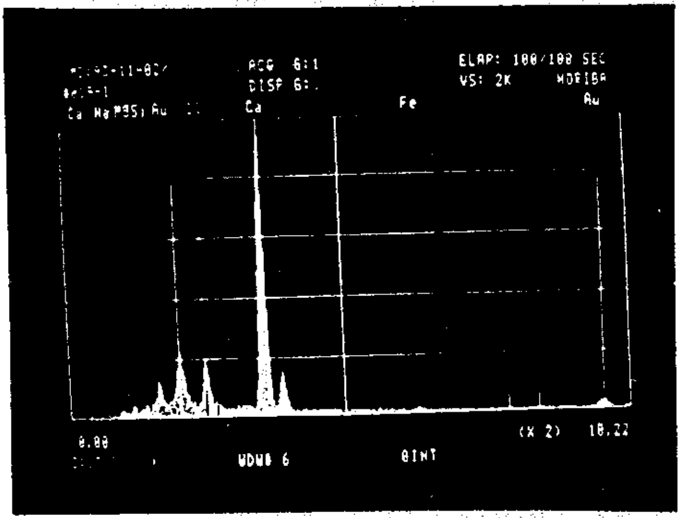
PHOTO 2-2 SEM AND EDX OF THE FOULED MEMBRANE SAMPLE (2)



SEM (X 800)

PHOTO 2-3 SEM OF THE FOULED MEMBRANE SAMPLE (2)

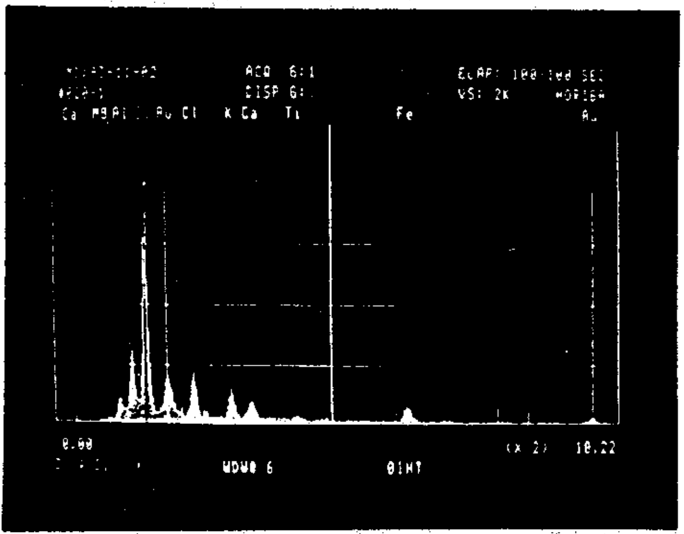
SEM (X 4000)



EDX SPECTRUM OVER THE ABOVE SCOPE

PHOTO 2-4 SEM AND EDX OF THE FOULED MEMBRANE SAMPLE (2)

SEM (X 4000)

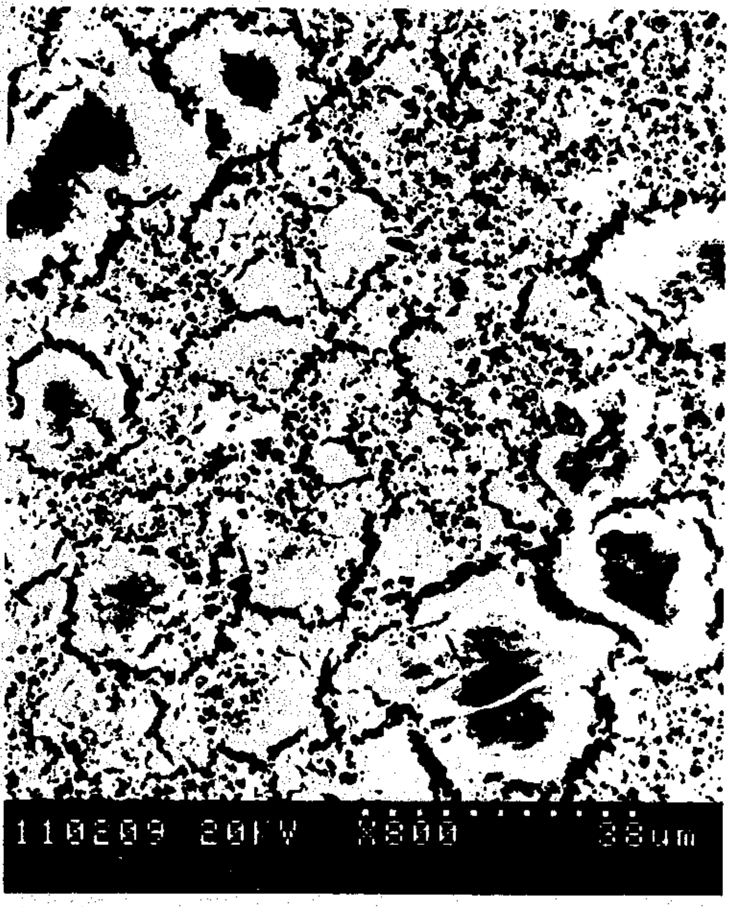


EDX SPECTRUM OVER THE ABOVE SCOPE

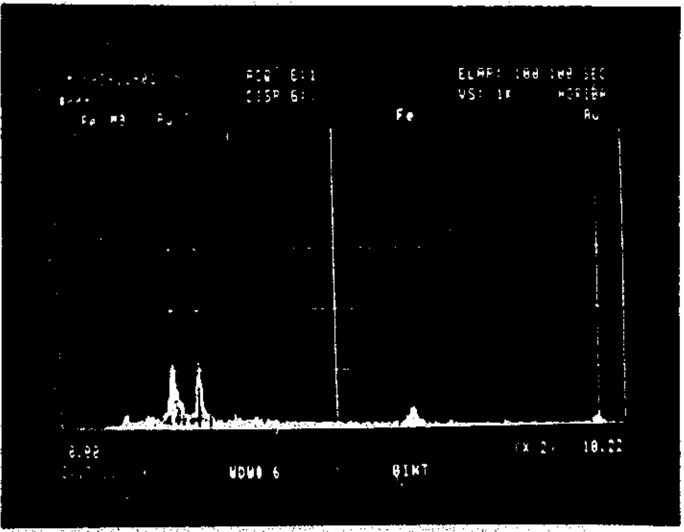
PHOTO 2-5 SEM AND EDX OF THE FOULED MEMBRANE SAMPLE (2)

SEM (X 800)

PHOTO 3-1 SEM OF THE FOULED MEMBRANE SAMPLE (5)



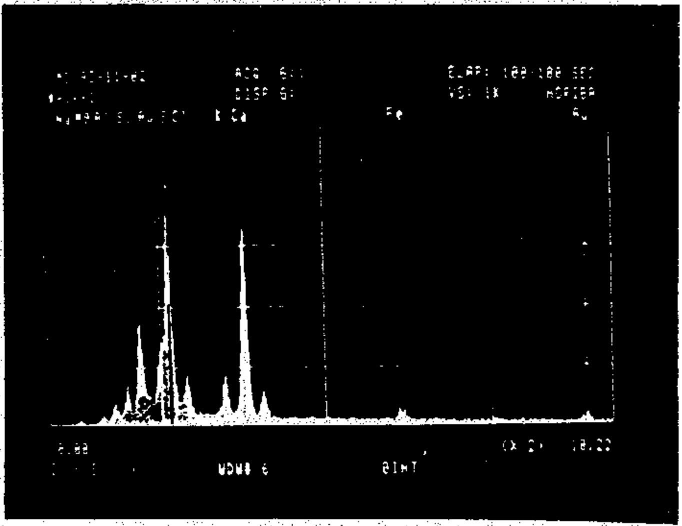
SEM (X 800)



EDX SPECTRUM OVER THE ABOVE SCOPE

PHOTO 3-2 SEM AND EDX OF THE FOULED MEMBRANE SAMPLE (5)

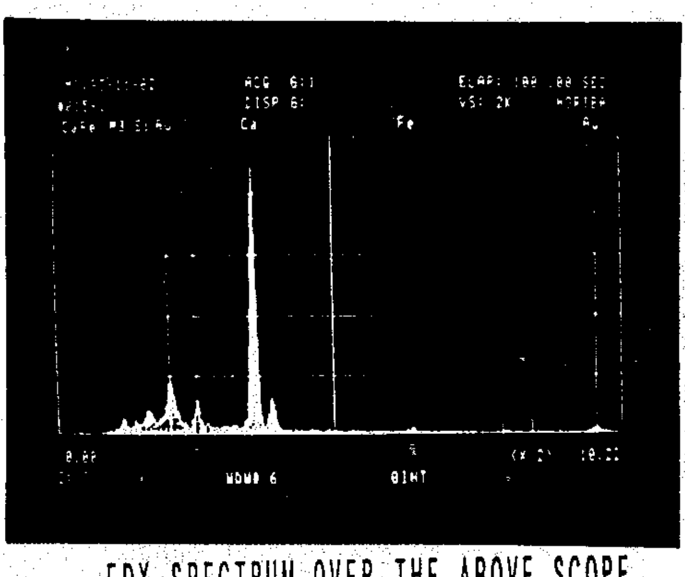
SEM (X 4000)



EDX SPECTRUM OVER THE ABOVE SCOPE

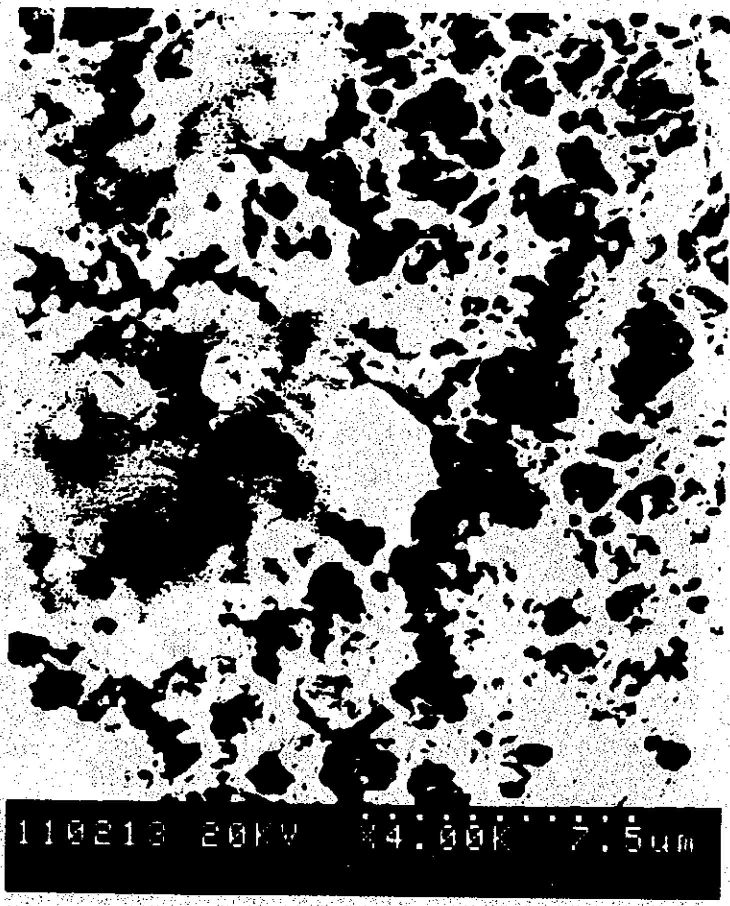
PHOTO 3-3 SEM AND EDX OF THE FOULED MEMBRANE SAMPLE (5)

SEM (X 4000)

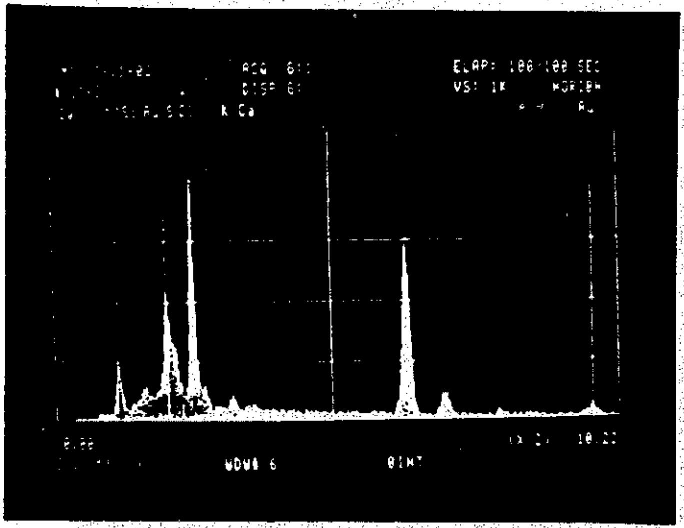


EDX SPECTRUM OVER THE ABOVE SCOPE

PHOTO 3-4 SEM AND EDX OF THE FOULED MEMBRANE SAMPLE (5)

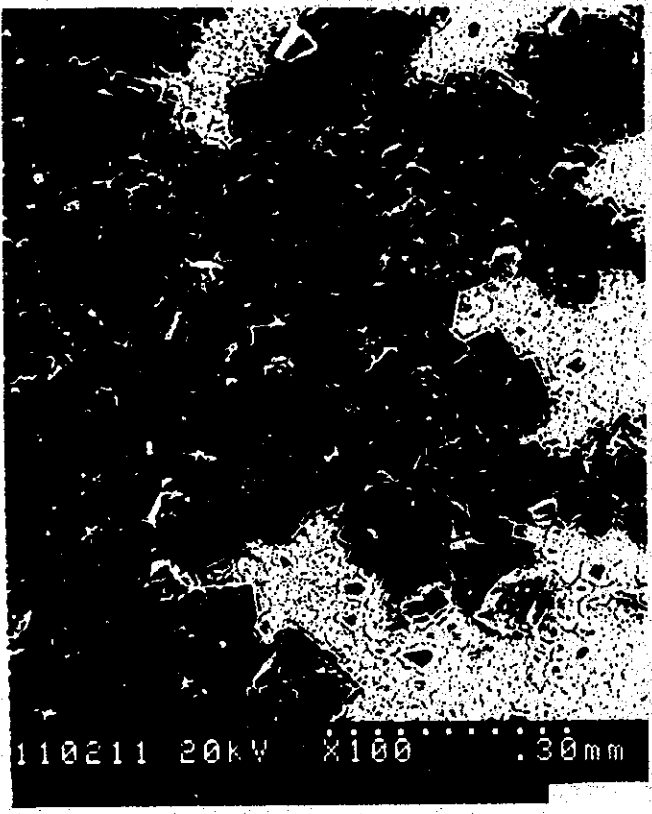


SEM (X 4000)



EDX SPECTRUM OVER THE ABOVE SCOPE

PHOTO 3-5 SEM AND EDX OF THE FOULED MEMBRANE SAMPLE (5)

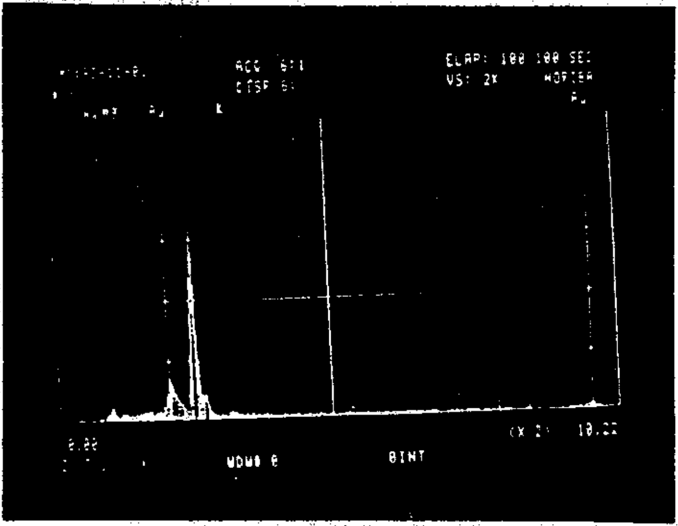


SEM (X 800)

PHOTO 3-6 SEM OF THE FOULED MEMBRANE SAMPLE (5)

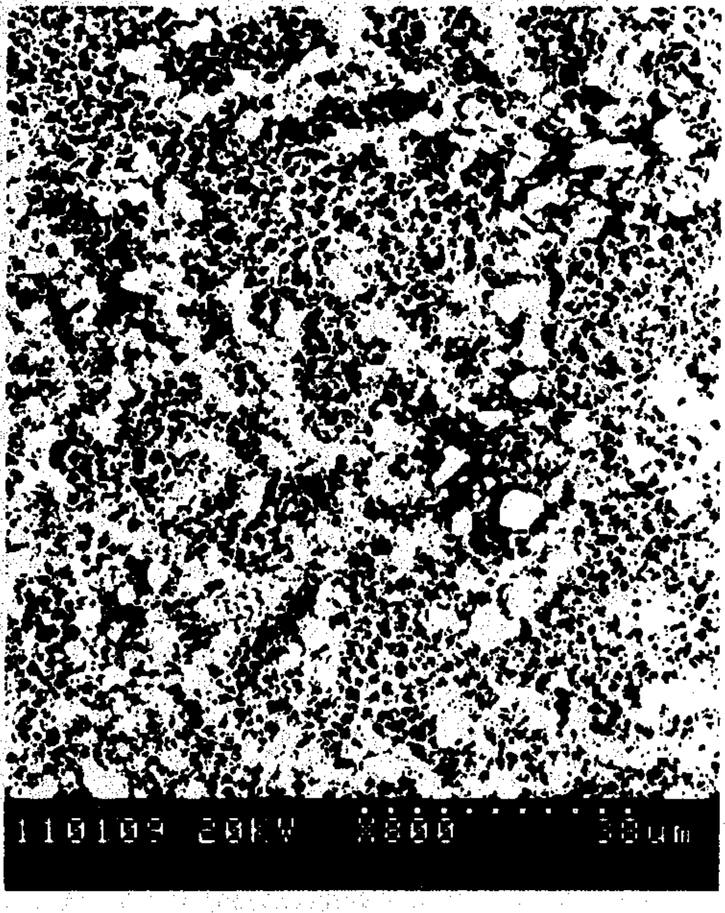
SEM (X 800)

SEM (X 800)



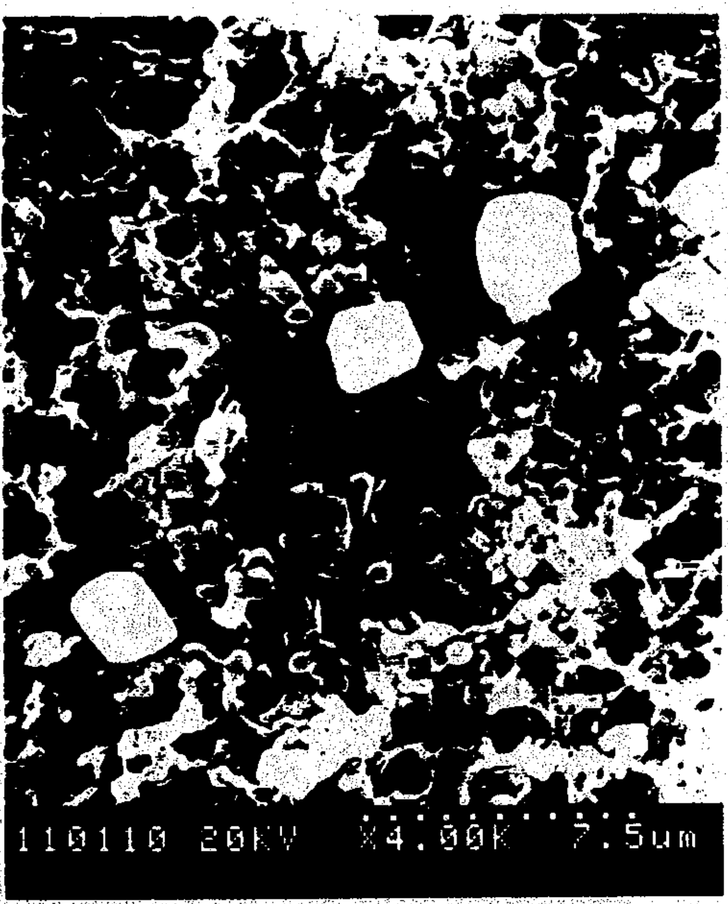
EDX SPECTRUM OVER THE ABOVE SCOPE

PHOTO 4-1 SEM AND EDX OF THE FOULED MEMBRANE SAMPLE (3)

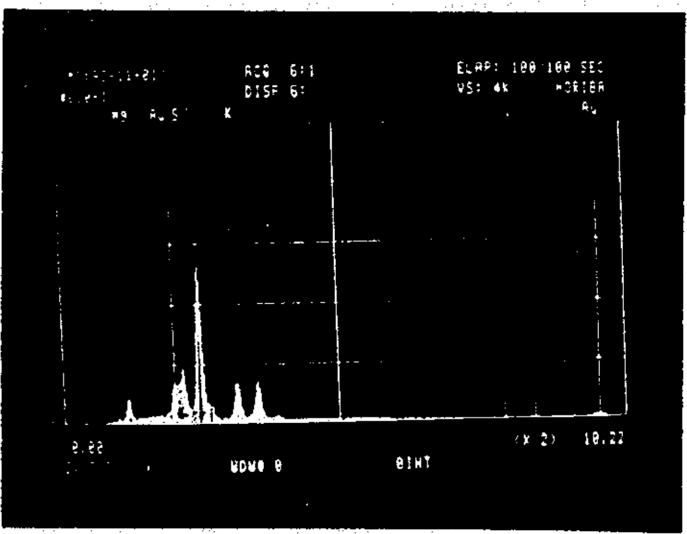


SEM (X 800)

PHOTO 4-2 SEM OF THE FOULED MEMBRANE SAMPLE (3)

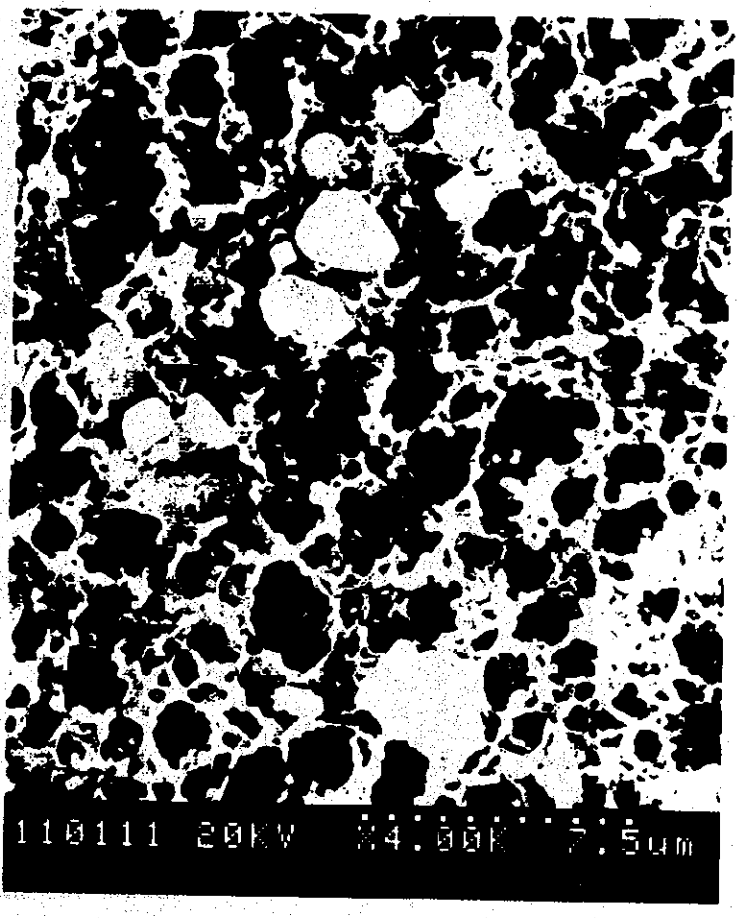


SEM (X 4000)

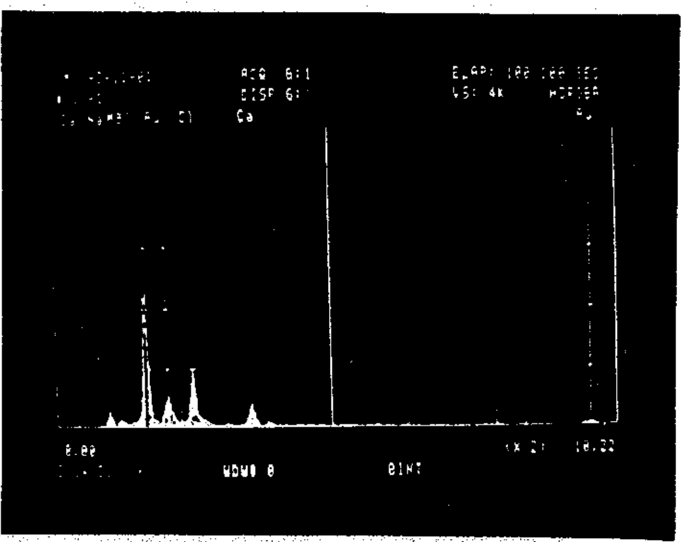


EDX SPECTRUM OVER THE ABOVE SCOPE

PHOTO 4-3 SEM AND EDX OF THE FOULED MEMBRANE SAMPLE (3)



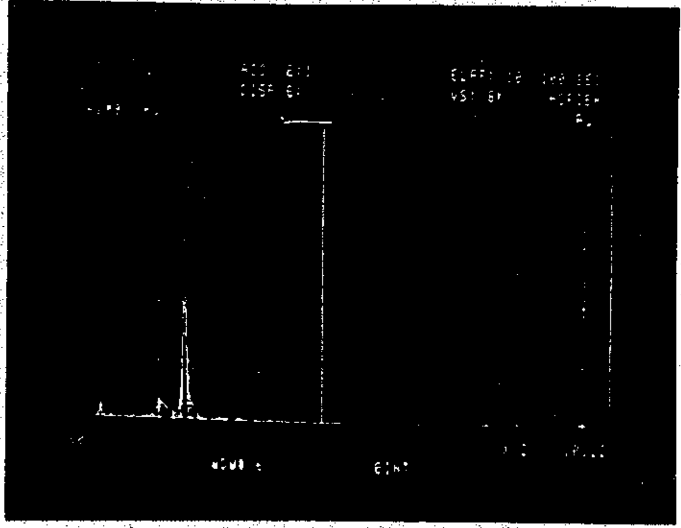
SEM (X 4000)



EDX SPECTRUM OVER THE ABOVE SCOPE

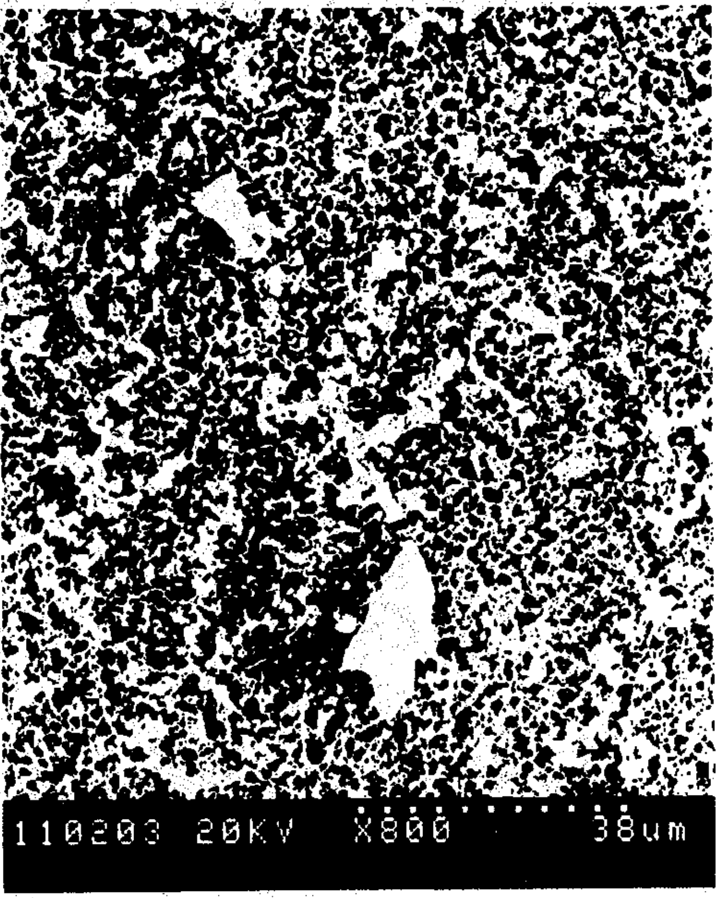
PHOTO 4-4 SEM AND EDX OF THE FOULED MEMBRANE SAMPLE (3)

SEM (X 4000)

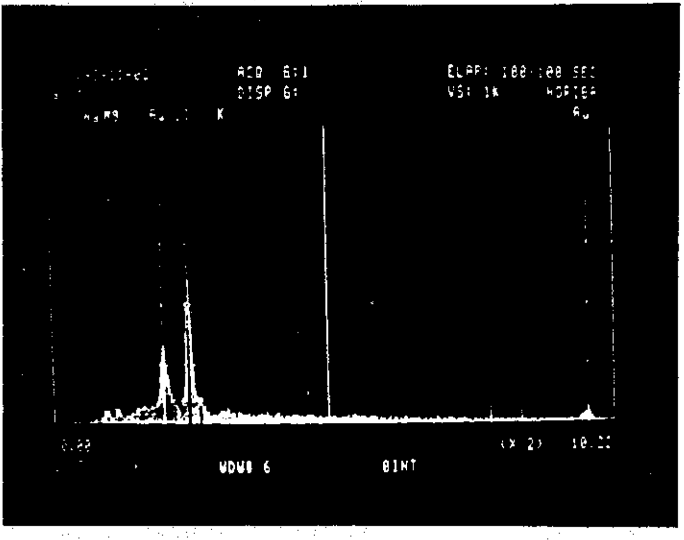


EDX SPECTRUM OVER THE ABOVE SCOPE

PHOTO 4-5 SEM AND EDX OF THE FOULED MEMBRANE SAMPLE (3)

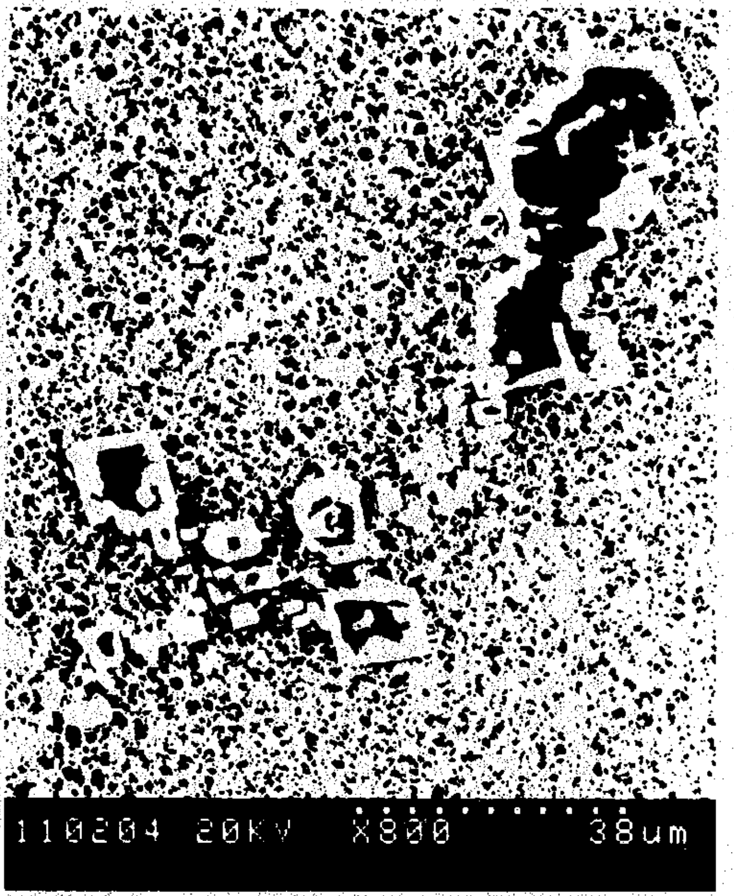


SEM (X 800)



EDX SPECTRUM OVER THE ABOVE SCOPE

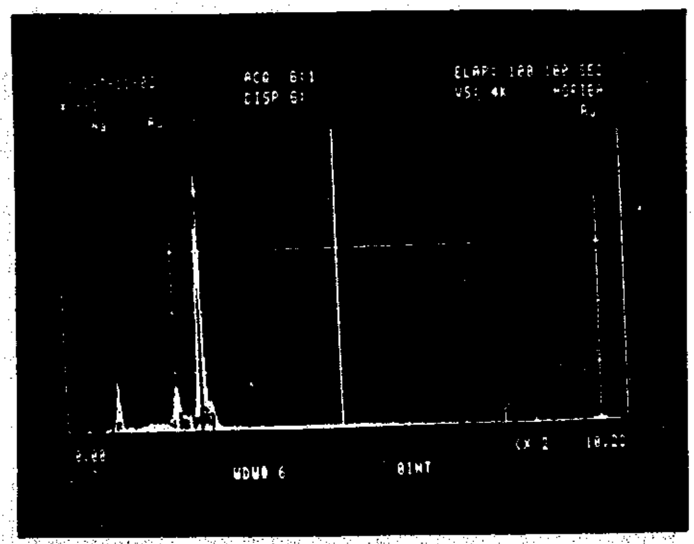
PHOTO 5-1 SEM AND EDX OF THE FOULED MEMBRANE SAMPLE (4)



SEM (X 800)

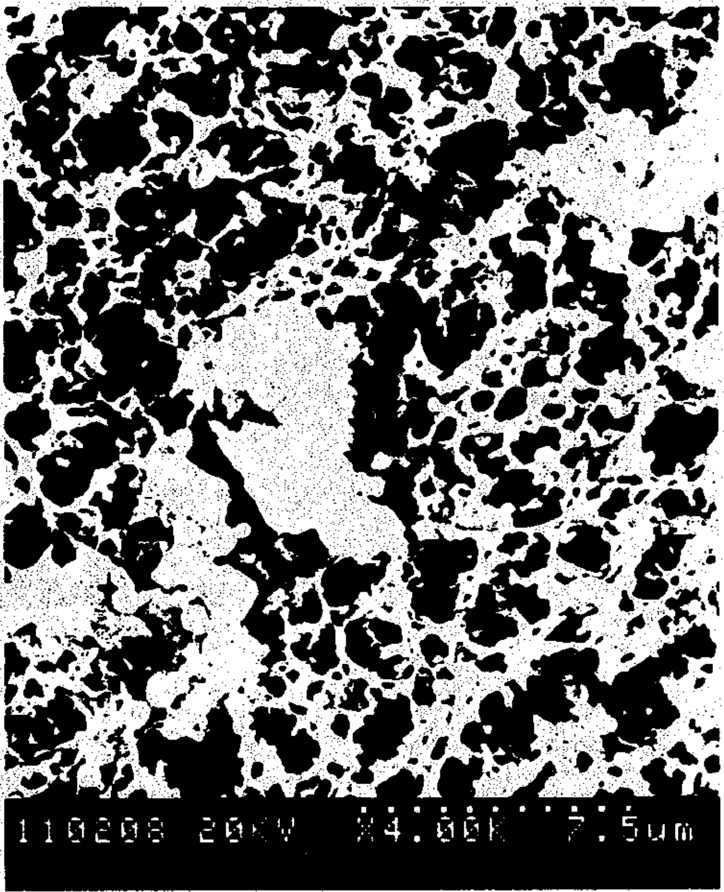
PHOTO 5-2 SEM OF THE FOULED MEMBRANE SAMPLE (4)

SEM (X 4000)

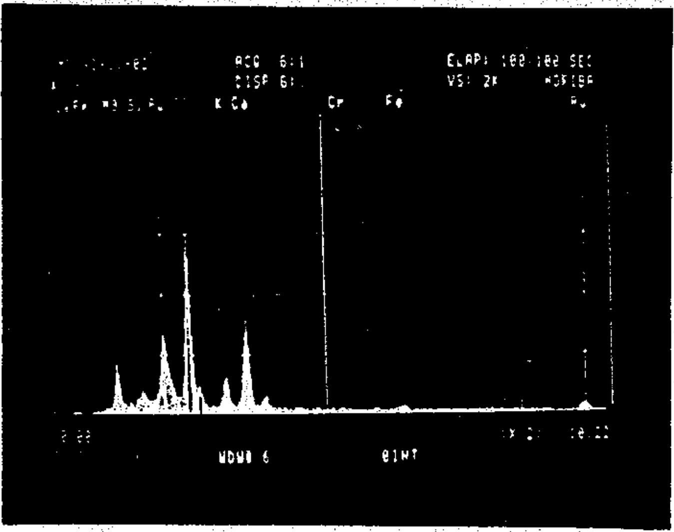


EDX SPECTRUM OVER THE ABOVE SCOPE

PHOTO 5-3 SEM AND EDX OF THE FOULED MEMBRANE SAMPLE (4)

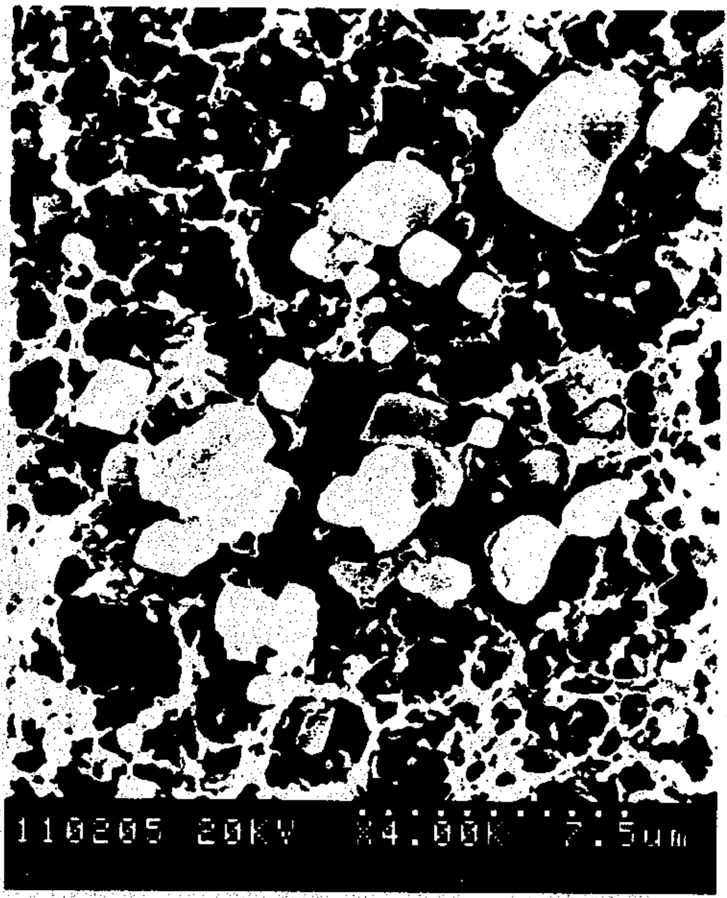


SEM (X 4000)

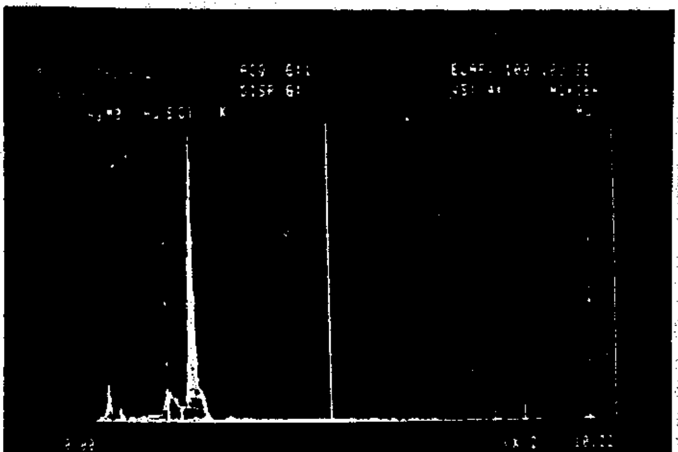


EDX SPECTRUM OVER THE ABOVE SCOPE

PHOTO 5-4 SEM AND EDX OF THE FOULED MEMBRANE SAMPLE (4)



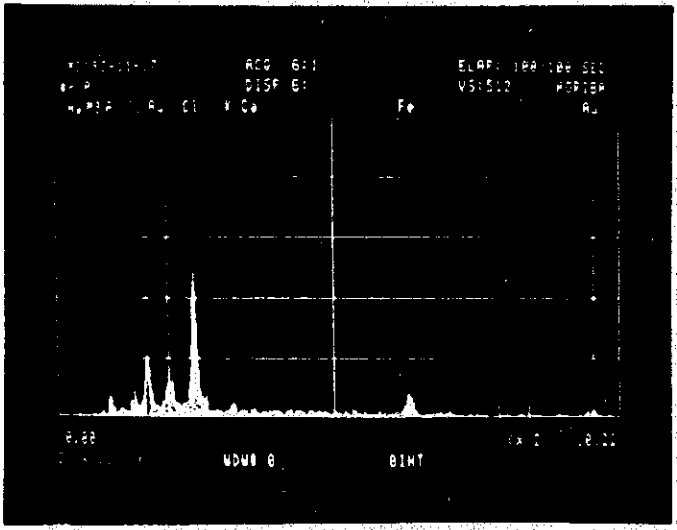
SEM (X 4000)



EDX SPECTRUM OVER THE ABOVE SCOPE

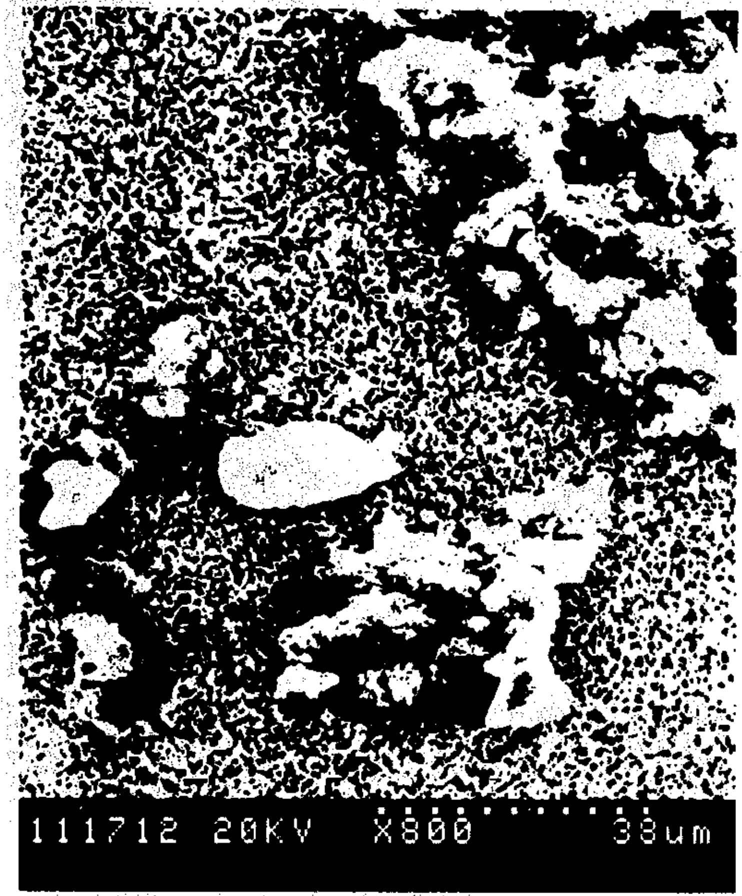
PHOTO 5-5 SEM AND EDX OF THE FOULED MEMBRANE SAMPLE (4)

SEM (X 800)



EDX SPECTRUM OVER THE ABOVE SCOPE

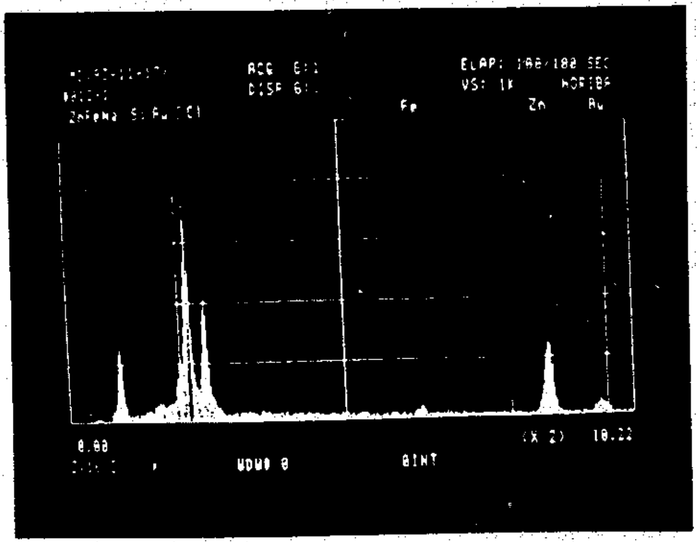
PHOTO 6-1 SEM AND EDX OF THE FOULED MEMBRANE SAMPLE (6)



SEM (X 800)

PHOTO 6-2 SEM OF THE FOULED MEMBRANE SAMPLE (6)

SEM (X 4000)



EDX SPECTRUM OVER THE ABOVE SCOPE

PHOTO 6-3 SEM AND EDX OF THE FOULED MEMBRANE SAMPLE (6)

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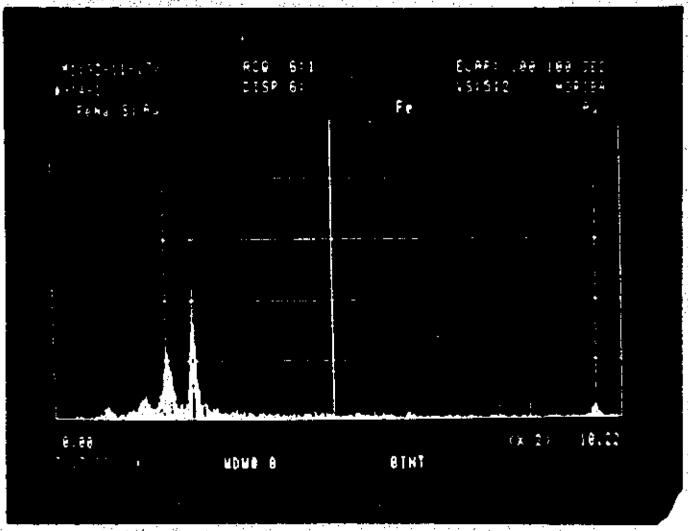

EDX SPECTRUM OVER THE ABOVE SCOPE

PHOTO 6-4 SEM AND EDX OF THE FOULED MEMBRANE SAMPLE (6)

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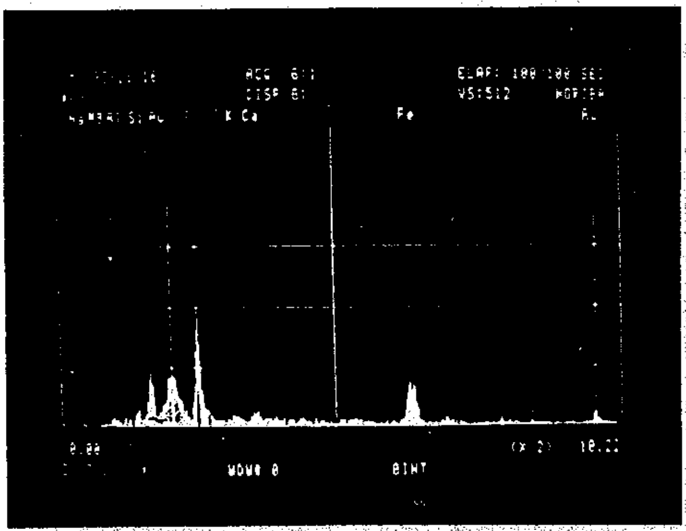
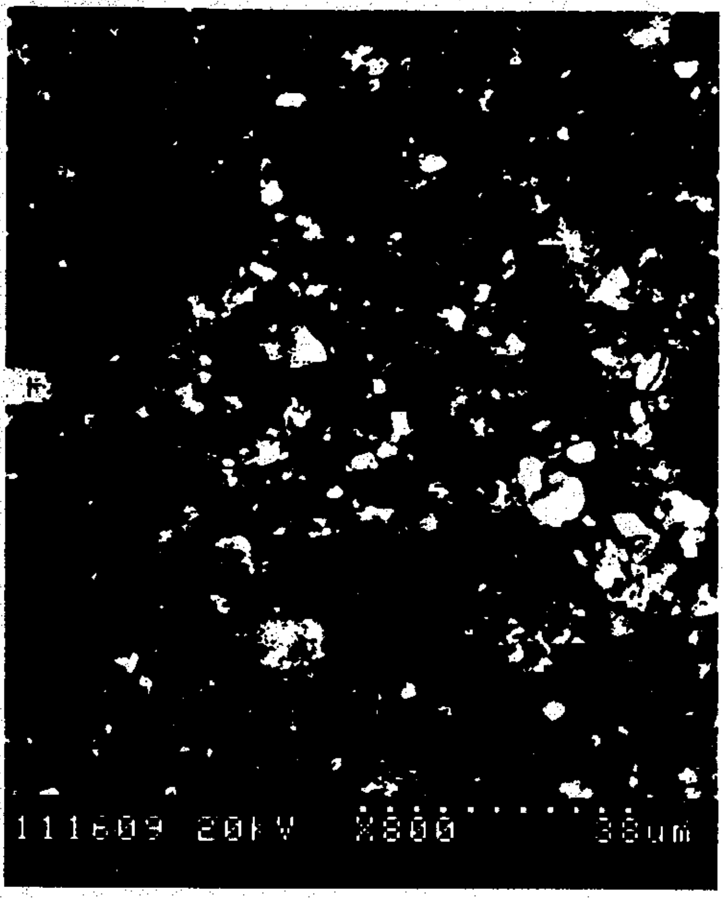


EDX SPECTRUM OVER THE ABOVE SCOPE

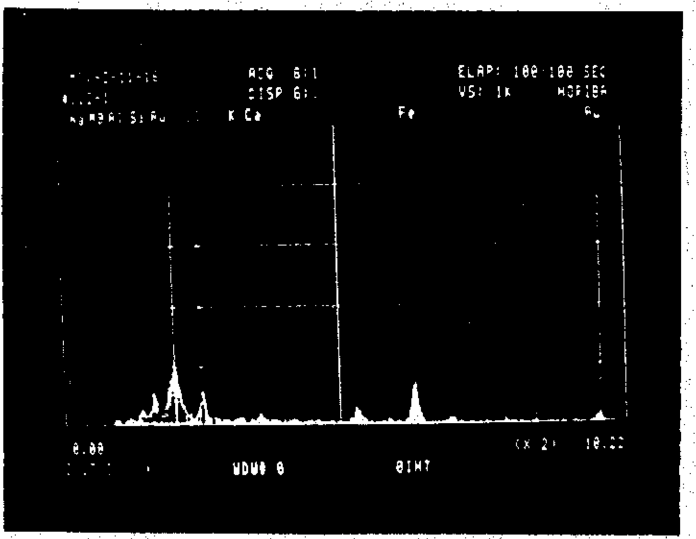
PHOTO 7-1 SEM AND EDX OF THE FOULED MEMBRANE SAMPLE (7)



SEM (X 800)

PHOTO 7-2 SEM OF THE FOULED MEMBRANE SAMPLE (7)

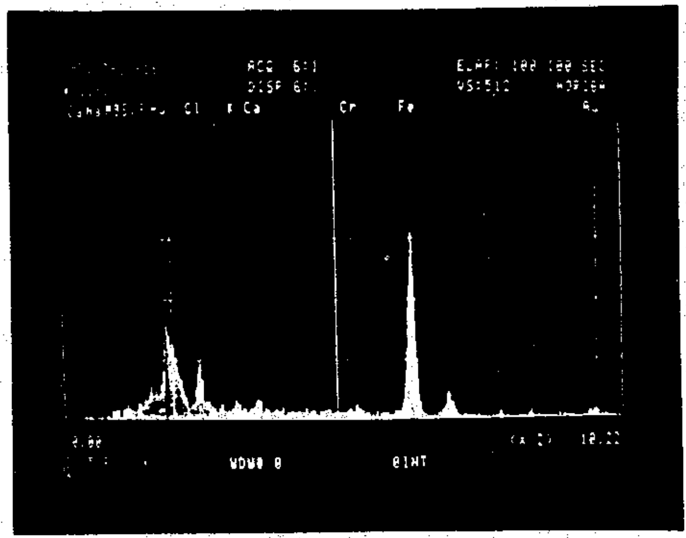
SEM (X 4000)



EDX SPECTRUM OVER THE ABOVE SCOPE

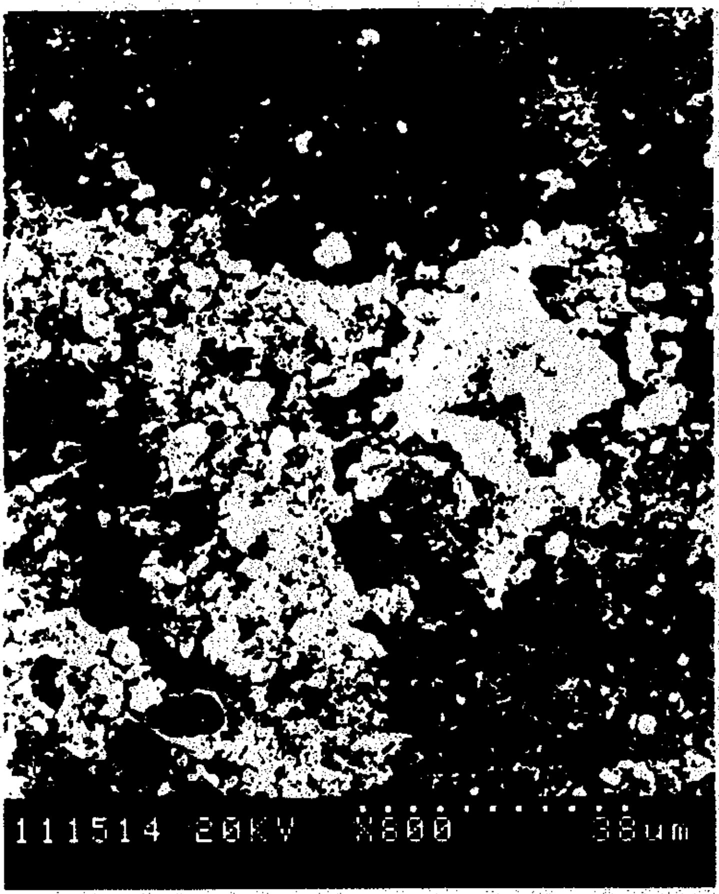
PHOTO 8-1 SEM AND EDX OF THE FOULED MEMBRANE SAMPLE (8)

SEM (X 4000)



EDX SPECTRUM OVER THE ABOVE SCOPE

PHOTO 8-2 SEM AND EDX OF THE FOULED MEMBRANE SAMPLE (8)



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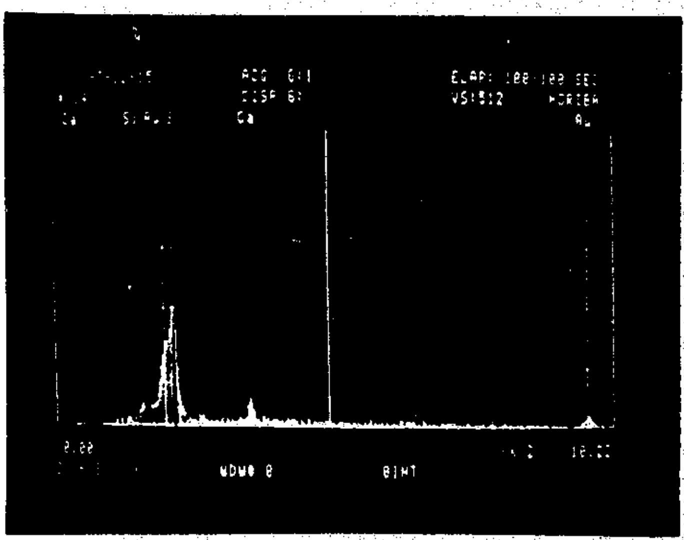
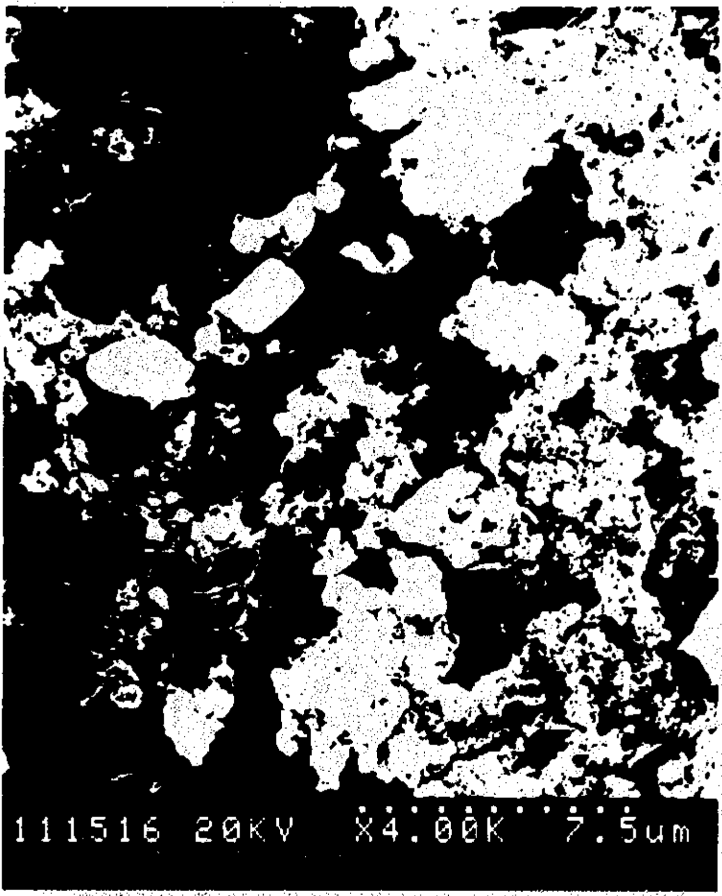
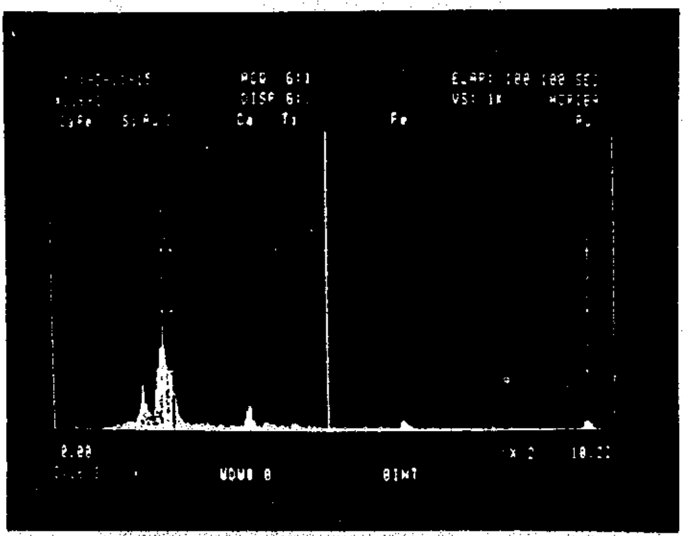


EDX SPECTRUM OVER THE ABOVE SCOPE

PHOTO 9 SEM AND EDX OF THE FOULED MEMBRANE SAMPLE (9)

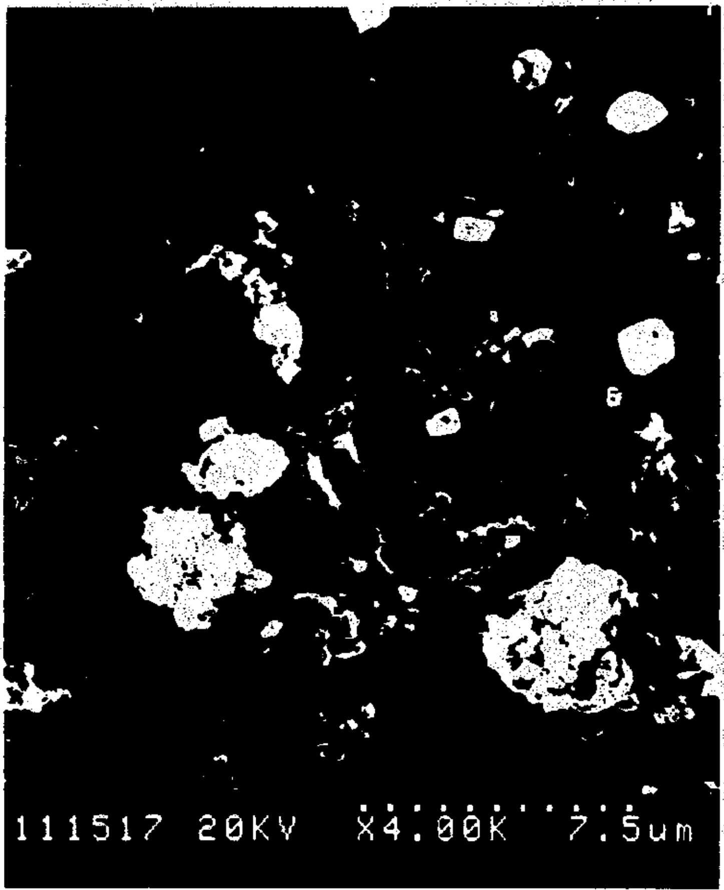


SEM (X 4000)



EDX SPECTRUM OVER THE ABOVE SCOPE

PHOTO 10 SEM AND EDX OF THE FOULED MEMBRANE SAMPLE (10)



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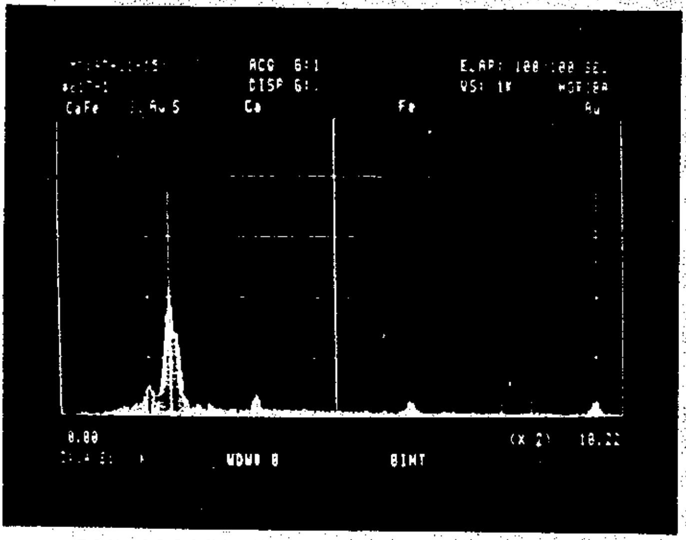
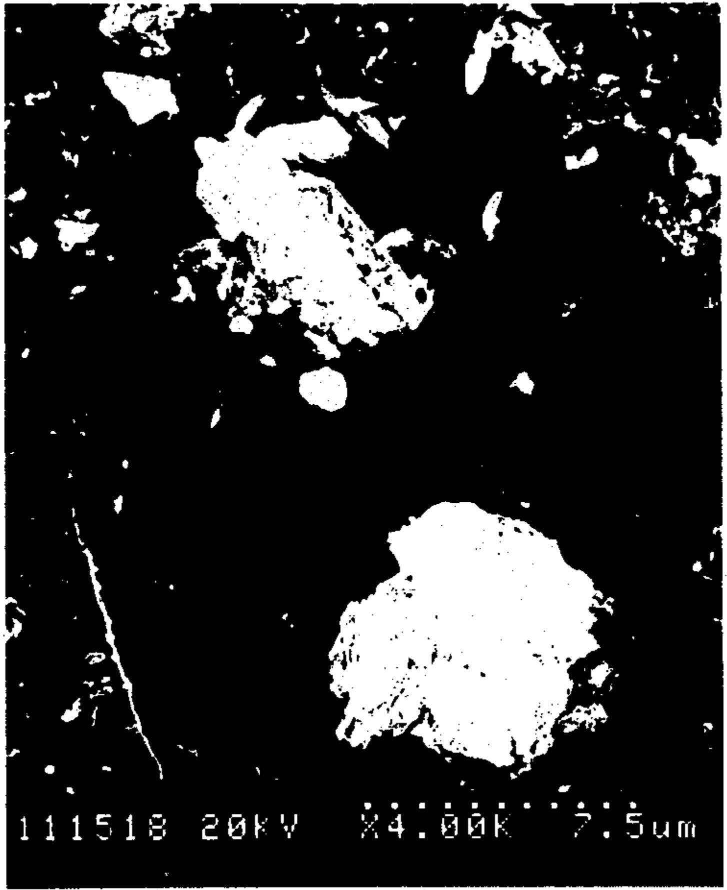


EDX SPECTRUM OVER THE ABOVE SCOPE

PHOTO 11 SEM AND EDX OF THE FOULED MEMBRANE SAMPLE (11)



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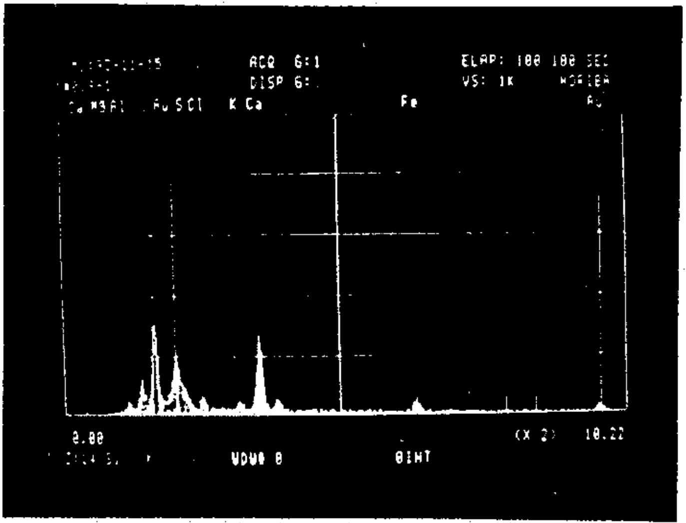

EDX SPECTRUM OVER THE ABOVE SCOPE

PHOTO 12 SEM AND EDX OF THE FOULED MEMBRANE SAMPLE (12)

Appendix 7.1.5-1

Treatment of Backwash Effluent from Pre-Treatment Filtration Equipment for RO Desalination

Treatment of Backwash Effluent from Pretreatment Filtration Equipment of Seawater Desalination Systems1)

Generally, backwash effluent from filtration equipment contains a highconcentration of turbid matter, the treatment and disposal of which is not easy. In RO plants for seawater desalination, highly advanced pretreatment equipment is necessary, and various studies are being made on the treatment of the backwash effluent that is discharged from such equipment.

We introduce herewith a recent research report on this point.

1. Introduction

Begining November 1992, more than a year was devoted to conducting a series of tests on seawater desalination applying the reverse osmosis method, and various data required for the designing of real facilities were collected. Results of tests on the treatment of backwash effluent of sand filtration are reported in particular detail below.

2. Test Plant

Of 100m3 water taken-in per day, 2m3 was discharged per day as backwash effluent. The discharged backwash effluent was treated by the backwash effluent treatment plant indicated in Fig. 1. Operation data were collected, and at the same time, batch tests were conducted and the test results were compared with the results of continuous tests.

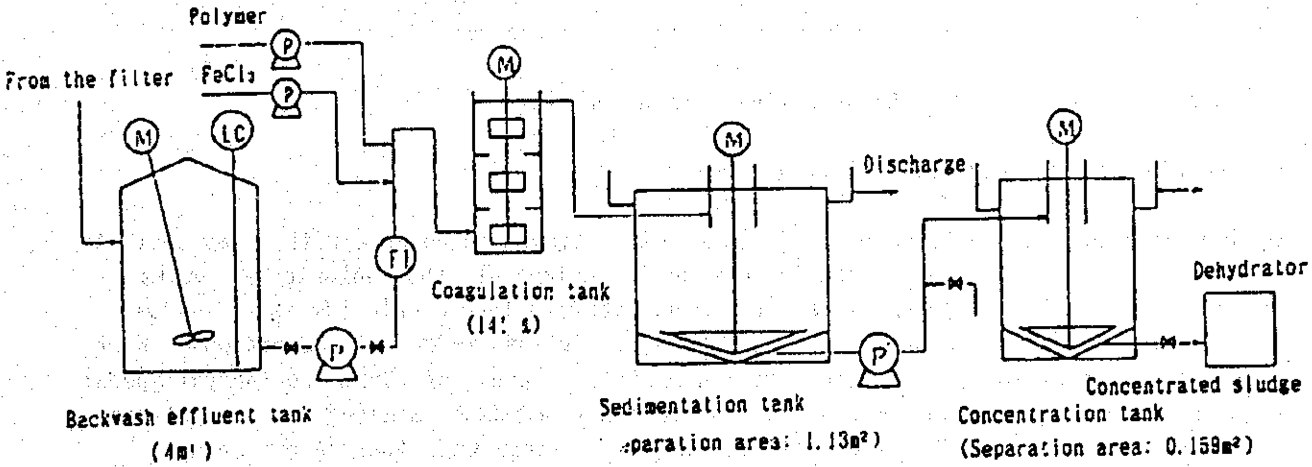

Fig. 1 Backwash Effluent Treatment Plant

3. Test Results

Tests on the treatment of backwash effluent were conducted two times, in spring (March) and in summer (July). As the tests were not much affected by the change of season, representative results of each test are indicated below.

3-1 Property of Backwash Effluent

Backwash effluent was discharged once every day, and the water discharged is reserved in the backwash effluent tank. Analysis results of the property of backwash effluent are indicated in Table 1. The values of SS concentration, turbidity and Fe content were lower in summer than in spring.

Table 1 Results of Backwash Effluent Analysis

Analysis item	Measured value (Spring)	Measured value (Summer)
pH [-]	8.1～ 8.2	8.1～ 8.3
TS [g/L]	37.2～ 37.5	37.8～ 38.8
SS [mg/L]	290 ～ 340	120 ～ 340
Turbidity [degree]	140 ～ 160	70 ～ 150
Colornees [degree]	-	150 ～ 400
Fe [mg/L]	78 ～ 99	22 ～ 64

3-2 Operation Results of Backwash Effluent Treatment Plant

1) Coagulation Tank and Sedimentation Tank

Optimum type and combinations of flocculants were studied in advance with a jar test. As a result, it was found that organic polymer flocculant of the anionic system is optimum, and that its single use or its use it with ferric chloride is effective. Tests were,therefore, conducted with the above flocculant injecting conditions. Best coagulation condition was obtained with an agitation speed of 15rpm (peripheral speed: 0.26m/s) whenthe residence time in the coagulation tank was 25 minutes and the polymer injection ratiow as 1mg/L. The agitation speed of 15rpm was, therefore, maintained thereafter.

Sedimentation tests were conducted using a batch sedimentation tester (104φ x 1100H). The vetention time in the coagulation tank was 25 minutes, and the flocculant injecting conditions were changed eachtime. Fig. 2 shows the relation of SS rejection and up-flow speedin the sedimentation tank, thatis, sedimentation speed. When 1mg/L polymer alone was injected, SS rejection was highest. When ferric chloride (10 - 30mg/L) was injected together with polymer, SS rejection fell. At the upflow speed of 25 mm/min, SS rejection of single polymer was morethan 95%, and that of polymer and ferric chloride was 71 - 94%.When no flocculant was injected, SS rejection was 55%. Table 2 indicates the results of continuous treatment applied using the coagulation tank and the sedimentation tank of the test plant. Changing the vetention time in the coagulation tank from 20 to 33 minutes,and the upflow speed in the sedimentation tank from 3.8 to 6.3mm/min, flocculant injection treatment was applied. As aresult. the turbidity of the overflow from the sedimentation tank was 3.9 - 7.4°, and SS concentration wdas 6 - 16mg/L. The values agree with the results of batch sedimentation.

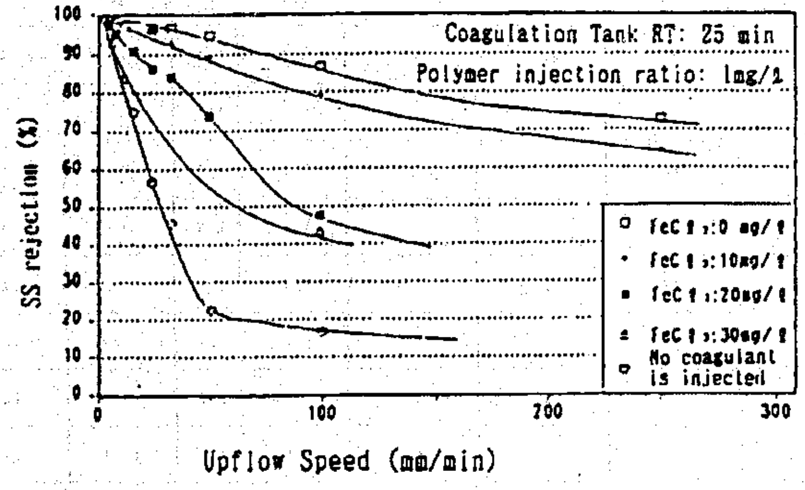

Fig. 2 Relation of Upflow Speed and Rejection (Summer)

Table 2 Operation Results of Coagulation Tank and
Sedimentation Tank (Summer)

No	Coagulation Tank					Sedimentation Tank					
	Concentration (mg/ℓ)	Flow rate (ℓ/min)	Retention time (min)	Polymer injection ratio (mg/ℓ)	$FeCl_3$ injection ratio (mg/ℓ)	Upflow speed (mm/min)	Overflow				Sludge concentration (g/ℓ)
							pH -	Turbidity(°)	SS (mg/ℓ)	Fe (mg/ℓ)	
1	236	5.6	25	1.0	0	5.0	7.5	5.6	7	1.3	
2	246	5.6	25	0.5	0	5.0	7.6	6.4	8	1.2	
3	266	5.6	25	1.5	0	5.0	7.9	5.4	6	0.3	21.2
4	194	7.1	20	1.0	0	6.3	7.6	7.6	6	0.9	46.9
5	128	4.3	33	1.0	0	3.8	7.7	3.9	8	2.1	
6	246	5.6	25	1.0	10	5.0	7.8	4.8	8	-	
7	138	5.6	25	1.0	20	5.0	7.6	7.4	16	2.7	
8	130	5.6	25	1.0	30	5.0	7.6	6.0	10	2.3	
9	164	5.6	25	0	0	5.0	8.1	21.2	26	6.4	

2) Concentration Tank

For the tests of the concentration tank, SS concentration was adjusted to5g/L in advancein the spare tank. Tests were conducted feeding the SS concentration adjusted effluent to the concentration tank continuously. Whenthe upflow speed in the concentration tank was between 2.5 and 7.6mm/min, the turbidity of the overflow was 4.3 - 8.1°, and SS concentration was 4 - 14mg/L. As a result of batch concentration tests, it was found that the sludge obtained has fairly high condensing property; the density after 24-hour concentration was 87 ~ 104g/L.

3-3 Results of Tests on the Dehydration of Backwash Effluent Sludge

Using the filterpress with compression function, tests were conducted onthe dehydration of the sludge discharged from the concentration tank. Test results are indicated in Table3. Changing the filtration time and the compression time respectively, optimum dehydration conditions were sought after. 20-minute filtration time and 20-minute compression time, the dehydration cake's water content reached 40%, and the filtration rate reached its maximum value at 7.1kg/m^2·h. The filtration rate was much higher than that in the dehydration of normal tap water sludge. The reason for this high filtration vate is considered to be the good condensing property of the sludge. Long hour filtrationtests without compression were conducted simultaneously. For the tests, the filtration pressure was raised stepwise, and after raising the pressure to 15kgf/cm^2 in 3 hours, the same pressure was maintained. After 8-hour filtration, the cake's water contentwas41.0%,and the filtration rate was 14kg/m2·d. The water content was almost the same as that obtained in the tests with compression.

Table 3 Results of Dehydration Tests Using Filter Press (Summer)

No	Filtration pressure (kgf/cm^2)	Filtration time (min)	Compression pressure (kgf/cm^2)	Compression time (min)	Cake's water content (%)	Filtration vate (kgf/min)
1	4	10	15	20	37.3	6.71
2	4	20	15	20	40.7	7.12
3	4	30	15	20	42.2	5.99
4	4	20	15	10	49.6	7.92
5	4	20	15	30	34.5	4.82

4. Conclusion

Backwash effluent of seawater desalination was treated continuously using a small-sized coagulation tank, sedimentation tank and concentration tank, and the data required for the designing of real treatment facilities were obtained. Tests on the dehydration of sludge discharged from the concentration tank were also conducted, and the sludge's rough dehydrating properties were ascertained.

1) T. Kobayashi, et al: The 45th National Service Water Research Presentation Conference (May 1994), Sendai City

Table 2 Trihalomethane (Abundance) and Trihalomethane FP

Operation time (hr)	Trihalomethane (μg/L) Upper value: Abundance Lower value (in parenthesis): FP					
	Sea water	Feed water	Cellulose acetate membrane		Polyamide membrane	
			Permeate	Brine	Permeate	Brine
140	 (54.5)	25.0 (41.8)	29.0 (32.5)	18.0 (48.2)	2.7 (2.7)	39.0 (63.7)
500	 (43.2)	15.0 (39.0)	22.0 (23.3)	14.0 (42.0)	2.0 (4.8)	24.0 (49.2)
1150	 (37.0)	16.0 (33.0)	22.0 (22.0)	13.0 (40.0)	3.0 (3.2)	24.0 (37.0)
2260	 (61.5)	21.5 (38.6)	30.0 (32.4)	18.0 (56.7)	2.6 (4.8)	27.0 (36.1)

Table 3 Items of Trihalomethan (Abunddance and FP)

	Trihalomethane (μg/ℓ)			Trihalomethane (μg/ℓ)FP			
	Feed water	CA membrane permeate	PA membrane permeate	Sea water	Feed water	CA membrane permeate	PA membrane permeate
Chloroform	<1.0	<1.0	<1.0	12.0	<1.0	<1.0	<1.0
Bromodichlormethane	<1.0	<1.0	<1.0	<1.0	<1.0	1.0	<1.0
Dibromochlormethane	<1.0	<1.0	<1.0	1.5	1.8	2.5	<1.0
Bromoform	25.0	29.0	2.7	41.0	40.0	29.0	2.7
Total trihalomethane	25	29	3	55	42	33	3

CA membrane: Cellulose acetate membrare PA membrane: Polyamide membrane