REPORT ON ADVANCED TECHNOLOGY FOR TREATMENT OF MARINE PRODUCT PROCESSING EFFLUENT IN COLD REGIONS

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NOTE

- Method of Measuring COD
  The COD values given in the text, unless specified otherwise, are obtained by the manganese measuring method.
- Currency used in this report is all Japanese Yen (JPY or yen).

I Necessity of Establishing Advanced Technology for Treatment of Marine Product Processing Effluent in Cold Regions

A. Introduction

Since the country is surrounded by sea, processed marine products are an indispensable part of the Japanese diet . The marine product processing industry centered around fishing ports is spread all over Japan. The current situation and the future of this marine product processing industry reveals are as follows:

1. Current Situation of Marine Product Processing Industry

1) Number of Marine Product Processing Business Entities
According to a fact-finding survey carried out by the National Federation of Marine Product Processors' Cooperatives from October 1971 to September 1972 commissioned by the Fisheries Agency, the situation is as shown in Table 1. It shows that the total number of actual business organizations standing at approximately 19,000 of which 7,543 or about 40% are involved in salted and dried products and 3,008 or 15.8% in boiled fish paste.

Table 1 Number of Business Organizations by Processed Products

Processed Product	No. of Business Organizations	Component Ratio
Total No.	18,979	100.0%
Salted and dried products	7,543	39.7
Smoked products	183	1.0
Dried fish meat	945	5.0
Planed dried fish meat (shavings of dried Fish meat)	431	2.3
Processed Marine products boiled down in soy sauce	600	3.2
Processed laver	262	1.4
Boiled fish paste	3,008	15.8
Fish meat ham and sausage	65	0.3
Canned and bottled products	252	1.3
Frozen products	1,065	5.6
Agar-agar	213	1.1
Other processed foods	4,005	21.1
Fish oil and fat	46	0.3
Feed and fertilizer	361	1.9

2) Distribution of Marine Product Processing Industry by Regions

According to the Ministry of Agriculture and Forestry's Annual Statistical Report on Marine Products Distribution for 1972, production of processed marine products is generally high in the so-called cold regions of Hokkaido and the Tohoku region. This is particularly true with regard to salt-preserved products, fish oil, feed and fertilizer, frozen products, and frozen ground fish meat, as shown in Table 2. Ninety-five point nine percent (95.9%) of all frozen ground fish meat is produced in the cold regions.

Table 2 Production of Processed Marine Products in Cold Regions

Processed Products		Overall (t/year)	Hokkaido/Tohoku Region		Hokkaido	
			(t/year)	Component ratio (%)	(t/year)	Component ratio (%)
1	Salt-preserved products	177,876	131,917	74.1	86,787	48.7
2	Smoked products	6,775	3,228	47.6	2,945	43.4
3	Dried fish meat	106,254	5,588	5.3	130	0.1
	Planed dried fish meat (shavings of dried fish meat)	43,723	1,151	2.6	130	0.2
4	Fish paste	1,156,205	211,831	18.3	41,951	3.6
	Fish meat ham and sausage	162,398	30,367	18.6	10,151	6.2
5	Frozen products	1,626,905	1,155,769	71.0	646,651	39.7
	Frozen ground fish meat	198,909	190,889	95.9	149,064	74.9
6	Fish oil	85,390	60,243	70.5	30,283	35.4
7	Feed and Fertilizer	747,131	409,439	54.8	242,324	32.4
8	Shade-dried products	46,092	31,643	68.6	29,718	64.4
9	Salt-dried products	177,212	23,136	13.0	18,190	10.2
10	Boiled-dried products	89,923	4,202	4.6	528	0.5
11	Other processed marine products	259,461	70,075	27.0	29,697	11.4

Note: 1. Table 2 is based on the Annual Statistical Report on Marine Products Distribution for 1972 of the Statistics and Survey Department, Economic Affairs Bureau, Ministry of Agriculture and Forestry.

2. It shows land-processed production volumes.

3. The quantity of planed dried fish meat (shavings of dried fish meat) was extracted from the quantity of dried fish meat.

4. The quantity of fish meat ham and sausages was extracted from the quantity of fish paste.

5. The quantity of frozen ground fish meat was extracted from the quantity of frozen products.

2. Future of Marine Products Processing Industry

Fishery production in 1971, at 990,900 tons, neared the 10 million-ton mark, but the average rate of increase in the past 10 years was about 4%. The coastal fisheries and medium and small fisheries did not increase production but the large-scale fisheries registered large gains.

Of the types of fish produced, the walleye pollack and mackerel comprised 40% of the total production, with sharp rises of 7.7 times and 3.7 times respectively in the past 10 years. However, the problem of ensuring future resources remains. The average length of the walleye pollack has decreased yearly from 43 cm in 1967 to 39 cm in 1971. On the other hand, looking at the production of processed marine products, as can be seen from Table 3, it approximately doubled in 10 years. It is said there is a tendency for it to increase even further in the future, especially with respect to frozen products, fish paste, and feed and fertilizer.

Table 3 Trends in Production of Processed Marine Products by Type

	1961	1966	1969	1970	1971	1972
	1000 tons	1000 tons	1000 tons	1000 tons	1000 tons	1000 tons
1 Total of food products	1,223	1,592	1,911	1,889	1,999	2,064
(1) Fish paste	573	895	1,077	1,081	1,127	1,156
(2) Salt-preserved products	113	167	206	180	223	222
(3) Miscellaneous products	168	197	246	251	241	259
(4) Salted and dried products	370	332	381	376	409	426
(i) Shade-dried products	39	39	38	42	40	46
(ii) Salt-dried products	125	121	160	144	182	177
(iii) Boiled-dried products	122	83	81	83	84	90
(iv) Smoked products	9	6	9	8	8	7
(v) Dried fish meat	74	83	94	98	95	106
2 Total of fish oil, fat, feed and fertilizer	552	576	885	979	1,003	1,087
(1) Fish oil and fat	190	125	145	177	160	163
(2) Feed and fertilizer	362	451	740	802	843	924
3 Canned products (number of standard cases)	13,228	12,755	14,116	16,210	18,289	17,575
4 Total of frozen products	1,086	1,826	2,207	2,434	2,750	2,929

Note: Table 3 is based on the Ministry of Agriculture and Forestry's Annual Statistical Report on Marine Products Distribution.

3. Modernization and Rationalization of Marine Products Distribution and Processing

Fisheries are tending to become large-scale and their landed catches are being concentrated in certain specific ports. Under such background, the industry, lead by the Fisheries Agency, has been forming marine products processing and distribution centers since 1969, for the purpose of setting up integrated processing and distributing facilities in the producing areas. The plan for this year is as per Table 4. The system is for the national government to subsidize the prefectural governments in constructing such installations as markets, refrigeration warehouses, treatment and processing plants, pollution control facilities, etc. These large producing districts are particularly numerous in the cold regions, and the development of pollution control technology suited to these regions is now required.

Table 4 Annual Plan for Formation of Marine Products Processing and Distributing Centers

○ Surveyed year ◎ Business year

Name of City	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978
Wakkanai	○	○	◎	◎	◎					
Hachinohe	○	○	◎	◎	◎					
Sakaiminato	○	○	◎	◎	◎					
Shimonoseki	○	○	◎	◎	◎					
Nagasaki	○	○	◎	◎	◎					
Ishinomaki		○	○	◎	◎	◎				
Nakaminato		○	○	◎	◎	◎				
Yaizu		○	○	◎	◎	◎				
Karatu		○	○	◎	◎	◎				
Makurazaki		○	○	◎	◎	◎				
Kushiro			○	○	◎	◎	◎			
Nemuro			○	○	◎	◎	◎			
Miyako			○	○	◎	◎	◎			
Onahama			○	○	◎	◎	◎			
Hamada			○	○	◎	◎	◎			
Abashiri				○	○	◎	◎	◎		

Name of City	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978
Kamaishi				○	○	◎	◎	◎		
Shiogama				○	○	◎	◎	◎		
Choshi				○	○	◎	◎	◎		
Katsuura				○	○	◎	◎	◎		
Monbetsu					○	○	○	◎	◎	
Rumoi					○	○	◎	◎	◎	
Oofunato					○	○	◎	◎	◎	
Kasumi					○	○	◎	◎	◎	
Kesennuma					○	○	◎	◎	◎	
Yoichi					○	○	◎			
Kanazawa					○	○	◎			
Akune					○	○	◎			

B. Problems of Marine Product Processing Industry Effluent

1. Water Quality of Effluent of Marine Product Processing

According to the 1971 report of the National Federation of Marine Product Processors' Cooperatives, the effluent produced by the processing of marine products generally has the following characteristics.

1) The volume of water is large.

2) In many cases the effluent is discharged into the sea area, polluting the water and causing damage to multiplication and cultivation of marine life.

3) Water quality varies widely, depending, for example, on the type of fish, the season, form of processing, freshness, etc. It also varies greatly depending on the working hours in processing lines.

4) Sea materials are extremely likely to decompose and emit a foul smell.

5) Sea materials contain a large amount of water soluble proteins and oil depending on the season.

6) Suspended solids (SS) is plenty and BOD is high.

7) Containing salt.

Table 5 shows the results of measurements made on effluent as given in the Report.

Table 5 - ①

Integrated Effluent	Volume of Processed Fish	BOD	Amount of Effluent	Surveyed by
	ton	ppm	m^3/day	
Raw ground meat	20	5,769	700 - 800	Aomori Processing Research Laboratory
Canned water-boiled mackerel	25	2,494	200	"
Dried "mirin" (sweet sake) - seasoned mackerel	20	2,773	119	Iwate Fisheries Experiment Station
Frozen products	-	1,740	50	"
Feed	100	9,610	270	Aomori Processing Research Laboratory
Primary treatment water	193	26,919	244	Shiogama Industrial Complex

Table 5 - ②

Effluent Classification	BOD	COD	SS	Surveyed by
	ppm	ppm	ppm	
Canned Product: Washing of raw material	172	273	130	Tottori Fisheries Experiment Station
After steaming/boiling	611	421	700	
Integrated level	1,240	590	3,160	
Primary Processed Fish: Washing	25,450			Shiogama Industrial Complex
Fish head storage tank	25,750			
Fish bowels washing process	17,300			
Primary Prepared Fish: Washing	1,375	509		Aomori Processing Research Laboratory
Rotary screening separator for blood from fish meet	5,325	2,039		
Integrated level	6,619	1,853		"

Table 5 - ③

Ground Fish Meat Factory Effluent by Measurement Hours	BOD	COD	SS	Oil Content	Surveyed by
	ppm	ppm	ppm	ppm	
9:30	532	131	890	Traces	Mie University
11:00	95	42	240	Traces	
14:00	508	168	770	60	
16:00	91	42	240	50	

Table 5 - ④

Integrated Effluent by Measurement Dates	BOD	COD	SS	Oil Content	T-N	Transparency	Surveyed by
	ppm	ppm	ppm	ppm	ppm	cm	
Boiled Fish Paste Factory A: Sep.	485	103	158	67	69	5.1	Wakkanai Fisheries Experiment Station
Boiled Fish Paste Factory A: Oct.	6,500	861	1,018	30	80	7.5	
Boiled Fish Paste Factory B: Sep.	13,400	282	199	163	124	5.0	
Boiled Fish Paste Factory B: Oct.	5,850	554	82	12	340	3.2	
Ground Fish Meat Factory C: Sep.	2,010	491	514	530	247	0.9	
Ground Fish Meat Factory C: Oct.	9,600	1,261	418	18	210	3.0	

Table 5 - ⑤

Effluent Classification	BOD	COD	T-N (total nitrogen) in Solids	Soluble Proteins State Nitrogen	Non-proteins StateNitrogen	Surveyed by
	ppm	mg %	mg %	mg %	mg %	
Ground Fish Meat Factory D Integrated	5,769	64.31	15.55	25.06	23.70	Aomori Processing Research Laboratory
Ground Fish Meat Factory E Integrated	2,438	29.02	5.72	14.14	9.16	
Ground Fish Meat Factory F Integrated	6,619	78.39	27.16	26.72	24.51	
G.F. Meat Factory G Preparation Washing	1,375	8.76	2.46	3.45	2.85	
G. F. Meat Rotary Screening Separator for Blood from Fish Meat	5,325	111.82	26.30	38.24	47.23	
Ground Fish Meat 3rd Water Rinsing	1,871	24.37	6.65	10.12	7.60	
Ground Fish Meat Integrated level	3,554	50.91	14.09	18.09	18.73	

As can be seen from the above, effluent with extremely high BOD, COD, SS, oil content, etc. is being discharged in considerably large quantities. Many of those responsible for the discharge are small and medium-sized enterprises of which 83% are very small businesses having 9 or less employees.

2. Outline of Legal Controls

Marine product processing effluent is regulated by the Water Pollution Control Law (as shown in Table 6). It is governed by the general standards and the provisional standards.

Table 6 General Standards and Provisional Standards

Type of Business	Item	General Standards: pH	General Standards: Max. BOD (Avg.)	General Standards: Max. COD (Avg.)	General Standards: Max. SS (Avg.)	General Standards: Normal Hexane (Animal and Vegetable Oils and Fats)	Provisional Standards From June 24, 1973 to June 23, 1976: Max. BOD (Avg.)	Provisional Standards: Max. COD (Avg.)	Provisional Standards: Max. SS (Avg.)	Provisional Standards: Normal Hexane (Animal and Vegetable Oils and Fats)	Remarks
122 Seafood Products	1221 Canned seafood and seaweed	Streams, rivers, lakes, swamps: 5.8-8.6 Sea areas: 5.0 - 9.0	ppm 160 (120)	ppm 160 (120)	ppm 200 (150)	ppm 30	ppm 390 (300)	ppm 260 (200)	ppm	ppm 70	
	1226 Frozen seafood products	"	160 (120)	160 (120)	200 (150)	30	390 (300)	260 (200)	330 (250)	70	Excluding frozen ground fish meat makers
	1226 "	"	160 (120)	160 (120)	200 (150)	30	780 (600)	780 (600)	330 (250)	70	Only frozen ground fish meat makers
	1223 Agar-agar and isinglass	"	160 (120)	160 (120)	200 (150)	30	390 (300)	390 (300)	330 (250)		
	1229 Miscellaneous seafood products	"	160 (120)	160 (120)	200 (150)	30	390 (300)	260 (200)		70	Excluding raw ground fish meat makers
	1229 "	"	160 (120)	160 (120)	200 (150)	30	780 (600)	780 (600)		70	Only raw ground fish meat makers
136 Prepared Animal Foods and Organic Fertilizers	Elemental feeds	"	160 (120)	160 (120)	200 (150)	30	780 (600)	780 (600)	330 (250)	70	Including fish meal feed makers (Production of concentrated water-soluble protein liquid)

In addition, regulations of each Prefecture, over and above the additional standards, are also in force.

The standards of those regulations are shown Table 7.

Table 7 Local Effluent Standards More Stringent Than the National Uniform Standards

As of June 1973

Note: Those in which type of business are specified

Classification No.	Name of Business	Names of Water Area	and Prefecture	Max. BOD (Avg.)	Max. COD (Avg.)	Max. SS (Avg.)	Normal Hexane (Animal and Vegetable Oils and Fats)	Remarks
122	Seafood Products	Class 3 Water Area	Chiba	130 (100)	130 (100)	150 (110)		Effluent 1,000 m³/day or less (only BOD and COD) - Already established
				25 (20)	25 (20)	90 (70)		Effluent 1,000 m³/day or less (only BOD and COD) - Newly established
				100 (80)	100 (80)			Effluent 1,000 m³/day or more - Already established
				25 (20)	25 (20)			Effluent 1,000 m³/day or more - Newly established
		Shinano River	Niigata	100 (80)		80 (60)		Facilities located in other areas. Facilities installed or construction started on or before December 24, 1971
				90 (70)		80 (60)		Facilities located in other areas. Facilities installed or construction started after Dec. 24, 1971
		Yodo River, Uji River	Kyoto	300 (250)			30	Already established
		Class 1 Water Area	Hiroshima	160 (120)				
		Class 2 Water Area		200 (150)				
		Class 3 Water Area		230 (180)				
		Class 4 Water Area		200 (150)				
		Yamaguchi Pref.	Yamaguchi	390 (300)	260 (200)		70	Provisional standards for 3 years
		Urato Bay and Niyodo River Water Areas	Kochi	180 (150)		90 (70)	20	

1221	Canned seafood and seaweed	Yamaguchi Pref.	Yamaguchi	390 (300)	260 (200)			Provisional standards for 3 years
1223	Agar-agar and isinglass	Class 1 Water Area	Hiroshima			130 (100)		
		Class 2 Water Area				200 (150)		
		Yamaguchi Pref.	Yamaguchi		390 (300)	330 (250)		
1225	Fish paste products	Urato Bay and Niyodo River Water Area	Kochi			90 (70)	20	
1226	Frozen seafood products (unprocessed and packaged)	Yamaguchi Pref.	Yamaguchi	390 (300)	260 (200)	330 (250)		
				790 (600)	780 (600)			
	Raw ground fish meat processors			780 (600)	780 (600)			
1226	Frozen seafood products (unprocessed and packaged)	Class 1 Water Area	Hiroshima			130 (100)		
		Class 2 Water Area				200 (150)		
1229	Miscellaneous seafood products	Jintsu River Water Area	Toyama	170 (140)		100 (80)		General area (facilities already installed or construction started on or before May 1, 1972)
122	Seafood products	Matsushima Bay	Miyagi	180 (150)	120 (100)	180 (150)	50	
1226	Frozen seafood products	Niida River Mouth Water Area	Aomori	200 (150)	130 (110)	180 (150)	20	Frozen and raw ground fish meat processors
1292	Starch			180 (150)	130 (110)	180 (150)	30	Including fish meal and feed makers (Production of concentrated water-soluble protein liquid)
1229	Miscellaneous seafood products			150 (120)	100 (80)	150 (120)	10	

122	Seafood products	Tokoro River Water Area	Hokkaido	300 (250)				Excluding seaweed products, except canned, fish meat ham and sausage, and fish paste products
		Abashiri River Water Area	Hokkaido	300 (250)				Excluding frozen seafood product s, seaweed products, except canned, fish meat ham and sausage, and fish paste products
1226	Frozen seafood products (unprocessed and packaged)	Abashiri River Water Area	Hokkaido	300 (250)		250 (200)		
1292	Starch			80 (60)		70 (50)		Including fish meal and feed makers (Production of concentrated water-soluble protein liquid)
122	Seafood products	Shari River Water Area	Hokkaido	300 (250)				Excluding seaweed products, except canned, fish meat ham and sausage, and fish paste products
		Arakawa River Area	Hokkaido	160 (120)		200 (150)		
				390 (300)		330 (250)		Limited to average daily effluent of 20 m^3 to less than 50 m^3 Up to June 23 1976
				160 (120)		200 (150)		Limited to average daily effluent of 20 m^3 to less than 50 m^3. From June 24 1976
	Raw ground fish meat processors, elemental feeds and frozen ground fish meat processors	Wakkanai Sea Area	Hokkaido		520 (400)			Including fish meal and feed makers (Production of concentrated water-soluble protein liquid)
122	Seafood products	Wakkanai Sea Area	Hokkaido		2,000 (1,500)			Limited to average daily effluent of 20 m^3 to less than 50 m^3 From June 24 1977

Even with these local effluent standards more stringent than the national uniform standards, there is a tendency to gradually make them even more strict. At the same time, the provisional standards of the Water Pollution Control Law are scheduled to expire on June 24, 1976. Furthermore, there is an active movement for area-wide total pollutant load control so it is conceivable that nitrogen and phosphorous with also become subject to control in the future.

3. Current State and Problems of Marine Product Processing Effluent

1) Current State

In order to cope with regulations, marine product processing factories have been treating effluent to a certain extent. However, according to a report of the research conference on the treatment of effluent of the marine product processing industry for the year 1971, the state of installation of such treatment facilities is as shown in Table 8.

Table 8 State of Installation of Effluent Treatment Facilities

Type of Business	Makers of Marine Products Boiled Down in Soy Sauce	Fish Paste Products	Fish Meat Ham and Sausage	Canned seafood and seaweed	Agar-agar and isinglass
No. of Factories Subjected to Fact-finding Survey	34	496	34	122	5
No. of Factories with Treatment Facilities Installed	4 (1)	81	23 (6)	78 (34)	4
Sedimentation	4 (1)	103	20 (3)	86 (17)	2
Flotation		18	11 (4)	16 (7)	
Filtration		13	7 (1)	18 (17)	1
Coagulation Sedimentation		6	9 (1)	3 (1)	
Neutralization		1		1	
Aeration			6	3	1
Activated Sludge		3	4	1 (1)	
Trickling Filter		1		3	
Others		26	3 (1)	11 (3)	1
Unknown				(2)	
Total	4 (1)	171	64 (10)	142 (48)	5

Note: Figures in ( ) = being planned

As can be seen from Table 8, physical treatment by sedimentation, flotation and filtration comprise the majority of facilities. As the survey was conducted some time ago, the results may not correctly reflect the current situation. However, we believe it is a fact that most factories find it difficult to get around to installing effluent treatment facilities because of the lack of funds.

2) Problems

i) Treatment of effluent of marine product processing factories is fraught with many difficulties because the raw material used is easily decomposable, operations are seasonal depending on the fishing period and fluctuation of catch quantity, and much of the effluent, compared to the waste water of other industries, contains salt. Also, water quality varies widely depending on the regional processing methods, and other factors.

ii) The marine product processing bodies are generally very small businesses, with factories on confined pieces of land so that most of them do not have the economical capability to build expensive effluent treatment facilities.

iii) As the effluent of marine product processing factories is mainly water for washing and water for miscellaneous use, much of it should be able to be recycled and reused. Therefore, further research and study are required on processing technology and processes, centering around the rationalization of the water being used.

3) Current State of Research and Problems on Treatment of Marine Product Processing Effluent

As the research laboratories of the state and local governments are studying and doing research on marine product processing effluent, some of the typical research and the attendant problems are described below.

i) Current Situation

- **1972 Research**

a) Tests and Research on Treatment of Marine Product Processing Effluent - II (by Hokkaido Prefecture Kunashiro Fisheries Experiment Station) (on sedimentation and precipitation process)
Cleaning of effluent from marine product processing and recovering proteins.

b) Research on Marine Product Processing Sewage and Effluent Treatment Technology (by Miyagi Prefecture Marine Products Processing Research Laboratory)
Development of a pretreatment test plant for a small-scale marine product processing factory (50 to 150 t/day) and also looking into a treatment method for generative froth from the production process.

c) Tests on Marine Product Processing Effluent Treatment Technology (by Fukushima Prefecture Fisheries Experiment Station)

Tests on (1) freshness of raw material fish and effluent, (2) effectiveness of cleansing by screening and filtration, (3) study of coagulating agents, (4) pressure flotation method, etc.

d) On Sewage and Effluent of Marine Product Processing Factories (by Ibaraki Prefecture Fisheries Experiment Station)

Marine product processing effluent was treated by the coagulation process, but as the COD elimination rate was from 30 to 60% and a great amount of scum was generated, this process is considered unsuitable for the purpose. Against this, the activated sludge process easily produced a discharged water quality of 120 ppm and less.

e) Tests on Making Effective Reuse of Marine Product Processing Effluent (by Tottori Prefecture Food Processing Research Laboratory)

Study of the recovery of the effective contents of marine product processing effluent and their effective reuse, development of advanced utilization of unused marine resources and aim to improve sewage treatment technology.

- **1973 Research**

a) Tests and Research on Treatment of Marine Product Processing Effluent (by Hokkaido Prefecture Kushiro Fisheries Experiment Station) Consecutive Test and Research of 1972.

b) Tests and Research on Pollution Control of Marine Products Processing Industry (by Hokkaido Prefecture Kushiro Fisheries Experiment Station)

Aim to establish effluent and foul odor elimination technology in answer to the various pollution control regulations.

c) Research on Reuse of Treated Waste (including Froth) from Marine Product Processing Sewage and Effluent (by Aomori Prefecture Marine Product Processing Research Laboratory)

Since a method of treating the froth discharged by the cleansing treatment of marine product processing sewage and effluent has not yet been established, there is an urgent demand for the development of ways and means of effectively reusing it.

d) Research on Development of Technology for the Reuse of Discharged Waste Contained in Processing Effluent (by Miyagi Prefecture Marine Product Processing Research Laboratory)

Research aiming to separate the coagulated proteins and oils contained in processing effluent and to dehydrate and dry the proteins into meal, or to contribute to running costs by using the proteins in their recovered state as feed or fodder. (Consecutive research of 1972)

e) Tests on Marine Product Processing Effluent Treatment Technology (by Fukushima Prefecture Fisheries Experiment Station)

Tests and research with the aim of establishing pretreatment processes for filtration, coagulation, sedimentation, and pressure flotation.

f) Research on Putting Small-scale Activated Sludge Processing Treatment Equipment to Practical Use (by Ibaraki Prefecture Marine Product Processing Research Laboratory)

Making of a prototype (batch type) activated sludge treatment facility (capacity 10 m^3/day), installing it in a marine product processing factory and collecting data from it.

g) Research on Treatment Technology of Marine Product Processing Effluent (by Yamaguchi Prefecture Open Sea Fisheries Experiment Station)

Investigation of methods of treating sewage and effluent from marine product processing factories, fact-finding investigation for the effective use of froth, dehydration and use of froth (sediment), and study of methods of electrical treatment of effluent.

h) Tests on Making Effective Reuse of Marine Product Processing Effluent (by Tottori Prefecture Food Processing Research Laboratory) Consecutive Tests of 1972.

ii) Problems

A) Processes up to secondary treatment have been incorporated as subjects of research, but advanced treatment, required to comply with the general standards after June 24 1976, is being insufficiently researched.

B) Currently there is no research being conducted on advanced biological treatment of marine product processing effluent in the cold regions that possess major fishing ports.

C) There is no research being conducted on technically and economically viable joint effluent treatment facilities.

C. Necessity of Establishing Advanced Technology for Treatment in Cold Regions

As mentioned previously, the majority of marine product processors are located in the cold regions of Tohoku and Hokkaido. As much as 95.9% of the total frozen ground fish meat is produced in these areas.

Many of the businesses are extremely small-scale and they discharge large quantities of effluent of considerably poor water quality. On the other hand, regulations are gradually being made more strict, but research on the treatment technology for coping with them is not necessarily adequate, and also fraught with problems, particularly since these areas are so cold.

Generally the temperature of the waste water in treating effluent in the cold regions reaches close to 0℃. Unless some countermeasures are taken, biological treatment methods are difficult to employ. The treatment of marine product processing effluent, in particular, is made even more difficult because there are considerable variations in the water volume and quality of the effluent. The treatment technologies currently being developed in the cold regions and the present state of effluent treatment in these areas and the attendant problems are as follows.

1. Current State of Biological Treatment Processes in Cold Regions

1) Lagoon (Morinaga Type) Process

This treatment method is the aeration type lagoon process and is a type of activated sludge process which takes a long residence time (of about 10 days) and sets BOD space loading at approximately 0.3 kg BOD/m^3/day or less.

a) Example of Treatment of Marine Product Processing Effluent in Ishinomaki

Generally, raw water BOD is 5,000 to 3000 ppm and treated water BOD is 100 to 40 ppm. The water temperature of the effluent is 7 to 3℃.

b) Example of Treatment of Milk Factory Effluent in Sapporo

Normally, raw water BOD is 400 to 500 ppm and treated water BOD is 4 to 8 ppm. Water temperature is about 6℃.

2) Example of Treatment of Effluent of Shiogama Marine Product Processing Factory Apartment

This treatment method used is the pressure flotation process and two-stage aeration activated sludge process.

3) In addition, the activated sludge process is being carried out by sewage treatment plants, pulp mills, etc. It is said that some sort of waste heat is being employed especially in the case of the pulp mills.

2. Problems of Effluent Treatment in Cold Regions

1) Variations in Water Volume and Quality

There are many types of operations in the marine product processing industry. The water volume and quantity of the effluent being discharged by these operations vary by time of day and season, and as they have a subtle effect on biological treatment in the winter, development of a treatment technology that can cope with such variations is required.

2) Effect of Water Temperature of Effluent

In the winter, the outside air temperature drops to about minus(-) 20℃ and lowers the temperature of or freezes water by radiation, thus lowering treatment capacity. Therefore some measures to counteract this must be devised.

3) Problem of Snow Radiation

As water temperature drops suddenly due to snow radiation, countermeasures to prevent the temperature from falling is required such as by building a shed or by heating.

4) Inflow of Salt Water

Since, depending on the marine product processing factory, fish are sometimes washed with salt water, the effect of micro-organisms due to the inflow of salt water becomes a problem.

5) Eutrophication

As considerable amounts of nitrogen and phosphorous are contained in effluent, nitrogen and phosphorous removal must be carried out in order to prevent eutrophication. In the winter, due to the drop in water temperature, the activity of nitrifying bacteria and denitrifying bacteria becomes sluggish so the removal of nitrogen is believed to become practically impossible.

6) Disposal of Generated Sludge

As a considerable amount of sludge is generated, there is need to think of such methods of disposing of the sludge as soil conditioners or fertilizer or by incineration, etc.

7) Construction Cost and Running Cost of Facilities

As the facilities must take into consideration the winter months, ways of keeping the construction and running costs economical will have be devised.

Based on the above investigation results, we decided to conduct studies on the technology for the treatment of marine product processing effluent in the cold regions, as it believes there is an urgent need for establishing such a technology.

Since the development of treatment technology that can deal with particularly severe natural conditions was necessary, we decided to carry out actual tests in the cold regions and to try to conduct tests with a pilot plant that was as close to the real thing as possible. In addition, in order to check the data derived from the pilot plant, we decided to do tests on the same effluent with a 20-liter water tank so as to obtain data under stable low temperatures.

II. Progress of Studies on Advanced Technology for Treatment of Marine Product Processing Effluent in Cold Regions Brief Explanation)

We conducted a total of four pre- and post-studies for the purpose of establishing an advanced technology for treating marine product processing effluent in cold regions (mainly so that the effluent would meet the general standards to be enforced from June 24, 1976).

An outline of the progress made is as follows.

Because of constraints of time, geography, budget, etc., it would be difficult to conduct research covering all marine processing and decided to limit its subject of research.

As can be seen from the 2nd Interim Report, as a result of studies, the effluent that was the subject of the research was one that had practically the same water quality as that on which the pressure flotation process and other pre-treatment had been carried out (i.e. a BOD of about 2000 ppm).

We decided that the subject of research would be the effluent that was discharged by the relatively clean ground fish meat making process and that it would be treated by the biological process of the lagoon and activated sludge treatment methods. We also decided we would try to gather as much reference data as possible on the physicochemical treatment methods that are currently employed to a great extent in the cold regions, i.e. the pressure flotation process and the electric coagulation process.

We made various studies of the results of the investigation and research that was conducted based on our Interim Report (Attachment 2), and then incorporated them into this Report.

A. First Phase

1. Studies on the Present and Future State of the Processed Marine Product Industry

1) There are many very small enterprises consisting of nine or less employees.
2) Much of the business in the cold regions covers salt-preserved products, fish oil, feed and fertilizer, frozen products, frozen ground fish meat, etc., and in particular, 95.9% of frozen ground fish meat is produced in those cold regions.

3) Enlargement of freezing capacities, development of processing techniques, and improvement of distribution and processing methods are being pushed forward in the main fishing ports. On the other hand, in order to ensure a stable supply of fish, frozen products, ground products, and fishery feed and fertilizer are expected to register gains in the future.

2. Study of Problem of Marine Product Processing Effluent

1) At present, controls that are less severe than the general standards are being implemented by means of provisional standards and designation by types of business.
2) As the general standards will be enforced from June 24, 1976, the development of treatment technology and the setting up of treatment facilities are being hastened in order to satisfy those general standards.

3. Studies on Treatment of Marine Product Processing Effluent

1) Although, generally, there is a desire to set up formal and effective treatment facilities, the actual state of affairs is that the business organizations are heavily involved in the investments for production facilities, etc. and do not have enough fund reserves to build effluent treatment facilities.
2) Due to decomposition, the period and fluctuation of catches, processing and treatment methods, and various other factors, treatment technology is accompanied by many difficulties.
3) Factory plots are confined and the ability of factories to bear economic burdens is poor.

4. Studies on Problem Points of Treatment of Marine Product Processing Effluent in Cold Regions

1) The temperature of the effluent in cold regions becomes close to 0℃. Therefore, biological treatment becomes difficult unless some countermeasures are taken.
2) As fish are sometimes washed and cleaned with salt water, the effect of micro-organisms due to the inflow of salt water becomes a problem.
3) Nitrogen and phosphorous removal must be carried out in order to prevent eutrophication.
4) Means must be devised of disposing of the sludge that is generated by using it as soil conditioners and fertilizer or by incineration, etc.
5) Economical construction and running costs must be conceived taking into consideration of the conditions that very small businesses and the winter period are involved.

5. Studies of Treatment Processes (Refer to Attachment 1)

Studies were made on the subjects of the investigation and research.

1) Necessity of Research on Reverse Osmosis Method

   We feel that advanced technology should also encompass the recycling of the treated water, as the full effect of reverse osmosis cannot be obtained unless SS, etc. is completely removed in pretreatment (The investigation and research report, part of the new technology development activities of 1971 of the Food Industry Center, an incorporated foundation).

2) Necessity of Research on Electric Coagulation Method

   A COD removal rate of an average of about 80% was obtained by this method as pretreatment. This is a somewhat better rate than that obtained by the pressure flotation process.

   The wear of electrodes is being investigated at present. From past experience, it seems that the raw water COD should be below approximately 1800 ppm in order to obtain a COD that is within the general standards (for effluent).

6. Investigation and Research Method

1) The location should be such that a constant supply of effluent is available.
2) Geographically the location should be in a cold area and should be near the site where treatment facilities are to be installed.
3) The method of investigation and research and the other related things shall be clearly defined after 1) and 2) have been decided.

B. Second Phase

An interim report (refer to Attachment 2) on the studies conducted by the previous Committee meeting was prepared and submitted.

C. Third Phase

The contents of the various investigation and research reports that was carried out based on the Interim Report were studied and the followings were pointed out.

1. There is a pressing need to develop a new technology for removing nitrogen and phosphorous due to the fact that biological treatment methods (activated sludge process and lagoon process) is difficult to be adapted. (Although the electrolysis process is deemed to be an effective method for removing phosphorous).

2. As it is believed that a change in the biological nature of the sludge takes place at 0℃ to 5℃ (meaning that the types of bacteria that can live in such low temperatures will change), the BOD space loading should be decided by checking the water temperature beforehand.

3. In cold regions, a long time treatment is required in the treatment tank. A detailed study should be made in advance of the quality and concentration of the raw effluent to be treated and the target of the treated water quality after treatment, in order to obtain optimum treatment results.

4. Even if the surface is frozen, if the water temperature is 0℃ plus, there appears to be no effect on the efficacy of treatment.

5. A study is to be made on the data obtained when the electrolysis process is used as the pretreatment (when BOD concentration is high).

D. Fourth Phase

Studies were made of the results of previous studies and the reports of investigation and research, and prepared and submitted as this report.

III Contents of Investigation and Research

A. Common Research Subjects of Lagoon Process and Activated Sludge Process

1. Research on BOD Space Loading and BOD Removal Rate

   Set various BOD space loading and obtain the optimum conditions from the BOD removal rate.

2. Research on Quantity of Excess Sludge Generated

   Set various operating conditions (BOD space loading) and determine the relationship between the operating conditions and the quantity of excess sludge that is generated.

3. Research on Aeration Tank Sludge Properties, Particularly Settling Property

   Measure the SVI (Sludge Volume Index) of the sludge generated in the aeration tank under various operating conditions.

4. Research on the Effects of BOD Load Fluctuation

   Vary the BOD space loading and obtain the allowable tolerance of the fluctuation from the effects on the treated water quality.

5. Research on Intermittent Inflow of Effluent

   Determine the effect on subsequent treatment of the load fluctuation caused by the stoppage of effluent inflow due to reasons of raw materials, holidays, and other factors.

6. Measurement of Effectiveness of Nitrogen and Phosphorous Removal
7. Observations on Foul Odor, Appearance, etc.
8. In order to make economic comparisons, conduct studies of construction costs, necessary land area, running costs, personnel required, etc. and report the results.

B. Lagoon Process

Analysis of the treated water of the electric coagulation process to be conducted in parallel.

C. Activated Sludge Process

Analysis of the treated water of the pressure flotation process to be conducted in parallel.

IV Results of Research

A. Lagoon Process

1. Aim of Research

As the water temperature of the effluent to be treated in cold regions is close to 0℃, biological treatment is difficult unless some sort of countermeasure is taken.

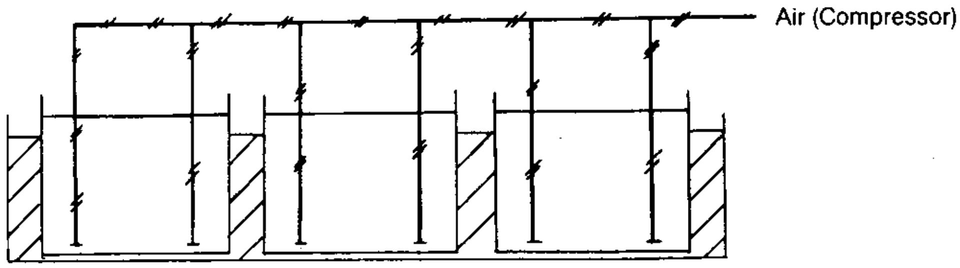
Treatment of marine product processing effluent in particular is made even more difficult because its volume and quality tend to fluctuate. As the general standards of the regulations on water quality of effluent will be applied to the marine product processing industry from June 24, 1976, the aim of the research is to find the biological treatment technology that will meet those conditions.

2. Outline of Research

As a method of treating effluent in cold regions, field tests were conducted in a pilot plant using effluent from the ground headless fish meat process that was equal to effluent that had undergone primary treatment. At the same time, supplementary tests were carried out using a 20-liter water tank to make the water temperature and other conditions the same as the pilot plant.

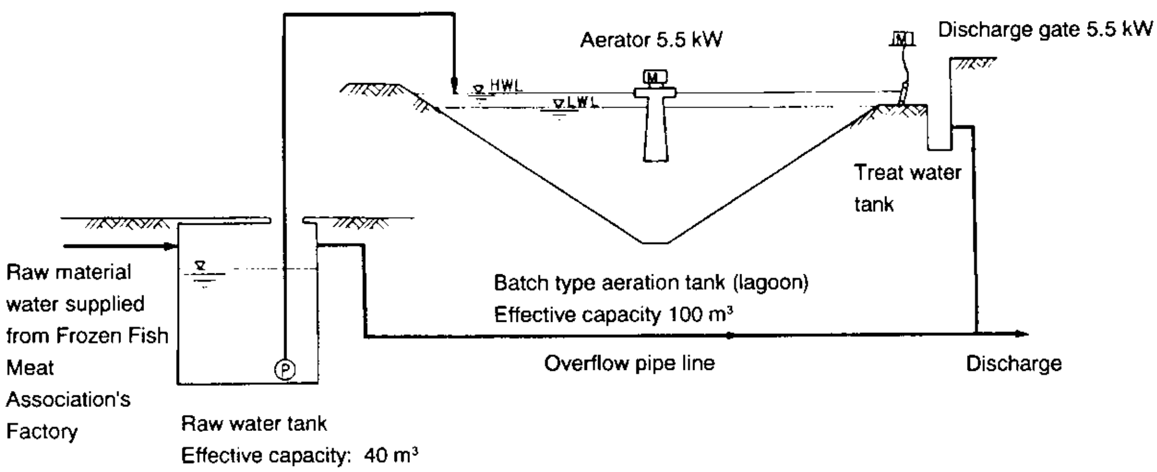
3. Outline of Research Facilities

1) Flow Chart of Batch Type Testing Equipment with 20-liter water Tank



Note: Excessive cooling was prevented by placing three sets of aeration tanks in the form of water baths in a steel water tank.

2) Flow Chart of Pilot Plant



4. Treatment Method

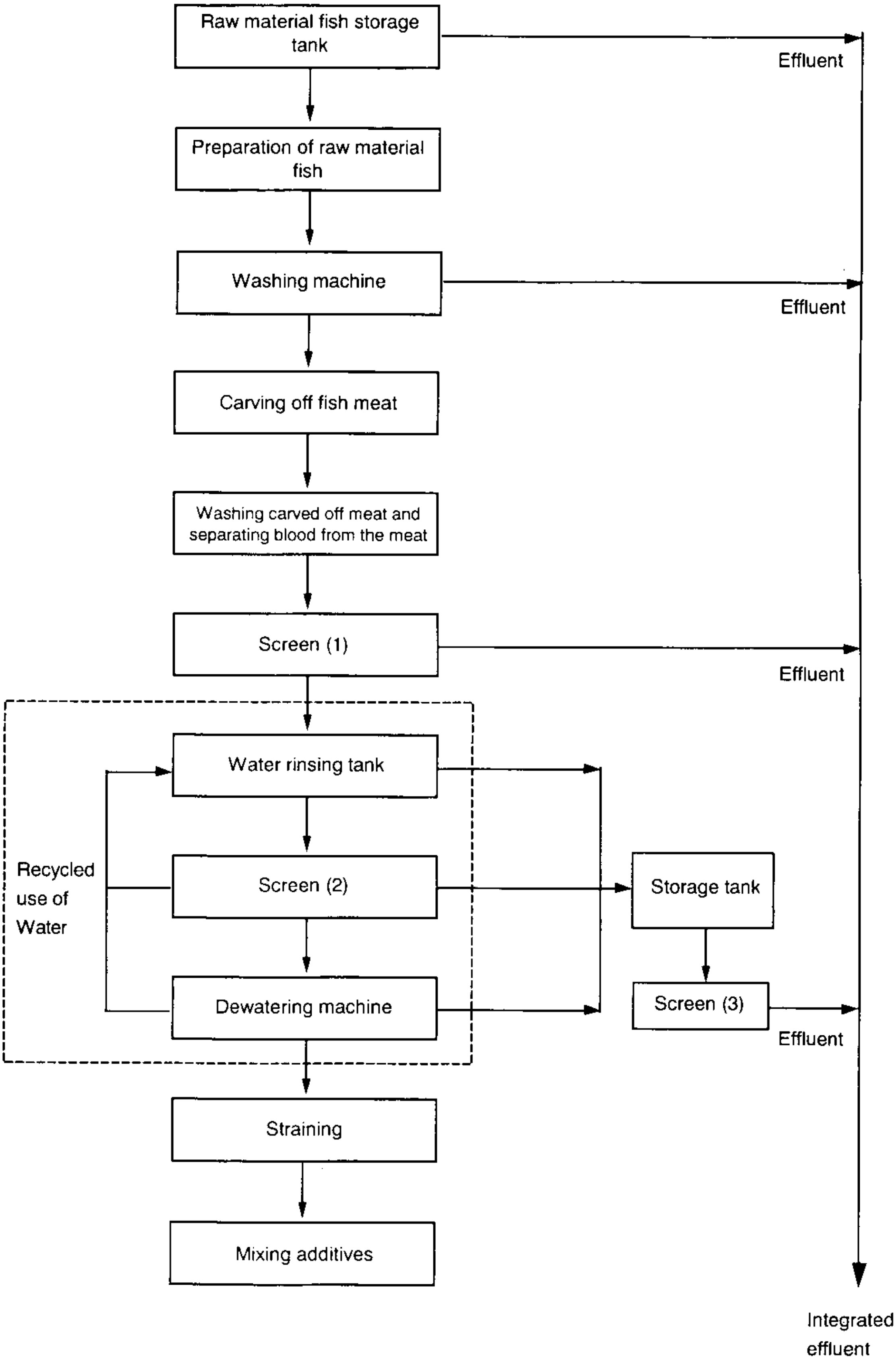
1) Batch Type Testing Equipment with the 20-liter Water Tank
Air venting aeration was carried out via an air diffusion pipe using a small compressor.

2) Pilot Plant
After storing marine product processing (ground fish meat) effluent in the raw water tank, a fixed quantity in accordance with the BOD space loading was introduced into the lagoon tank and aerated using a 7.5 HP high-speed aerator (Aquajet Type 7.5 for cold regions) with a capability of supplying oxygen at the rate of 10.8 kgO_2/Hr.

5. Test Effluent

The effluent was that from a frozen ground fish meat making factory which uses walleye pollack as the raw material fish. As the raw material was without head and entrails (such processed form was called "gara"), the degree of pollution was low compared to using fish with heads as the raw material.

1) Course of Effluent by Ground Fish Meat Making Process (at the National Fish Meat Association's Affiliated Factory)



2) COD and Quantity of Effluent by Processes of Above Factory (1)

(Results of Fish Meat Association's Analysis, March 9 1974)

	pH	Transparency	Appearance	COD (Mn)	Quantity of Effluent (tons)
Raw material fish storage tank	7.1	1.5	Brown	1655	15
Washing of raw material fish	7.1	1.5	Light brown	385	30
Washing of carved off meat and separating blood from the meat	7.3	1.5	Reddish brown	3207	15
First rinsing and bleaching	7.4	6.0	Turbid light red	323	17
Second rinsing and bleaching	7.2	7.0	Turbid light red	310	17
Third rinsing and bleaching	7.2	9.0	Turbid pale white	315	17
Dewatering machine effluent	7.2	1.0	Turbid greyish white	334	5
Water for miscellaneous use					5
Integrated effluent	7.1	3.0	Faint yellowish brown	656	120

6. Course of Research

One day after start of operations, the froth generated on the surface of the tanks froze, covering the surface of the tank like fallen snow, and MLSS (Mixed Liquor Suspended Solid) became almost 0. The temperature of the liquid in the aeration tank was 0 to minus(-) 1℃ so that if left standing, the surface of the liquid soon froze over. After that, the freezing of the froth increased until a sherbet-like layer of ice 40 to 50 cm thick was formed in a few days under the snow-like frozen froth layer. In order to suppress the forming of ice, the quantity of inflowing effluent was increased from December 12 to 20 m^3/day. When it was further increased to 40 m^3/day, the tank water temperature rose so that by December 22 no ice was present, and at the same time, MLSS also became 1000 ppm. This sludge exhibited an oxygen absorption of total O_2 = about 10 ppm/hr at 20℃. On December 24 there was no factory effluent so that operation was temporarily suspended.

Experiments with the 20-liter water tank were carried out in parallel with the experiments with the lagoon tank. The top of the water tank froze except for the air bubble vent hole and the air diffusion pipe. The air diffusion pipe was covered with ice due to the absorption of temperature caused by the expanding air accompanying the emission of pressurized air. This caused the air to dribble out until finally it did not escape at all.

Treatment tests with the 20-liter water tank were carried out using three types of water, namely, raw effluent, electric coagulation treated water, and pressure flotation treated water. They were comparison-tested between December 11 and 24, 1973 and January 17 and February 4, 1974.

On December 24, 1973, the sludge in the lagoon was transferred to the raw water storage tank, after sedimentation and concentration, and the lagoon tank was made empty. This was because there was the danger that freezing would become a hindrance to the resumption of tests during the days at year end and start of the new year when tests were suspended. From January 9, 1974, when the tests were resumed, the sludge was transferred to the lagoon which was then filled with water, and a small amount of effluent was added. In addition, a special nutritive agent was added, after which the liquid underwent acclimatization until January 17 when regular operation was started.

For three days, from January 25 to 27, there was a fierce blizzard, so that snow collected on the top of the wind-breaker sheet, and fell into the surface of treating water in the tank obstructing the operation of the aerator. So the sheet was removed and operation was continued. However, around January 31, the ice became 50 to 70 cm thick, and as the entire tank was liable to freeze, operation was suspended on February 4, the tank was emptied, after which tests were resumed from February 19.

On the experiment term, the emphasis of the treatment tests was placed on the 20-liter water tank, and the aim of this experiment in the lagoon tank was collecting of heat balance calculation data with respect to the relationship between aeration volume and cooling of the lagoon tank, and between the amount of inflowing effluent and cooling.

Heat was applied to the 20-liter water tank so that the water temperature did not fall below 0℃ and experiments on BOD space loading were conducted. By heating the water, the temperature was able to be kept at 0 to 2℃ during the period of the tests.

7. Results of Research (Refer to attached Tables 1 to 7 and Figures 1 to 7)

The results from the pilot plant are shown in the following table.

1) BOD Space Loading and BOD (COD) Removal Rates

BOD Space Loading	BOD Removal Rate	COD Removal Rate	Water Temperature
0.08 (Kg/m^3/day)	95 (%)	85 (%)	-0.5 - 0 (℃)
0.18 - 0.2	90	80	-0.2
0.2	95	85	0 - 2
0.3	94	85	0 - 2

The results of tests with the 20-liter water tank are as shown in attached Tables 5, 6 and 7 and Figures 6 and 7. They exhibit results that are better than those of the pilot plant.

In the 20-liter water tank tests, there were fluctuations of 1.5 to 2 times 0.2 kg/m^3/day. However, even with these fluctuations, there was no lack of oxygen supply.

2) Quantity of Excess Sludge Generated

BOD Space Loading	MLSS	Treat Water SS	Water Temperature
0.08 -0.1 (Kg/m^3/day)	Equilibrium	100 ppm or less	-0.5 - 1.5 (℃)
0.2	Increase of 80 ppm/day	10 - 80 ppm	0 - 2
0.35	Increase of 130 - 140 ppm/day	20 - 90 ppm	0 - 2

The results of tests with the 20-liter water tank are as shown in attached Tables 5, 6 and 7 and Figures 6 and 7.

3) Sludge Volume Index (SVI), Sedimentation Property, and Biota of Sludge

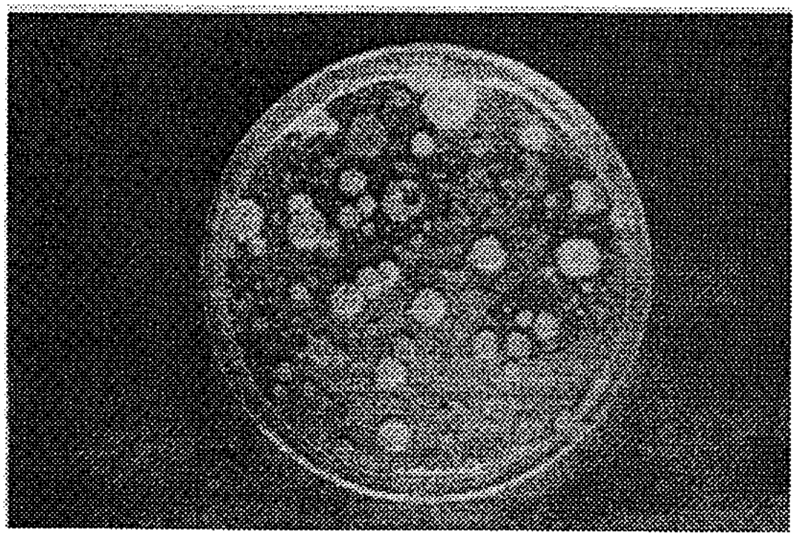
i) SVI

BOD Space Loading	Sludge Volume Index	Water Temperature
0.2 Kg/m^3/day or less	100 - 160	-0.5 - 2℃
0.35 Kg/m^3/day	200 - 300	0 - 2℃

Approximately the same results were obtained with the 20-liter water tank tests.

ii) Photograph 1 is the sludge biota at the water temperature of 0 to 2℃, and in photograph 2, the sludge was plate-cultivated in a water temperature of minus(-) 0.5 to 0℃ and shows many micrococcus-like bacteria.

Photograph 1 Microphotograph of sludge biota (0 - 2℃)



Photograph 2 Viable cell count culture plate of 0.5 - 0℃ sludge.
Dilution 10^6. There are many cocci.

4) Effect of Intermittent Inflow of Effluent

There was not much effect of two 2 days' of interrupted inflow (January 25 and 26). Even interruptions of long periods can be covered by controlling operations.

In extremely frigid periods, there is not only the problem of the load on the sludge, but also that of the heat balance caused by the drop in temperature or freezing of the water in the tank. Thus non-freezing device for the treatment is desirable.

5) Measurement of Effectiveness of Removal of Nitrogen and Phosphorous

i) The rise and fall of total nitrogen by the kjeldahl method in the lagoon tank are shown below.

Item / Month/Day	T - N (Total Nitrogen)	
	Raw Water	Treated Water
Feb. 20	297 (ppm)	103 (ppm)
" 27		90
" 28		126
Mar. 4	297	138
" 6	276	177
" 12	208	179

From these differences, there was some removal of nitrogen although the rate is not high. Judging from the nitrogen concentration of the treated water, this method cannot be said to be very effective.

ii) The rise and fall of phosphorous ion in the lagoon tank is shown below.

Item / Month/Day	PO_4^{3-}	
	Raw Water	Treated Water
Mar. 5	36.0 (ppm)	42.0 (ppm)
" 13	210.0	181.0
" 15	202.0	160.0

There was no removal effect as there was no meaningful differences in the phosphorous concentration of the raw water and the treated water.

6) Views on Foul Smell, Appearance, Etc.

There was no foul smell from the aeration tank, but from the raw water tank there was a smell of decomposition despite the low temperature. This foul raw water becomes odorless in the aeration tank.

Foaming occurred until sludge had been fully generated. Foaming can be suppressed with antifoaming agents (silicone). The froth froze and covered the surface of the tank, except for the center, with a snow-like layer of foam. However it may be useful for the prevention of freezing in cold winds from a different aspect. Even if seeding sludge was added, if the water temperature is too low, the sludge tends to float possibly from shock, and freezes together with the foam. In such a case, the foam is a dirty black. There is no recourse but to wait for the sludge to propagate naturally. This sort of sludge does not float and adhere to the foam. The COD of the ice in the lagoon was around 50 ppm.

8. Comments

1) Despite a water temperature in the neighborhood of 0℃, the rate of removal of BOD and COD was high. A large number of micrococcus-like bacteria appeared in the activated sludge, which indicates that the microbiota that make up the sludge consist of bacteria and other organisms that are vigorously active in low temperatures.

2) The effect of temperature on sludge was that when seeding sludge (4℃) was introduced into the lagoon (0 - 1℃), the sludge was prone to float because of the sudden change in temperature. Furthermore, it was seen to adhere to the foam and float to the top.

   When this sort of activated sludge, as well as sludge containing micrococci, froze, and then was melted, the sludge exhibited extremely good settling characteristics and, of course, also became active.

   It was confirmed from the relationship between aeration time and treated water quality of the lagoon tank from February 19 to March 15 that the activity of the sludge, despite the low temperature, was governed by the oxygen supply rate.

3) The increase in MLSS, even at a BOD space loading of about 0.35 $kg/m^3/day$, was surprisingly large compared to the activated sludge process at ordinary temperature. This is believed to be caused by the slow rate of metabolism (rate of autolysis) due to the low temperature. This slow rate of metabolism also means that the BOD space loading cannot be set too high.

4) As the degree of pollution of the effluent produced when the walleye pollack with head is processed becomes higher, the electric coagulation and pressure flotation processes are employed as primary treatment. Experiments were carried out using the 20-liter

water tank to see if there was any effect on the biological treatment of the two processes, but there was hardly any difference in the BOD and COD values of the treated water. Care should be taken so that excessive hypochlorous acid is not generated when combining the electric coagulation process with a biological treatment process. A system of automatic reduction by means of a residual chlorine measurement instrument and oxidation-reduction potentiometer also needs to be incorporated.

5) When phosphorous in the treated water is a problem, the electric coagulation process is an extremely effective method of removing it. This sort of result cannot be expected of the pressure flotation process that was carried out.

6) It is now clear that high level treatment of marine product processing effluent in cold regions is possible. However, the followings can be said about the conditions for designing future treatment facilities based on the measures that had to be taken against the cold in order to obtain these data.

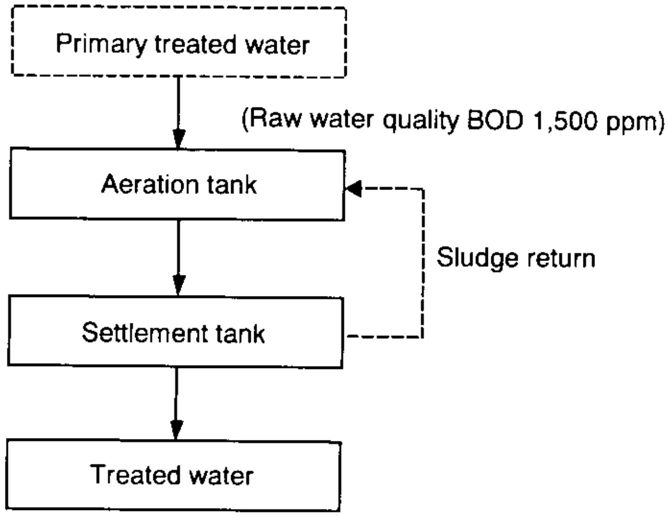
   i) The water temperature in the aeration tank needs to be maintained at 0℃ or more and heat radiation should be prevented.

   ii) In the case of diffused air aeration, adherence of ice to the air diffusion pipe in the water of the tank needs to be prevented by keeping the air blowing chamber well-heated, and insulating the piping to prevent heat radiation.

   iii) BOD space loading is best kept at 0.2 $kg/m^3/day$ or less as a condition for satisfying the general standards from the standpoint of load fluctuations, superfluous amount of sludge generation.

9. Construction of an Actual Plant (as of March 1974)

1) Flow Chart (primary treatment is not included)



2) Specifications of Facilities

Capacity \ Water Volume	1000 m³/day	3000 m³/day	6000 m³/day
Aerator	8,000 m³ Width Length Water Depth 27 m x 54 m x 5.5 m	24,000 m³ Width Length Water Depth 54 m x 81 m x 5.5 m	48,000 m³ Width Length Water Depth 93 m x 94 m x 5.5 m
Settlement tank	180 m³ Water Depth Φ 10 m x 3 m	450 m³ Water Depth Φ 12 m x 3 m x 2	1,080 m³ Water Depth Φ 16 m x 3 m x 2
Aerator	37 kW x 2	37 kW x 6	55 kW x 9

3) Construction Costs

	1000 m³/day	3000 m³/day	6000 m³/day
Including Building	JPY 240 million	JPY 510 million	JPY 890 million
Excluding Building	JPY 200 million	JPY 450 million	JPY 780 million

4) Running Costs

i) Aeration Method

Unit: 10 yen/kWH

	1000 m^3/day	3000 m^3/day	6000 m^3/day
Power requirement	2,000 kWH	6,000 kWH	12,200 kWH
Cost	20,000 yen/day	60,000 yen/day	122,000 yen/day

ii) Blower Method for extremely cold regions

	1000 m^3/day	3000 m^3/day	6000 m^3/day
Power requirement	4,000 kWH	12,000 kWH	24,400 kWH
Cost	40,000 yen/day	120,000 yen/day	244,000 yen/day

5) Area Required

	1000 m^3/day	3000 m^3/day	6000 m^3/day
Area	2,100 m^2	6,200 m^2	12,200 m^2

6) Operating Personnel

	1000 m^3/day	3000 m^3/day	6000 m^3/day
No. of Persons	2	2	3

Table 1-① Pilot Plant (Lagoon Process) Test Results

	Measurement Date	12/7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	1/17	18	19	20	21	22	23
Raw Water	pH	7.6	7.5		7.5	7.4	7.8	7.5	7.6	7.8		7.3	7.8	7.3	7.7	7.6	7.8		7.5	6.9	6.9	6.9	6.9	6.9	7.4	7.7
	BOD (prm)	1680					2014					3272								2415	2415	2415	2415	2415		1957
	COD (ppm)	461	521		256	624	552	585	464	638		636	868	1064	209	798	630		224	1180	1180	1180	1180	1180	522	450
	SS (ppm)																			95	95	95	95	95	100	
	Extracted Substance (ppm)	673					590					1083								45.5						
	NH_4-N (ppm)																									
	PO_4 (ppm)																									
	Evaporation Residue (ppm)																									
	Ash (ppm)																								239	
	T - N (ppm)																									
Treated Water	pH	7.6	7.6		7.4	7.6	7.5	7.8	7.3	7.3		7.5	7.6	7.6	7.5	7.4	7.5			8.4	8.4	8.3	8.3	8.6	7.2	8.4
	BOD (ppm)						563					721														48.5
	COD (ppm)	312	191		106	135	168	231	336	217		295	266	243	302	291	230				37.7	34.5	33.8	32.3	28.1	30.4
	SS (ppm)																				53.0			25.0		
	T - N (ppm)																									
	NH_4-N (ppm)																									
	PO_4 (ppm)																									
	Evaporation Residue (ppm)																									
	Ash (ppm)																									
	Transparency (cm)																				12.0	13.5	11.0	10.5	15.5	11.0
Aeration Tank	Water Temperature (℃)	-0.5	-0.5	-0.5	-0.5	-0.5	-0.2	-0.2	-0.2	-0.2	-0.2	0.4	1.0	1.0	1.0	1.0	1.0		0	-0.2	-1.0	-0.5	-0.5	-0.5	-0.5	-0.5
	SV_{30} (%)						0.5		0.5	0.5			1.0		2.0		3.0			1.0	1.8	2.3	2.8	3.4	3.2	4.0
	SV_{60} (%)																									
	SVI																			62.5	83.7	92.0	80.0	106.3	91.4	95.2
	MLSS (ppm)				200		140		280	320			350		420		1000			160	215	250	350	320	350	420
	Inflow Rate (m^3/day)	10	10	10	10	10	20	20	20	20	20	30	40	40	40	40	40	40		4	4	4	4	4	4	4
	BOD Space Loading (kg/m^3/day)	0.16					0.4					0.97								0.09	0.09	0.09	0.09	0.09	0.1	0.08
	Residence Time (hr)																									

Table 1-②

	Measurement Date	1/24	25	26	27	28	29	30	31	2/1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Raw Water	pH	7.6	7.4			7.2	7.3	7.3	7.3	7.7	7.5	7.3	7.1													
	BOD (ppm)	1980	1581		1496	1652				2230	1982	1741	1620													
	COD (ppm)	439	447			425	688	550	656	512	520	475	545													
	SS (ppm)	60	65			76.9	433		25		82.5		260													
	Extracted Substance (ppm)						51.0							Discontinuation ← (5–15) →											Acclimatization ← (16–17) →	
	NH_4^+-N (ppm)													Water and snow removal and repair work												
	PO_4 (ppm)																									
	Evaporation Residue (ppm)		2050				2550																			
	Ash (ppm)																									
	T - N (ppm)						304																			
Treated Water	pH	8.2	8.2		7.8	8.2	8.3	8.3	8.1	8.0	8.2	8.3	8.3													
	BOD (ppm)	>90											105.2													
	COD (ppm)	35.7	49.3		24.2	23.4	32.3	31.7	40.1	55.2	55.0	47.6	59.3													
	SS (ppm)	46.7	100.0			103	50.6				52.5		40.0													
	T -N (ppm)		45.2																							
	NH_4^+-N (ppm)																									
	PO_4 (ppm)																									
	Evaporation Residue (ppm)		2000				250																			
	Ash (ppm)																									
	Transparency (cm)	9.5	7.0		11.0	16.0	23.0	18.0	11.0	11.0	10.0	8.5	10.0													
Aeration Tank	Water Temperature (℃)	-0.5	-0.5	-1.0	-1.0	-0.5	-0.5	-0.5	-0.5	-0.5	-0.5	-0.5	-0.5													
	SV_{30} (%)	3.9			4.0	2.9	3.1	4.2	4.1	4.2																
	SV_{60} (%)																									
	SVI	97.5			108.1	71.6	77.5	89.4	85.4	84.0																
	MLSS (ppm)	400			370	405	400	470	480	500																
	Inflow Rate (m^3/day)	4	0	0	4	4	8	8	8	8	8	8	8													
	BOD Space Loading (kg/m^3/day)	0.09			0.06	0.06	0.16	0.14	0.15	0.17	0.16	0.14	0.13													
	Residence Time (hr)																									

Table 1 - ③

	Measurement Date	2/18	19	20	21	22	23	24	25	26	27	28	3/1	2	3	4	5	6	7	8	9	10	11	12	13	14
Raw Water	pH		7.1	7.0	7.3	7.2	7.3		7.2	7.2		7.6	7.3	7.3	7.3	7.4	7.7	7.1	7.1		6.7	7.0	7.4	6.6	6.7	7.4
	BOD (ppm)		1521	1812	1820	2660	3200		2158	2558		1651	1780	2058	1704	1692	1855	1210	1840		2740	1560	1275	1605	2361	1980
	COD (ppm)		440	421	467	433	513		589	550		488	478	451	422	508	527	411	915		899	386	305	341	470	510
	SS (ppm)			250			300		600	200		162	47	225		275	80	90	86.7		1200	270	667		125	367
	Extracted Substance (ppm)																	15.2								
	NH_4^+N (ppm)																								34.3	
	PO_4 (gm)																36.0							193.5	210	
	Evaporation Residue (ppm)								2780									2000						2000		
	Ash (ppm)								470									580								
	T - N (ppm)			297												292		276						208		
Treated Water	pH		8.1	8.1	8.9	7.9	8.0	8.2	7.9	8.0	8.1	8.0	7.9	8.0	8.0	8.0	7.7	7.6	8.0	8.1	8.4	8.2	8.0	8.1	8.2	8.4
	BOD (ppm)		98.6	134	182	266	264	421.2	360	442.3	431	422	440.8		763	642	640.2	605	584	548	496	488	392	291	182	182
	COD (ppm)		36.7	51	74.6	119.1	127.5	136.3	128.7	158.9	158.7	149.2	161.5	174.3	256	230	227	206	196	228	183	200.2	154	118	66.1	103.0
	SS (ppm)						70.0		87.0	83.0	130	150	165			233	229	214	200	107	97	140	117	120	90.0	150
	T - N (ppm)			103							90	126				138		177						182		
	NH_4^+N (ppm)																	33.3							150	
	PO_4 (ppm)																42							143.5	181	
	Evaporation Residue (ppm)						1200											1440						1460		
	Ash (ppm)						630											610						960		
	Transparency (cm)		17.5	12.4	7.5	7.3	6.2	6.0	5.8	5.2	4.5	3.5	2.8	2.6	2.5	2.2	2.3	2.1	2.0	1.8	2.0	2.0	2.2	2.0	2.2	2.6
Aeration Tank	Water Temperature (℃)		1.0	0	0	-0.2	-0.2	-0.2	-0.2	-0.3	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.5	-0.2	-0.2	-0.2
	SV_{30} (%)			2.0	2.5	2.9	3.0	1.9	3.0	0	1.0	0.5	1.0	0.5		0	0.1	0.1		Sludge	10	7	14	10	5	1
	SV_{60} (%)			2.5	3.0	3.0	2.9	2.0	2.9	2.0	2.0	2.0	2.0	1.0		0.8	1.0	0.6			8	7	11.9	8	5.5	2
	SVI			76.9	80.6	96.7		59.4	78.9		31.3	22.7	25.0	15.1							106	945	119	106	63.3	20
	MLSS (ppm)		160	260	310	300		320	380	280	320	220	400	330	310	410	560	400	575	580	940	740	1180	941	790	550
	Inflow Rate (m^3/day)	20	20	20	20	15	15	0	20	0	0	20	20	20	20	20	5	5	5	0	10	20	10	10	10	10
	BOD Space Loading (kg/m^3/day)		0.3	0.36	0.36	0.4	0.74		0.43			0.33	0.35	0.4	0.34	0.34	0.09	0.06	0.09		0.27	0.31	0.13	0.16	0.23	0.2
	Residence Time (hr)		6	9	10	5	5	7	8	8	5	4	9	9	8	10	10	10	10	10	10.5	11				

Table 1 - ④

	Measurement Date	15																								
Raw Water	pH	7.3																								
	BOD (ppm)	139.6																								
	COD (ppm)	444																								
	SS (ppm)	281																								
	Extracted Substance (ppm)																									
	NH_4^+ N (ppm)	33.7																								
	PO_4 (ppm)	202																								
	Evaporation Residue (ppm)																									
	Ash (ppm)																									
	T - N (ppm)	245																								
Treated Water	pH	8.6																								
	BOD (prm)	193																								
	COD (ppm)	67.7																								
	SS (ppm)	120																								
	T - N (ppm)	178																								
	NH_4^+ N (ppm)	223																								
	PO_4 (ppm)	160																								
	Evaporation Residue (ppm)																									
	Ash (ppm)																									
	Transparency (cm)	2.8																								
Aeration Tank	Water Temperature (℃)	-0.2																								
	SV_{30} (%)																									
	SV_{60} (%)	2																								
	SVI																									
	MLSS (ppm)	400																								
	Inflow Rate (m^3/day)	10																								
	BOD Space Loading (kg/m^3/day)	0.14																								
	Residence Time (hr)																									

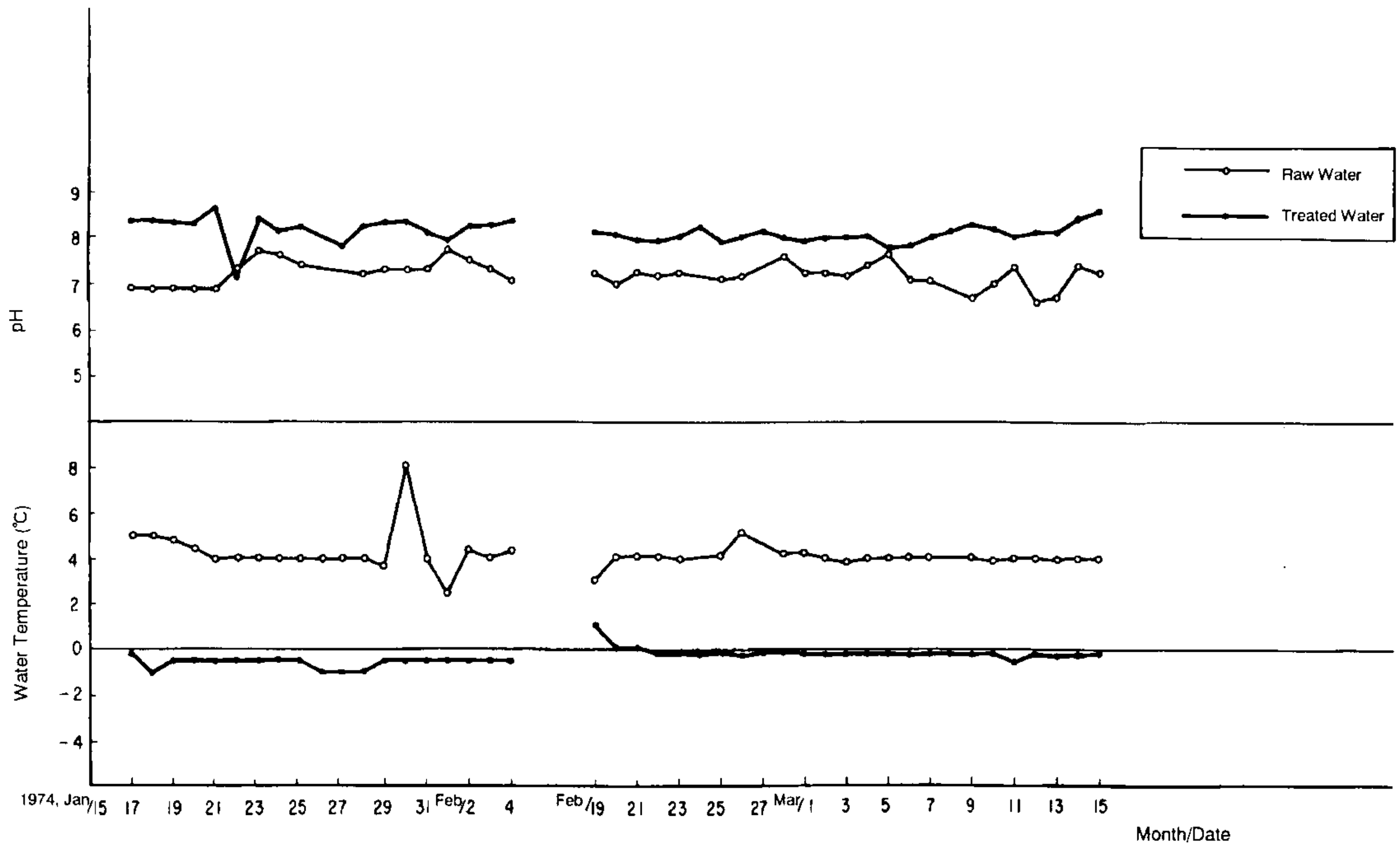


Figure 1 Changes in Water Temperature and pH (Refer to Table 1)

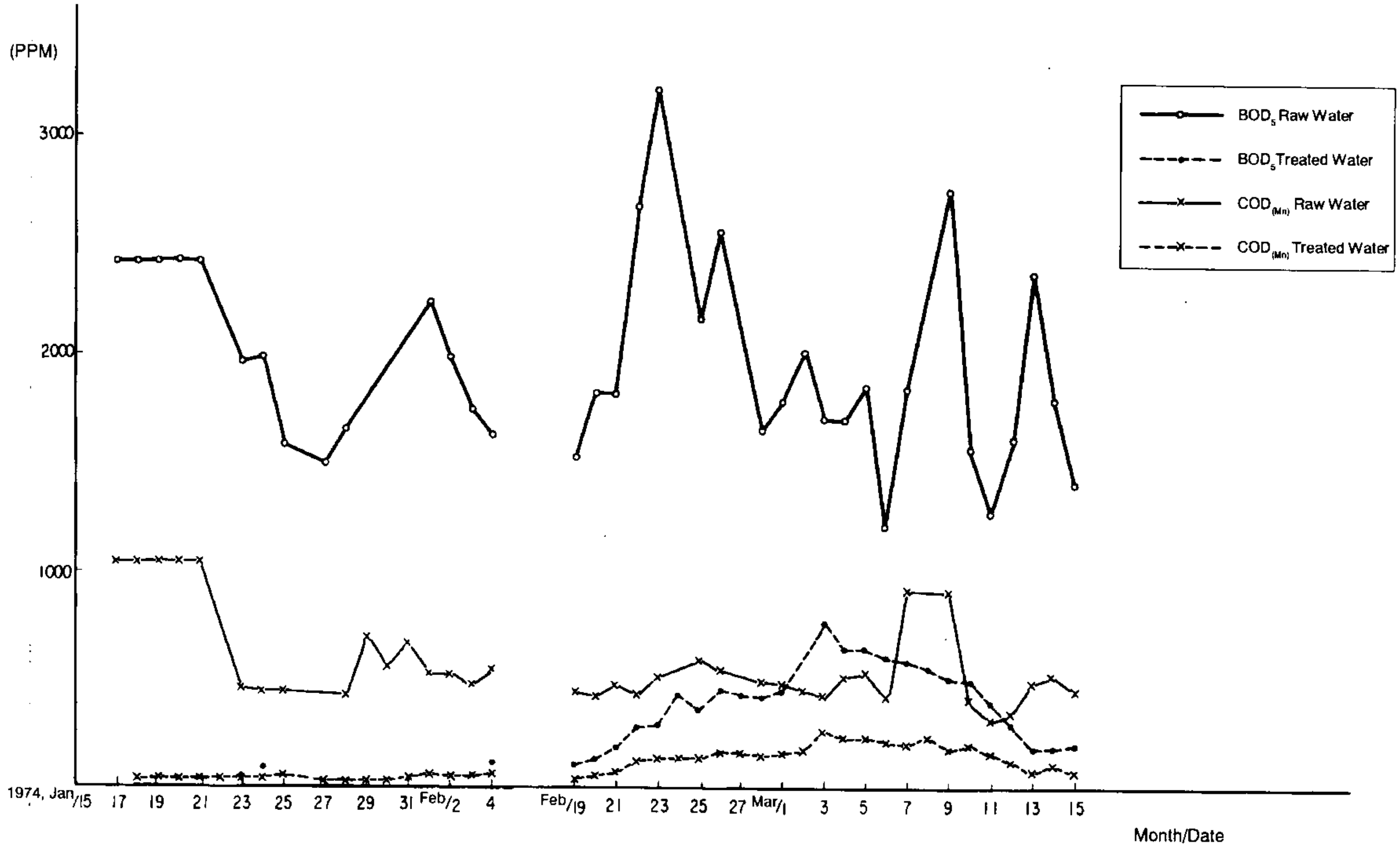


Figure 2 Daily Changes in BOD_5 and $COD_{(Mn)}$ (Refer to Table 1)

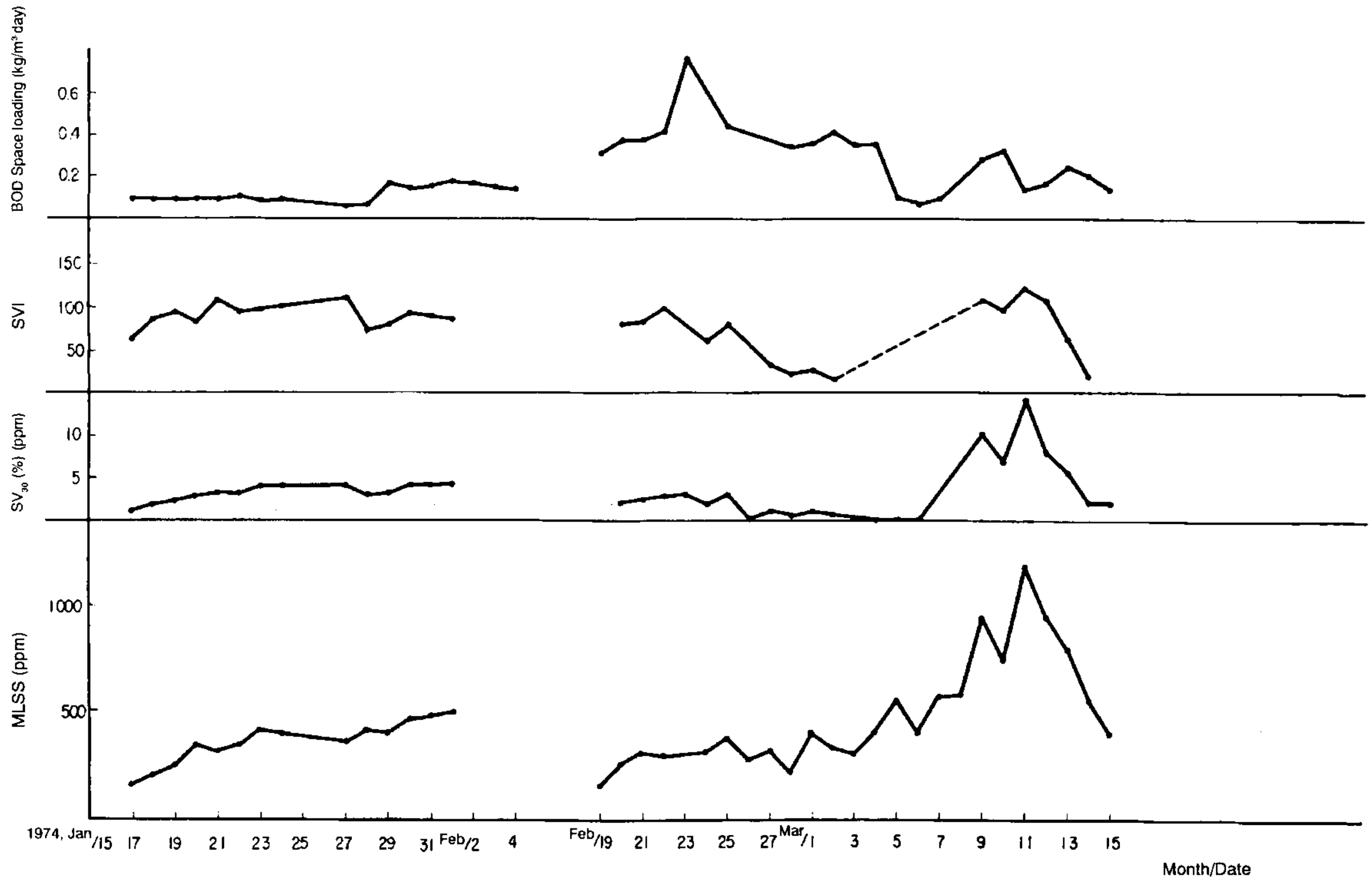


Figure 3 Daily Changes in MLSS, SV, SVI, and BOD Space loading (Refer to Table 1)

Table 2-① 20-liter water Tank Test Results (Raw Water was Untreated Effluent)

	Measurement Date	12/11	12	13	14	15	16	17	18	19	20	21	22	23	24											
Raw Water	pH	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2												
	BOD (prm)	2410	2410	2410	2410	2410	2410	2410	2410	2410	2410	2410	2410	2410												
	COD (ppm)	636	636	636	636	636	636	636	636	636	636	636	636	636												
	SS (ppm)	421	421	421	421	421	421	421	421	421	421	421	421	421												
	Extracted Substance (ppm)	1121	1121	1121	1121	1121	1121	1121	1121	1121	1121	1121	1121	1121												
	NH_4 - N (ppm)																									
	PO_4 (ppm)																									
	Evaporation Residue (ppm)																									
	Ash (ppm)																									
	T - N (ppm)																									
Treated Water	pH	7.4	7.5	7.5	7.7	7.8		7.8	7.8	7.7	7.7	7.5	7.8		7.8											
	BOD (ppm)		185					116		144																
	COD (ppm)	405	50.1	44.2		36.0		27.0	36.5	47.6	39.9	36.2	39.4		41.6											
	SS (ppm)																									
	T - N (ppm)																									
	NH_4 - N (ppm)																									
	PO_4 (ppm)																									
	Evaporation Residue (ppm)																									
	Ash (ppm)																									
	Transparency (cm)																									
Aeration Tank	Water Temperature (℃)	0	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.3	-0.2	-0.2	-0.2											
	SV_{30} (%)	5.5		6.0		5.5		6.0		6.5			6.5													
	SV_{60} (%)																									
	SVI	66		68		84		64		68			67													
	MLSS (ppm)	830		885		650		940		960			972													
	Inflow Rate (m^3/day)	1	1	1	1	1	1	1	1	1	1	1	1	1												
	BOD Space Loading (kg/m^3/day)	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12												
	Residence Time (hr)																									

Table 2-②

	Measurement Date	1/17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	2/1	2	3							
Raw Water	pH	9.6	9.6	9.6	9.6	9.6	7.4	7.7	7.6	7.4			7.2	7.3	7.3	7.3	7.7	7.5	7.3							
	BOD (ppm)	2415	2415	2415	2415	2415	2000	1957	1980	1581		1496	1652				2230	1982	1741							
	COD (ppm)	1180	1180	1180	1180	1180	522	450	439	447			425	688	550	656	512	520	475							
	SS (ppm)	95	95	95	95	95	100		60	65			76.9	433		25		82.5								
	Extracted Substance (ppm)																									
	NH_4 N (ppm)																									
	PO_4 (ppm)																									
	Evaporation Residue (ppm)									2050				2550												
	Ash (ppm)																									
	T - N (ppm)							239						304												
Treated Water	pH	8.0	8.3	8.0	8.0	8.4	7.9	8.1	8.1	8.2	8.1	8.2	8.2	8.2	8.1	8.3	8.3	8.1	8.3							
	BOD (ppm)	86.0						49.9	68.5																	
	COD (ppm)		41.1	27.9	29.3	31.2	25.0	27.7	37.9	50.9	21.0	37.0	26.8	34.3	33.0	35.5	30.2	57.6	45.9							
	SS (ppm)		12.5			24.0			40.0	50.0			12.0	18.9		10.0		40.0								
	T - N (ppm)						68.8			72.4				50.6												
	NH_4 N (ppm)																									
	PO_4 (ppm)																									
	Evaporation Residue (ppm)									175				250												
	Ash (ppm)																									
	Transparency (cm)		14.0	18.0	14.0	12.5	23.0	17.0	11.0	10.0	25.0	21.0	16.0	21.0	15.0	21.5	18.5	13.0	16.5							
Aeration Tank	Water Temperature (℃)	-0.5	-0.1	-0.5	-0.5	-0.5	-0.5	-0.5	-0.5	-0.5	-0.5	-0.5	-0.5	-0.5	-0.5	-0.5	-0.5	-0.5	-0.5							
	SV_{30} (%)	14.0	12.0	13.0	13.0	12.0	12.0	12.5	9.0	13.0	10.0	12.0	13.0	11.0	10.5	13.0	14.0	13.0	17.0							
	SV_{60} (%)	12.0	10.0	11.0	11.0	9.0	11.0	11.0	8.5	10.0	9.0	9.5	11.0	10.0	9.5	11.0	12.0	11.0	13.0							
	SVI	155	143	158	175	193	133	139	145	162	156	158	130	157	122	159	159	157	154							
	MLSS (ppm)	900	840	820	740	620	900	900	620	800	640	760	1000	700	860	820	880	830	1100							
	Inflow Rate (m^3/day)	0.4	0.4	0.4	0.4	0.4	0.8	0.8	0.8	0.8	0.8	0.8	0.8	1.0	1.0	1.0	1.0	1.0	1.5							
	BOD Space Loading (kg/m^3/day)	0.03	0.03	0.03	0.03	0.03	0.08	0.08	0.08	0.06	0.06	0.06	0.06	0.14	0.11	0.13	0.11	0.1	0.15							
	Residence Time (hr)																									

Table 3-① 20-liter water Tank Test Results (Raw Water was Water Treated by Pressure Flotation Process)

DO 10 - 11 ppm

	Measurement Date	12/11	12	13	14	15	16	17	18	19	20	21	22	23	24											
Raw Water	pH	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2												
	BOD (ppm)	1334	1334	1334	1334	1334	1334	1334	1334	1334	1334	1334	1334	1334												
	COD (ppm)	372	372	372	372	372	372	372	372	372	372	372	372	372												
	SS (ppm)	52	52	52	52	52	52	52	52	52	52	52	52	52												
	Extracted Substance (ppm)	326	326	326	326	326	326	326	326	326	326	326	326	326												
	NH_4 N (ppm)																									
	PO_4 (ppm)																									
	Evaporation Residue (ppm)																									
	Ash (ppm)																									
	T - N (ppm)																									
	COD (cr) (ppm)	1206	1206	1206	1206	1206	1206	1206	1206	1206	1206	1206	1206	1206												
Treated Water	PH	7.6	7.7	8.1	7.6	8.0		7.8	8.0	8.1	7.9	7.9	7.8		7.7											
	BOD (ppm)		192					220		152																
	COD (ppm)	35.3	46.0	45.5	66.1	56.1		49.7	51.3	56.9	54.2	42.4	39.2		38.7											
	SS (ppm)																									
	T - N (ppm)																									
	NH_4 N (ppm)																									
	PO_4 (ppm)																									
	Evaporation Residue (ppm)																									
	Ash (ppm)																									
	Transparency (cm)																									
Aeration Tank	Water Temperature (℃)	0	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.3	-0.2	-0.2	-0.2											
	SV_{30} (%)	10		9.5		11		10.5		9			9													
	SV_{60} (%)																									
	SVI	102		116		122		126		115			108													
	MLSS (ppm)	980		821		900		830		780			831													
	Inflow Rate (m^3/day)	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8												
	BOD Space Loading (kg/m^3/day)	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12												
	Residence Time (hr)																									

Table 3 - ②

	Measurement Date	1/18	19	20	21	22	23	24	25	26	27	28	29	30	31	2/1	2	3	4							
Raw Water	pH	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2							
	BOD (ppm)	2400	2400	2400	2400	2400	2400	2400	2400	2400	2400	2400	2400	2400	2400	2400	2400	2400	2400							
	COD (ppm)	329	329	329	329	329	329	329	329	329	329	329	329	329	329	329	329	329	329							
	SS (ppm)	190	190	190	190	190	190	190	190	190	190	190	190	190	190	190	190	190	190							
	Extracted Substance (ppm)	87.0	87.0	87.0	87.0	87.0	87.0	87.0	87.0	87.0	87.0	87.0	87.0	87.0	87.0	87.0	87.0	87.0	87.0							
	NH_4^+ N (ppm)																									
	PO_4 (ppm)																									
	Evaporation Residue (ppm)	1800	1800	1800	1800	1800	1800	1800	1800	1800	1800	1800	1800	1800	1800	1800	1800	1800	1800							
	Ash (ppm)	870	870	870	870	870	870	870	870	870	870	870	870	870	870	870	870	870	870							
	T - N (ppm)	255	255	255	255	255	255	255	255	255	255	255	255	255	255	255	255	255	255							
Treated Water	pH	8.0	7.7	8.1	7.9	8.0	8.0	8.2	7.9	8.0	8.0	8.0	8.2	8.2	8.2	8.0	8.3	8.4								
	BOD (ppm)	43.0					60.7	> 90.0								225										
	COD (ppm)	41.2	30.8	30.8	27.5	34.9	27.7	46.0	33.1	21.2	32.1	35.1	36.3	29.8	34.0	27.4	51.0	31.0	34.6							
	SS (ppm)	13.2			25.0			80.0	16.7			17.0	15.0		13.9		111.1		200							
	T - N (ppm)					34.4			34.4				68.8													
	NH_4^+ N (ppm)																									
	PO_4 (ppm)																									
	Evaporation Residue (ppm)								400				550													
	Ash (ppm)																									
	Transparency (cm)	15.0	14.0	13.0	13.0	19.0	23.0	15.0	20.0	> 30.0	20.0	13.0	21.0	26.0	25.0	21.5	12.0	21.0	19.0							
Aeration Tank	Water Temperature (℃)	-0.5	-0.5	-0.5	-0.5	-0.5	-0.5	-0.5	-0.5	-0.5	-0.5	-0.5	-0.5	-0.5	-0.5	-0.5	-0.5	-0.5	-0.5							
	SV_{30} (%)	12.0	11.5	12.0	18.0	10.0	11.0	11.0	10.0	8.5	6.5	11.5	10.0	9.0	8.5	8.0	10.0	10.0	10.0							
	SV_{60} (%)	10.5	9.5	10.0	13.0	9.0	10.0	9.5	9.0	8.0	6.0	10.0	9.0	9.0	8.0	8.0	9.0	9.0	9.0							
	SVI	150	151	140	167	128	145	107	132	139	112	112	139	85	133	114	125	118								
	MLSS (ppm)	800	760	860	1080	780	760	1030	760	610	580	1020	720	1060	640	700	800	850								
	Inflow Rate (m^3/day)	0.5	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.5	1.5							
	BOD Space Loading (kg/m^3/day)	0.06	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.18	0.18							
	Residence Time (hr)																									

Table 4 - ① 20-liter Water Tank Test Results (Raw Water was Water Treated by Electric Coagulation Process)

DO 10 - 11 ppm

	Measurement Date	12/11	12	13	14	15	16	17	18	19	20	21	22	23	24											
Raw Water	pH	7.6	7.6	7.6	7.6	7.6	7.6	7.6	7.6	7.6	7.6	7.6	7.6	7.6	7.6											
	BOD (ppm)	1264	1264	1264	1264	1264	1264	1264	1264	1264	1264	1264	1264	1264	1264											
	COD (ppm)	354	354	354	354	354	354	354	354	354	354	354	354	354	354											
	SS (ppm)	35	35	35	35	35	35	35	35	35	35	35	35	35	35											
	Extracted Substance (ppm)	326	326	326	326	326	326	326	326	326	326	326	326	326	326											
	NH_4 - N (ppm)																									
	PO_4 (ppm)																									
	Evaporation Residue (ppm)																									
	Ash (ppm)																									
	T - N (ppm)																									
	COD (cr) (ppm)	1296	1296	1296	1296	1296	1296	1296	1296	1296	1296	1296	1296	1296	1296											
Treated Water	pH	7.7	7.9	8.1	7.7	8.0		7.9	8.0	7.8	7.6	8.0	7.9		8.1											
	BOD (ppm)		204					245		163																
	COD (ppm)	47.2	59.7	52.4	77.1	75.5		67.7	47.3	52.5	44.0	60.2	36.4		42.3											
	SS (ppm)																									
	T - N (ppm)																									
	NH_4 - N (ppm)																									
	PO_4 (ppm)																									
	Evaporation Residue (ppm)																									
	Ash (ppm)																									
	Transparency (cm)																									
Aeration Tank	Water Temperature (℃)	0	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.3	-0.2	-0.2	-0.2											
	SV_{30} (%)	6.0		6.0		6.5		6.5		6.5			6.5													
	SV_{60} (%)																									
	SVI	78.9		82.7		95.5		77.3		77.3			73.6													
	MLSS (pmm)	760		725		680		840		840			882													
	Inflow Rate (m^3/day)	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	0											
	BOD Space Loading (kg/m^3/day)	0.114	0.114	0.114	0.114	0.114	0.114	0.114	0.114	0.114	0.114	0.114	0.114	0.114	0											
	Residence Time (hr)																									

Table 4 - ②

	Measurement Date	1/18	19	20	21	22	23	24	25	26	27	28	29	30	31	2/1	2	3	4							
Raw Water	pH	7.6	7.1	7.1	7.1	7.1	7.1	7.1	7.1	7.1	7.1	7.1	7.1	8.5	8.5	8.5	8.5	8.5	7.3							
	BOD (ppm)	1264	601	601	601	601	601	601	601	601	601	601	601	1160	1160	1160	1160	1160	610							
	COD (ppm)	354	116	116	116	116	116	116	116	116	116	116	116	232	232	232	232	232	117							
	SS (ppm)	35	17.2	17.2	17.2	17.2	17.2	17.2	17.2	17.2	17.2	17.2	17.2	11.1	11.1	11.1	11.1	11.1								
	Extracted Substance (ppm)	87.0	200	200	200	200	200	200	200	200	200	200	200													
	NH_4^-N (ppm)																									
	PO_4 (ppm)																									
	Evaporation Residue (ppm)	1800	3070	3070	3070	3070	3070	3070	3070	3070	3070	3070	3070													
	Ash (ppm)	870	2480	2480	2480	2480	2480	2480	2480	2480	2480	2480	2480													
	T - N (ppm)	255	177	177	177	177	177	177	177	177	177	177	177													
Treated Water	pH	8.4	7.9	8.0	8.1	7.6	7.9	8.0	8.0	7.9	7.8	7.9	7.9	8.0	8.0	8.1	8.0	8.2	8.3							
	BOD (ppm)	34																								
	COD (ppm)	41	27.8	38.8	51	44	34.6	47.2	41.2	31.0	36.0	32.6	31.6	36.6	40.1	29.1	27.4	27.5	35.6							
	SS (ppm)	13.3			45			37.5	18.9			1.0	12.5		35		37.5		15.4							
	T -N (ppm)					54.3						39.8														
	NH_4^-N (ppm)																									
	PO_4 (ppm)																									
	Evaporation Residue (ppm)					2000						1950														
	Ash (ppm)																									
	Transparency (cm)	13	11.5	12	11.5	20.5	30	16	25	>30.0	20	19	>30.0	16	23.5	>30.0	22	>30.0	>30.0							
Aeration Tank	Water Temperature (℃)	-0.5	-0.5	-0.5	-0.5	-0.5	-0.5	-0.5	-0.5	-0.5	-0.5	-0.5	-0.5	-0.5	-0.5	-0.5	-0.5	-0.5	-0.5							
	SV_{30} (%)	11	19	13	9	11	9.5	8	9	6.5	10	10	9	9	6.5	8.5	8	8	7.5							
	SV_{60} (%)	10	16	11	8	11	8	8	8	6.5	9.5	9	8.5	9	6.5	8	7.5	7.5	7							
	SVI	122	179	118	150	166	140	123	123	118	103	98	106	102	101	94	95	95								
	MLSS (ppm)	900	1060	1100	600	660	680	650	730	550	970	1020	850	880	640	900	840	840								
	Inflow Rate (m^3/day)	2	4	4	4	4	4	4	4	4	4	4	4	4	3	3	3	4	3							
	BOD Space Loading (kg/m^3/day)	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.23	0.17	0.17	0.17	0.23	0.09							
	Residence Time (hr)																									

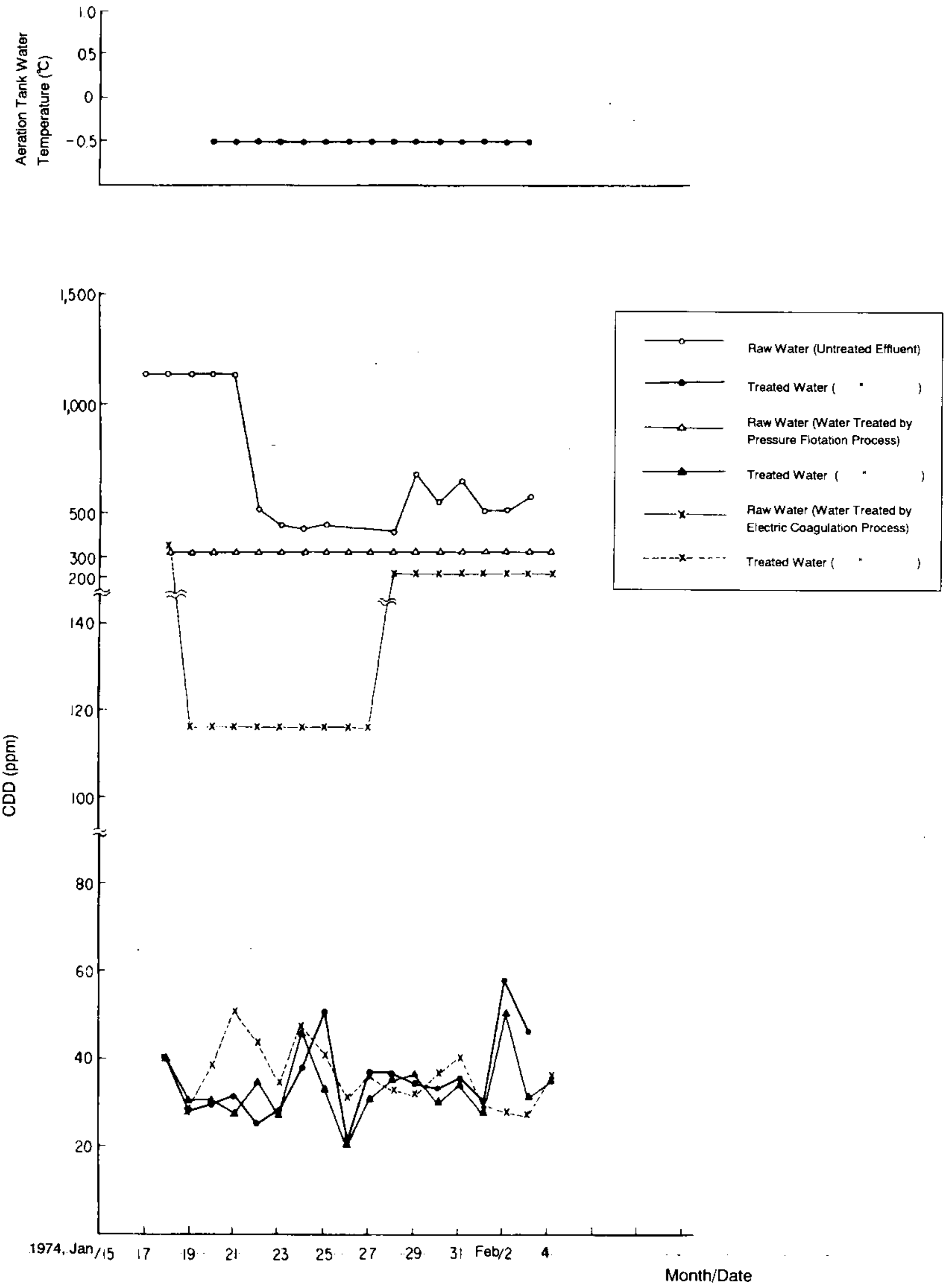


Figure 4. Daily Changes in COD (Refer to Tables 2, 3 and 4)

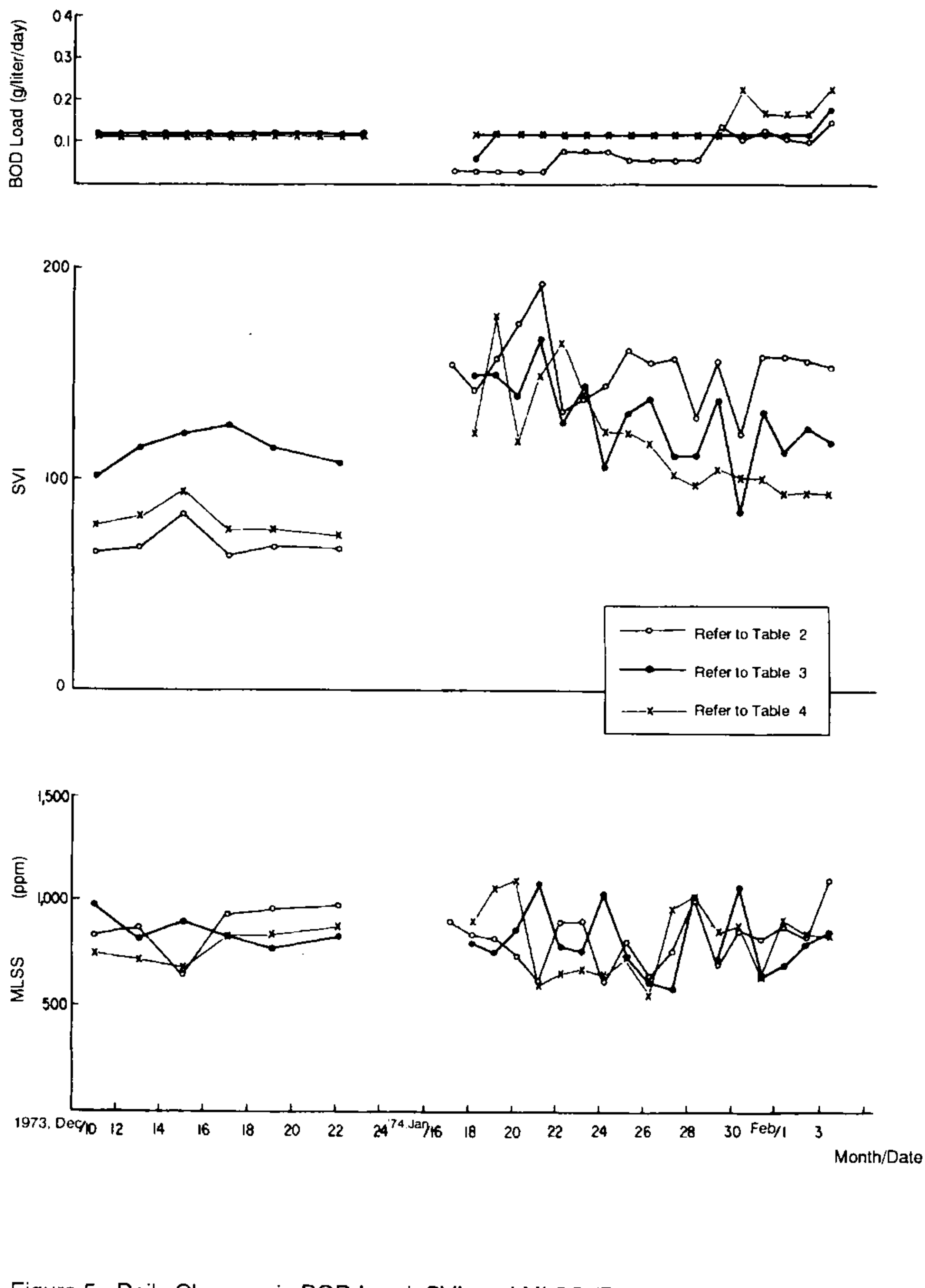


Figure 5 Daily Changes in BOD Load, SVI, and MLSS (Refer to Tables 2, 3, and 4)

Table 5 Results of BOD Space loading Variation Test with 20-liter Water Tank

	Measurement Date	2/19	20	21	22	23	24	25	26	27	28	3/1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Raw Water	pH	7.1	7.0	7.3	7.2	7.3	7.3	7.3	5.4	7.5	7.3	7.8	7.5	7.5	7.5	7.6	7.4	7.4	7.2	7.2	7	7		7.4	7.2	7.1
	BOD (ppm)	1521	1812	1820	2660	1700	1700	1700	3500	2160	5805	2010	1428	1428	846	1560	1840	2520	3240	1092	1560	2225	2280	2622	2390	1712
	COD (ppm)	440	421	467	433	556	556	556	798	475	1739	643	500	500	485	521	915	813	1146	587	386	839	805	887	622	773
	SS (ppm)					925	925	925	1700	500	740	367	650	650	450	419	214	650	1067	650	270	667	833	750	600	1000
	Extracted Substance (ppm)																									
	NH_4-N (ppm)																							8.7		16.1
	PO_4 (ppm)																						143.2			261.1
	Evaporation Residue (ppm)																						3390			
	Ash (ppm)																						49.0			
	T - N (ppm)																									
Treated Water	pH	8.2	8.1	8.2	8.1	8.4	8.3	8.1	8.3	8.2	8.1	8.5	8.3	8.7	8.5	8.6	8.0	8.6	8.6	8.3	8.7	8.6	8.5	8.7	8.8	8.6
	BOD (ppm)					164.2	153.4	96.2	89.4	59.4	127.8	116.2	46.7	73	13	50.9	57.9	43.1	86.5	87.5	50.9	37.1	38.3	81.0	48.9	33.8
	COD (ppm)	106	81.5	71.2	79.8	92.4	94.6	70.9	61.3	69.9	54.6	70	69.8	78.2	81.3	75.5	72.9	70.4	85.8	82.7	74.4	71.4	71.1	88.7	82.4	54.8
	SS (ppm)		17.5			27.5		22.5	27.5	30.8	30	36	45		90	46.7	33				30	15	16	80.6	40	30
	T - N (ppm)		134								177				217		209						195			181
	NH_4-N (ppm)																									197.8
	PO_4 (ppm)																						103.8			117
	Evaporation residue (ppm)							1460										1210					1200			
	Ash (ppm)																	460					590			
	Transparency (cm)	10		11		8.5		9	9	10.6	8	7.5	8.2	5.2	5	8	8		6.8		10	10.4	11	5.7	8.2	11.7
Aeration Tank	Water Temperature (℃)	1	1.5	1	1	1	-0.2	0.8	0.6	0.8	0.8	0.5	0.4	0.3	1.8	1.4	0.8	0.5	0.2	0	0.8	1	-0.2	1	1	2.0
	SV_{30} (ppm)	6.5	13	13	17.2	19	23	29.5	29	28.5	33	39	43	44	48	80	97	97	98	96.2	96	96	96.9	97	98.4	33
	SV_{60} (ppm)	7	11	11	13.9	15	18.8	22	24.7	23	30	32	35.5	35.5	39	57	92	94	96	93.5	66	90	91.8	95	97	29
	SVI	103	94.9	86.7	99.4		97.9	112	111	105	127	122	136	131	133	220	249	231	226	240	322	291	277	259	268	159
	MLSS (pmm)	630	1370	1500	1730		2350	2640	2620	2720	2600	3190	3162	3360	3600	3630	3890	4200	4340	4010	2980	3300	3260	3740	3670	2080
	Inflow Rate (m^3/day)	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	3	3	3	3	2	3	3	3	3	3
	BOD Space Loading (kg/m^3/day)	0.3	0.36	0.36	0.53	0.34	0.34	0.34	0.7	0.43	1.16	0.4	0.28	0.28	0.17	0.31	0.37	0.37	0.47	0.16	0.16	0.33	0.34	0.39	0.36	0.26
	Residence Time (hr)																									

Table 6 Results of BOD Space loading Variation Test with 20-liter Water Tank

	Measurement Date	2/19	20	21	22	23	24	25	26	27	28	3/1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Raw Water	pH	7.1	7.0	7.3	7.2	7.3	7.3	7.3	5.4	7.5	7.3	7.8	7.5	7.5	7.5	7.6	7.4	7.4	7.2	7.2	7	7		7.4	7.2	7.1
	BOD (ppm)	1521	1812	1820	2660	1700	1700	1700	3500	2160	5805	2010	1428	1428	846	1560	1840	2520	3240	1092	1560	2225	2280	2622	2390	1712
	COD (ppm)	440	421	467	433	556	556	556	798	475	1739	643	500	500	485	521	915	813	1146	587	386	839	805	887	622	773
	SS (ppm)					925	925	925	1700	500	740	367	650	650	450	419	214	650	1067	650	270	667	833	750	600	1000
	Extracted Substance (ppm)																									
	NH_4-N (ppm)																							8.7		16.1
	PO_4 (ppm)																						143.2			261.1
	Evaporation Residue (ppm)																						3394			
	Ash (ppm)																						490			
	T - N (ppm)																									
Treated Water	pH	8.3	8.3	8.3	8.4	8.7	8.8	8.4	8.6	8.4	8.5	8.6	8.4	8.7	8.4	8.5	8.0	8.5	8.4	8.3	8.5	8.6	8.6	8.7	8.8	8.7
	BOD (ppm)							170	304		196.8	103.6	49.7	27.8	18.7	42.3	38.3	28.5	77.3	71.1	34.7	29.3	38.7	63.2	27	26.6
	COD (ppm)	96.9	70	61	54.4	58.6	63.3	56.4	62.5	58.1	65.6	59.9	46.5	44.6	62.5	48.1	41.5	42.7	59.6	56.4	49.1	47.9	58.2	61.2	46	47.2
	SS (ppm)		17.5			37.5		45	60	50	53	40	35		37.5	38.5	33.3	23.3	27	32	40	20	20	16	16	20
	T - N (ppm)		188								167				107		110						154			298
	NH_4-N (ppm)																150									289
	PO_4 (ppm)																						75.1			150.2
	Evaporation Residue (ppm)							2400									1042						1200			
	Ash (ppm)							1760									820						940			
	Transparency (cm)	13.5		11.5		7.5		7.5	6.5	7.5	7.5	8	11.2	11	8.5	10	10.6	10.5	8	12	10	11.5	10.2		18.5	18
Aeration Tank	Water Temperature (℃)	1	1.5	1	1	1	-0.2	0.8	0.6	0.8	0.8	0.5	0.4	0.3	1.8	1.4	0.8	0.5	0.2	0	0.8	1	-0.2	1	1	2
	SV_{30} (%)	7	11	11	11	12	14.8	15	14	14.8	17	18	15.1	18.5	18.5	19.2	20.8	21	28	27	31	35.5	36	38	46.5	45.5
	SV_{60} (%)	7	9.5	10	9.8	11	12.6	12.2	11.6	12	14	15	12.9	14.5	15.3	15.3	15.5	16.5	19	23	25	28	30	30.4	35	39
	SVI	108	99.1	89.4	89.4		93.1	89.2	85.9	88.6	103	102	89	110	117	112	120	122	151	121	138	134	149	141	180	143
	MLSS (pmm)	650	1110	1230	1230		1590	1680	1630	1670	1650	1760	1700	1680	1580	1710	1740	1720	1860	2240	2250	2640	2420	2700	2590	3180
	Inflow Rate (m^3/day)	4	4	4	1	1	1	1	1	1	1	1	1	1	1	1	2	3	3	3	2	3	3	3	3	3
	BOD Space Loading (kg/m^3/day)	0.3	0.36	0.36	0.13	0.08	0.08	0.08	0.17	0.11	0.29	0.1	0.07	0.07	0.04	0.08	0.18	0.37	0.47	0.16	0.16	0.33	0.34	0.39	0.36	0.25
	Residence Time (hr)																									

Table 7 Results of BOD Space loading Variation Test with 20-liter Water Tank

	Measurement Date	2/19	20	21	22	23	24	25	26	27	28	3/1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Raw Water	pH	7.1	7.0	7.3	7.2	7.3	7.3	7.3	5.4	7.5	7.3	7.8	7.5	7.5	7.5	7.6	7.4	7.4	7.2	7.2	7.0	7.0	7.2	7.4	7.2	7.1
	BOD (ppm)	1521	1812	1820	2660	1700	1700	1700	3500	2160	5805	2010	1428	1428	846	1560	1840	2520	3240	1092	1560	2225	2280	2622	2390	1712
	COD (ppm)	440	421	467	433	556	556	556	798	475	1739	643	500	500	485	521	915	813	1146	587	386	839	805	887	622	773
	SS (pmm)					925	925	925	1700	500	740	367	650	650	450	419	214	650	1067	650	270	667	833	750	600	1000
	Extracted Substance (ppm)																									
	NH_4-N (ppm)																							8.7		16.1
	PO_4 (ppm)																						143.2			261.1
	Evaporation Residue (ppm)																						3390			
	Ash (ppm)																						490			
	T - N (pmm)																									
Treated Water	pH	8.2	8.3	8.2	8.2	8.5	8.5	8.3	8.4	8.2	8.4	8.6	8.5	8.8	8.4	8.6	8.2	8.7	8.6	8.6	8.6	8.6	8.6	8.8	8.8	8.7
	BOD (ppm)					70.7	71.6	49	50.4	65.0	61.2	71.8	53.1	73.2	34.4	45.3	66.0	39.5	34.4	30.8	31.8	21.2	34.8	35.4	29.1	27.8
	COD (ppm)	60.8	45.0	39.0	46.9	53.4	60.9	45.9	45.5	51.7	56.0	59.9	62.6	60.6	62.5	58.8	66.5	59.6	49.6	70.1	58.3	53.9	59.4	63.8	64.2	67.6
	SS (ppm)		20.0			27.5		11.5	30.0	30.0	40.0	32.0	60.0		60.0	40.0	75.0	40.0	40.0	80.0	45.0	15.0	20.0	10.0	16.0	15.0
	T - N (ppm)		125								134				169								184.0			204
	NH_4-N (ppm)																							208.9		307.9
	PO_4 (ppm)																						93.5			189.7
	Evaporation Residue (ppm)							1160									1210						1240			
	Ash (ppm)							320									500						600			
	Transparency (cm)	7.0		11.5		9.0			9.0	11.5	8.0	8.0	8.0	6.5	4.7	9.0	7.0	8.0	7.0	8.0	12.0	13.5	11.0	10.0	15.2	18.0
Aeration Tank	Water Temperature (℃)	1	1.5	1	1	1	-0.2	0.8	0.6	0.8	0.8	0.5	0.4	0.3	1.8	1.4	0.8	0.5	0.2	0	0.8	1.0	-0.2	1.0	1.0	2.0
	SV_{30} (%)	7.0	10.0	9.5	10.5	11.5	17.0	16.2	16.5	17.5	17.0	20.5	20.5	24.0	22.2	24.0	27.5	27.5	30.0	29.5	35.5	37.0	41.1	43.2	47.0	43.2
	SV_{60} (%)	6.5	9.0	8.0	9.1	10.0	14.0	13.1	14.0	15.0	15.0	16.0	17.3	19.5	17.3	18.9	20.0	22.0	24.5	24.5	27.2	28.5	33.0	32.8	35.0	36.0
	SVI	66.7	76.3	69.3	81.4		91.4	83.1	91.7	91.1	87.0	89.5	93.0	104.0	96.0	105.0	108.0	108.0	110.0	112	134	138	149	138	161	132
	MLSS (ppm)	1050	1310	1370	1290		1860	1950	1800	1920	1950	2290	2200	2310	2310	2290	2540	2540	2720	2640	2640	2690	2750	3140	2920	3280
	Inflow Rate (m^3/day)	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
	BOD Space Loading (kg/m^3/day)	0.15	0.18	0.18	0.27	0.17	0.17	0.17	0.35	0.22	0.58	0.2	0.14	0.14	0.08	0.16	0.18	0.25	0.31	0.11	0.16	0.22	0.23	0.26	0.24	0.17
	Residence Time (hr)																									

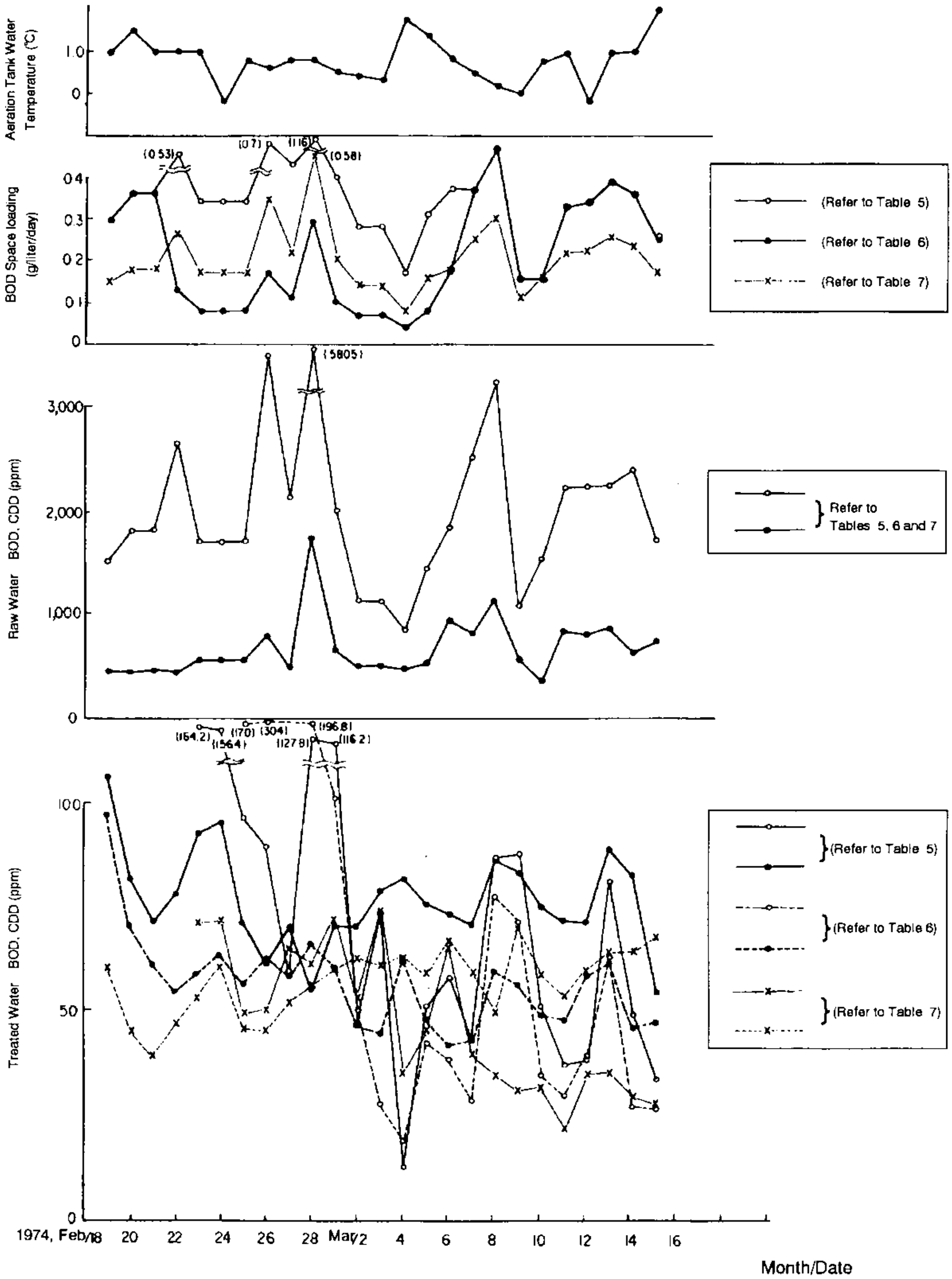


Figure 6 Daily Changes in Water Temperature, BOD Space loading, BOD, and COD (Refer to Tables 5, 6 and 7)

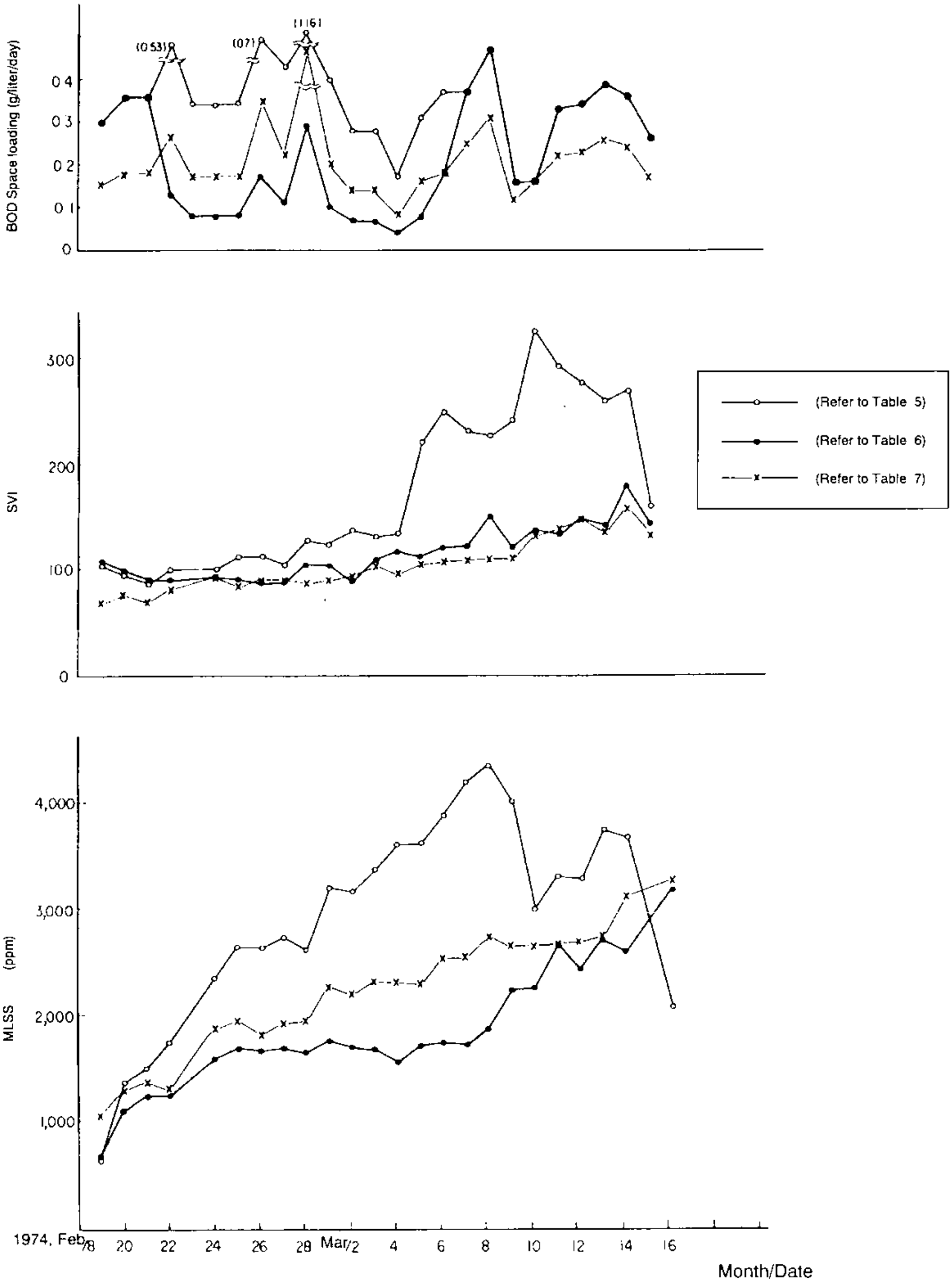


Figure 7 Daily Changes in BOD Space loading, SVI, and MLSS
(Refer to Tables 5, 6 and 7)

December 1973 Weather (Source: Abashiri Weather Station)

Table (1)

Dec / Date	Weather	Temperature			Wind		Sunshine Duration	Flux of Global Solar Radiation 2)
		Average 1)	Maximum	Minimum	Direction	Velocity		
1		-1.6℃	0.8℃	-5.7℃	SSW	3.5 m/s	4.9 hours	129
2		2.5	6.1	-0.4	SSW	1.9	7.0	162
3		3.1	8.9	-1.2	SSW	3.6	3.9	110
4		-2.5	0.7	-6.4	S	3.8	6.1	146
5		-5.0	-2.5	-7.6	W	4.3	5.4	145
6		-4.2	-1.4	-6.4	SW	2.3	1.4	84
7		-6.4	-2.6	-9.3	NW	3.7	7.7	178
8		-6.0	-1.1	-9.7	WSW	4.6	6.0	155
9		-3.5	0.2	-9.0	W	3.1	8.0	164
10		-2.0	1.7	-4.9	SSW	3.6	3.3	101
11		-4.2	-0.5	-8.3	SSE	3.5	6.4	156
12		-1.2	2.9	-7.5	NW	4.4	6.5	134
13		-3.7	2.1	-6.5	SSW	6.4	4.3	117
14		-3.0	1.0	-9.6	W	2.5	5.8	135
15		-1.7	1.6	-4.0	W	3.8	7.3	163
16		-3.8	-1.2	-7.6	SSW	1.7	7.0	144
17		-3.1	-0.5	-7.5	NW	3.8	3.1	105
18		-3.0	-0.1	-5.3	SW	2.1	1.9	90
19		-3.2	-0.1	-5.4	NW	2.5	4.6	146
20		-4.1	-2.5	-7.0	SSW	2.6	1.6	85
21		0.0	2.9	-3.6	SSW	3.2	1.6	91
22		0.0	5.9	-7.2	SSW	6.5	7.4	163
23		-5.1	-1.5	-8.1	SW	5.9	4.8	122
24		-3.3	-1.9	-5.3	NW	8.7	0	48
25		-5.1	-3.7	-6.8	NNW	5.9	1.4	83
26		-3.7	-1.1	-8.5	W	2.5	4.9	143
27		0.0	3.3	-3.5	SW	4.7	7.1	165
28		-0.9	1.4	-2.5	ENE	3.1	0	65
29		-4.7	-2.4	-6.4	N	4.2	5.5	129
30		-5.1	-0.7	-7.2	SSW	4.6	4.2	118
31		-3.6	-0.6	-6.5	SW	3.5	6.2	144
		-28℃	0.5℃	-6.3℃	-	3.9 m/s	Total 145.3 hours	Total 3920 Avg. 126

Average Daily Clouds		No Sunshine	Snow
< 2.5	≧ 7.5		
5	9	7	18

1) Average temperature is the average of the temperature every 3 hours (8 times per day)

2) Cal/cm^2/day

January 1974 Weather (Source: Abashiri Weather Station)

Table (2)

Jan / Date	Weather	Temperature Average 1)	Temperature Maximum	Temperature Minimum	Wind Direction	Wind Velocity	Sunshine Duration	Flux of Global Solar Radiation 2)
1		-2.8℃	-1.1℃	-4.6℃	NW	3.2 m/s	3.7 hours	116
2		-1.3	2.4	-3.5	SSW	3.6	4.8	133
3		-3.3	-2.8	-4.1	NW	5.9	0.7	87
4		-3.9	-1.6	-8.3	SSW	2.9	1.0	75
5		-3.2	0.3	-9.5	N	2.2	1.8	108
6		-3.2	-0.5	-5.6	NNW	5.3	0.4	62
7		-5.0	-3.4	-6.8	NW	6.3	1.0	89
8		-6.2	-5.0	-7.1	WNW	7.1	4.1	119
9		-4.3	-3.2	-6.3	NW	9.4	0	66
10		-1.9	-0.9	-3.4	NNW	8.4	0	52
11		-2.6	-1.0	4.1	NW	8.1	0	44
12		-3.7	-3.1	-4.5	NW	4.6	0	75
13		-5.7	-3.1	-8.1	NWN	6.1	1.4	108
14		-6.2	-4.2	-8.4	WNW	6.1	0	83
15		-3.7	-2.3	-5.4	NW	4.2	0	83
16		-4.0	0.4	-7.5	NW	2.3	7.1	192
17		-4.9	-2.3	-8.0	NW	3.0	1.1	127
18		-5.0	-0.9	-8.2	SW	1.8	6.1	188
19		-5.7	-1.8	-10.3	NW	2.8	7.1	197
20		-4.0	-2.6	-5.1	NW	6.4	0.9	124
21		-6.8	-3.0	-10.2	NNW	2.1	7.1	209
22		-7.5	-5.2	-10.6	N	1.5	0	120
23		-5.9	-1.6	-8.4	ESE	1.9	0	99
24		-7.3	-2.7	-13.7	NW	5.0	7.3	182
25		-4.6	-3.4	-5.9	NNW	14.1	0	58
26		-6.4	-5.7	-6.8	NW	11.5	0	71
27		-6.6	-5.8	-7.7	NW	6.7	0	124
28		-9.7	-7.7	-14.0	WNW	5.7	0	127
29		-6.2	-5.3	-8.9	WNW	6.7	0	156
30		-5.7	-2.6	-8.6	NW	3.5	5.2	226
31		-4.8	-1.2	-7.9	N	1.4	1.0	198
		-4.9℃	-2.6℃	-7.5℃	-	5.2 m/s	Total 61.8 hours	Total 3698 Avg. 119

Average Daily Clouds		No Sunshine	Snow
<2.5	≧7.5		
0	23	13	29

1) Average temperature is the average of the temperature every 3 hours (8 times per day)

2) Cal/cm²/day

February 1974 Weather (Source: Abashiri Weather Station)

Table (3)

Feb / Date	Weather	Temperature			Wind		Sunshine Duration	Flux of Global Solar Radiation 2)
		Average 1)	Maximum	Minimum	Direction	Velocity		
1		-6.4℃	-3.8℃	-9.6℃	N	1.5 m/s	3.8 hours	194
2		-4.8	-3.3	-6.2	NW	5.5	0	153
3		-6.4	-5.3	-7.6	NW	4.5	0	163
4		-6.9	-4.4	-8.8	WNW	3.1	6.3	220
5		-10.6	-7.0	-14.7	N	1.4	3.2	209
6		-12.4	-7.8	-15.9	NW	2.1	7.0	238
7		-13.7	-10.7	19.5	W	1.0	6.9	252
8		-9.9	-5.2	-14.9	N	1.5	0	126
9		-7.1	-4.3	-10.5	NNW	9.6	0	130
10		-7.9	-6.3	-10.0	WNW	9.9	1.2	196
11		-8.1	-6.9	-8.9	NW	6.1	2.1	204
12		-9.1	-5.9	-12.8	NW	3.2	5.9	242
13		-7.7	-3.0	-12.4	W	2.7	7.4	248
14		-7.7	-5.0	-9.9	WNW	4.9	7.4	273
15		-7.1	-3.9	-11.4	SW	2.0	7.9	269
16		0.3	5.2	-6.8	SSW	2.9	8.4	267
17		-3.7	0.3	-6.9	NW	2.2	8.1	280
18		-6.5	-2.8	-10.5	N	2.9	1.8	184
19		-8.3	-3.2	-16.0	SSW	2.7	8.7	310
20		-0.8	5.6	-6.1	NW	5.4	3.0	202
21		-5.4	-2.5	-9.5	W	3.3	8.1	290
22		-3.4	1.0	-9.7	S	2.2	5.1	231
23		-7.1	-3.0	-10.3	WNW	3.9	3.1	213
24		-5.9	0.0	-13.7	SW	2.2	9.0	342
25		-5.4	-2.0	-8.6	W	1.1	0	163
26		-4.8	-1.3	-8.9	SW	1.5	2.4	213
27		-5.2	-0.9	-10.0	N	2.1	9.7	343
28		-6.0	-3.8	-8.5	NW	4.0	0.4	174
		-6.7℃	-3.2℃	-10.7℃	-	3.4 m/s	Total 126.9 hours	Total 6329 Avg. 226

Average Daily Clouds		No Sunshine	Snow
< 2.5	≧ 7.5		
		5	22

1) Average temperature is the average of the temperature every 3 hours (8 times per day)

2) Cal/cm²/day

March 1974 Weather (Source: Abashiri Weather Station)

Table (4)

Mar / Date	Weather	Temperature			Wind		Sunshine Duration	Flux of Global Solar Radiation 2)
		Average 1)	Maximum	Minimum	Direction	Velocity		
1		-4.4℃	1.0℃	-10.2℃	SSW	3.0 m/s	9.4 hours	359
2		-5.1	-2.0	-8.3	SSW	4.2	4.4	246
3		-4.3	0.1	-10.8	SW	3.4	9.5	380
4		-0.3	4.8	-3.1	SW	3.8	5.9	261
5		-4.8	-2.4	-6.9	N	2.7	2.0	217
6		-3.4	1.3	-10.1	S	3.3	8.8	346
7		-3.1	-1.4	-5.4	N	2.3	0	138
8		-5.4	-3.6	-7.2	NW	3.7	1.7	245
9		-4.7	-0.4	-8.8	SSE	3.2	9.6	401
10		-1.3	5.3	-4.1	SSE	6.3	9.1	396
11		-3.5	-0.7	-7.9	SW	7.7	9.2	399
12		-5.8	-2.2	-8.9	SSW	3.4	5.0	242
13		-6.2	-2.2	-9.7	NW	4.2	9.0	390
14		-4.6	-1.5	-10.3	SW	2.8	7.5	325
15		-3.3	1.4	-6.8	SW	2.6	4.7	283
16		-4.3	-1.8	-7.3	SW	2.3	3.7	261
17		-3.0	0.8	-6.9	NW	3.7	10.6	449
18		-3.5	-0.3	-8.1	W	2.1	10.9	448
19		-4.1	-0.9	-8.2	NE	1.6	10.9	455
20		-3.6	-0.4	-7.4	NW	2.2	9.6	407
21		-3.8	-1.8	-5.7	N	2.0	8.8	406
22		-4.4	-2.9	-5.7	N	2.9	4.3	271
23		-4.6	-1.8	-6.6	NW	3.6	8.7	425
24		-4.4	-1.5	-8.7	NW	3.6	5.3	341
25		-3.3	-1.5	-5.3	NW	5.2	4.3	288

1) Average temperature is the average of the temperature every 3 hours (8 times per day)

2) $Cal/cm^2/day$

Results of Research

B. Activated Sludge Process

1. Aim of Research

Same as A-1.

2. Outline of Research

As a method of treating effluent in cold regions, field tests were conducted in a pilot plant (aeration tank capacity 17 m^3) using effluent from the ground headless fish meat process that was equal to effluent that had undergone primary treatment.

3. Outline of Research Facilities

See attached Figure 1.

4. Treatment Method

The treatment method was the standard activated sludge process. For heat insulation, an embankment of volcanic ash was built around the aeration tank and the final settling basin. In addition, the top of the aeration tank was covered with panels. The raw water first entered an underground storage tank and was then fed to the aeration tank by means of a submersible pump. The rate of flow was measured by a triangular notch weir at the entrance to the aeration tank.

The effective capacity of the aeration tank and settling basin was 17 m^3 and 8 m^3 respectively. The average residence time at the aeration tank was 57 to 240 hours, and operation was carried out with a BOD space loading of 0.2 to 0.8 kg-BOD/m^3/day.

Six to seven m^3 of seeding sludge was brought in from the Kitami City Sewage Treatment Plant. The total quantity of sludge was recirculated and the test facility was run at a return rate of 100 to 300%.

5. Test Effluent

The same effluent as A-4 was used.

6. Progress of Research

The tests began in December but as the month was taken up in servicing the equipment, very little data was obtained. However, there was no breakdown in equipment and the tests proceeded smoothly from January until the end of the tests in March.

In January, at the time of sampling (9 a.m. to 10 a.m.) the average temperature was minus(-) 5℃ and the days were extremely cold with the temperature never going above 0℃ even in the daytime. Ice floes appeared about one week earlier than usual. Moreover, from January 25 to 27, there was an unusually severe blizzard which caused all schools and factories in town to close, and which completely paralyzed the transportation system of the area. The pumps and other equipment of the test facility, which was near the seashore, were buried under snowdrifts of more than 2 m, but did not stop functioning.

February was the coldest period of these tests, there being as much as five days in which the average temperature at the time of sampling was lower than minus(-) 10℃. However, from the latter half of February to the end of the tests in March, the situation changed completely and there were continuous days of warm and fine weather.

From January 24, when the facility was run at a BOD space loading of 0.8 kg-BOD/m^3/day, the dissolved oxygen (DO) was a low 0.7 to 0.8 ppm, and the aeration tank temperature was 2.0 to 3.5℃. The treated water quality practically stabilized at $COD_{(Mn)}$ 157 - 200 ppm. However, as the settlement of the sludge became worse by the day and it appeared that the effectiveness of treatment would not become any better than it was, the load was reduced to half from February 9.

At a BOD space loading of 0.4 kg-BOD/m^3/day, the dissolved oxygen (DO) rose to 2.5 to 3.2 ppm. The treated water quality improved in about one week (February 18) after the load was changed and the aeration tank temperature also rose to 4.5℃. However, as the settling property of the sludge worsened and foaming in the aeration tank became severe, a small quantity of antifoaming agent (Silicone SH-505) was scattered (February 18 to 23). The $COD_{(Mn)}$ of the treated water became 92 - 98 ppm (removal rate 75 to 85%).

In order to improve the quality of the treated water even more, the load was further dropped and the facility was run from February 25 at 0.2 kg-BOD/m^3/day. With this load, the DO became excessive at 7 to 8 ppm, so the air volume was reduced. However, the dissolved oxygen (DO) did not drop. The quality of the treated water greatly improved with the BOD becoming 40 to 50 ppm. But the settling property, at SV 98% and SV1200 or more, did not change for the better. It was however noted that no increase in the outflow of SS was seen in the treated water because the final settling basin had a large capacity and the water surface area load was about 0.25 m/day.

If operated at 0.2 kg-BOD/m^3/day, the average residence time is 10 days and treated water at this load cannot be obtained unless the facility is run for about 30 days.

However, the values of $COD_{(Mn)}$, BOD, and $COD_{(Cr)}$ more or less met the general standards and as it appeared that there would not be much change even if the facility was operated further, the test at 0.2 kg-BOD/m^3/day was ended on March 8, 11 days after it was started. With this, all the current tests also came to an end.

7. Results of Research (Refer to attached Tables 1 and 2 and Figures 2 to 7)

1) BOD Space loading and Removal Rate of BOD (COD), etc.

Item	Raw Water	Treated Water		
		0.8 kg- BOD /m³/day	0.4 kg- BOD /m³/day	0.2 kg- BOD /m³/ day
pH	6.5 - 7.6		7.5 - 7.9	
$COD_{(Mn)}$	400 - 600	157 - 200	92 - 98	84 - 89
	max 1350	(50 - 74)	(75 - 85)	(78 - 86)
$COD_{(Cr)}$	2000 - 3000	600 - 700	300	220
	max 7500	(65 - 08)	(85 - 90)	(89 - 92)
BOD	1500 - 2500	700	200	40
	max 3800	(54 - 72)	(87 - 92)	(96 - 98)
SS	45 - 800	30 - 50	12 - 24	110 - 35
N-Hex	16 - 200	10 - 100	< 5.0	18 - 66
T-N	199 - 355	160 - 259	266	230 - 255
	Av 270			
NH_4^+	63 - 134	242	-	224 - 253
	Av 94			
NO_3^-	0.8	-	-	trace
NO_2^-	trace	-	-	trace
PO_4^{3-}	115 - 125	-	-	107 - 110
	Av 120			
Transparency	< 6	7 - 8	12 - 13.5	20.0

Units: pH is [-], transparency is [degrees], and others are ppm.
( ) = Removal rate %.
Max. = Maximum value
Av. = Average value

When operated at 0.8 kg-BOD/m^3/day, treatment was not very effective, the removal rates being 50 to 74% for $COD_{(Mn)}$, 65 to 80% for $COD_{(Cr)}$, and 54 to 72% for BOD, and the transparency too was 7 to 8 degrees. When the load was lowered to 0.4 kg-BOD/m^3/day, there was a considerable improvement in effectiveness, the removal rates becoming 75 to 85% for $COD_{(Mn)}$, 85 to 90% for $COD_{(Cr)}$, and 87 to 92% for BOD, and transparency also became better to 12 to 13.5 degrees. However, as the BOD was a high 200 ppm, the load was reduced to 0.2 kg-BOD/m^3/day. Whereupon, considerably good results were obtained because, although the removal rates of $COD_{(Mn)}$ and $COD_{(Cr)}$ did not change much, BOD became 40 ppm for a removal rate of 96 to 98% and transparency became 20 degrees.

Therefore, we believe that in order to meet the general standards by the activated sludge process in cold regions, treatment plants should be operated at a BOD space loading of 0.2 to 0.4 kg-BOD/m^3/day.

2) Quantity of Excess Sludge Generated

BOD Space loading	MLSS	Treated Water SS	Water Temperature
0.2 (kg-BOD/m^3/day)	Almost no increase	10 - 35 ppm	3.2 - 4.8℃
0.4 (kg-BOD/m^3/day)	Increase of 0.4 kg-MLSS/day	12 - 30 ppm	3.0 - 4.8℃
0.8 (kg-BOD/m^3/day)	Increase of 1.76 kg-MLSS/day	30 - 55 ppm	1.0 - 3.5℃

3) Sludge Volume Index (SVI), Settling Property, and Biota of Sludge

i) SVI

BOD Space loading	SVI	Water Temperature
0.2 (kg-BOD/m^3/day)	200 - 230	3.2 - 4.8℃
0.4 (kg-BOD/m^3/day)	150 - 230	3.0 - 4.8℃
0.6 (kg-BOD/m^3/day)	100 - 105	2.0℃
0.8 (kg-BOD/m^3/day)	140 - 200	1.0 - 3.5℃

ii) Settling Property and Biota

At a high BOD space loading (0.8 kg-BOD/m^3/day), floating and swimming protozoa (Mastigophora, Ciliata) as well as activated sludge floc were seen. Some filamentous bacteria were also seen. From February 18, the settling property of the sludge deteriorated but no particular increase in filamentous bacteria was found. However, it seemed that the sludge floc became smaller and less concentrated. (The same when the BOD space loading was 0.2 kg-BOD/m^3/day). Since the aeration tank dissolved oxygen (DO) was a high 7 to 8 ppm, it assumed that the floc was dispersed due excessive aeration caused by the long residence time of 10 days, resulting in worsening of the settling property of the sludge. Practically no Vorticella Carchesium Sp was found.

4) Effect of BOD Space Loading Variation

In the current tests, operations were carried out setting the BOD space loading at 0.2, 0.4, and 0.8 kg-BOD/m^3/day. As the raw water BOD fluctuates, there were fluctuations in space loading of from 0.5 to 1.0 kg-BOD/m^3/day when the operation was at 0.8, from 0.3 to 0.7 kg-BOD/m^3/day when at 0.4, and from 0.2 to 0.4 kg-BOD/m^3/day when at 0.2. However, there was no particular deterioration of the treated water quality due to these fluctuations in BOD space loading.

Therefore, if the BOD space loading is set at 0.4 kg-BOD/m^3/day, it is presumed that the treated water quality will satisfy the general standards even though there may be some fluctuations in the space loading.

5) Effect of Intermittent Inflow of Effluent

There was not much effect of two days of stoppage of inflow. Even if stoppages are for longer periods, operational control will be able to cover any effect those stoppages may have.

6) Measurement of Effectiveness of Nitrogen and Phosphorous Removal

i) Rise and Fall of Nitrogen

Month/Day \ Item	T - N (Total Nitrogen)	
	Raw Water	Treated Water
Jan. 21	250 (ppm)	188 (ppm)
25	199	163
Feb. 1	355	219
6	282	250
8	291 NH_4^+ 98.4	259 NH_4^+ 242
15	287	266
25	317 NH_4^+ 89.0	247 NH_4^+ 245
28	250 NH_4^+ 63	255 NH_4^+ 253
Mar. 4	228 NH_4^+ 86.9	244 NH_4^+ 243
7	240	232
	NH_4^+ 134	NH_4^+ 224
	NO_3^- 0.8	NO_3^- trace
	NO_2^- 0.1	NO_2^- 0.1

Although T-N of the raw water and treated water does not change, it can be seen that in the treated water it has been almost all decomposed to NH_4^+.

ii) As per the table below, there is practically no removal of phosphorous ions.

Month/Day \ Item	PO_4^{3-}	
	Raw Water	Treated Water
Mar. 7	125 (ppm)	110 (ppm)
8	115	107

7) Views on Foul Odor and Appearance

The aeration tank was constantly foaming and particularly during the period of February 18 to 23, when operation was carried out at 0.4 kg-BOD/m^3/day, small quantities of antifoaming agent were introduced most intensely. This is because the effluent itself was prone to foam and also it foamed most actively when the raw water resided in the raw water tank for 4 to 5 days and became old. It is presumed that this foaming can be prevented by sprinkling a small quantity of foam breaking water or antifoaming agent.

With regard to the problem of odor, there was a smell of fish meat and ammonia over the entire facility. As the aeration tank was covered with panels, there was relatively little smell from it, but the open settling basin is a problem. It should be covered with panels or some such lid. Putting a lid on the basin would not only prevent the foul odor from escaping but would also act to prevent the effluent from coming in direct contact with the outside air.

8. Comments

1) Interrelationship between $COD_{(Mn)}$ and BOD, $COD_{(Cr)}$, T-N (Refer to attached Figures 8 - 9)
Empirical formulas of BOD = 3.6 $COD_{(Mn)}$, COD(Cr) = 4.1 $CD_{(Mn)}$, and T-N = 0.4 $COD_{(Mn)}$ + 60 were obtained.

When BOD was at a low load (0.2 kg-BOD/m^3/day), treated water slipped above the straight line. This is believed to be due to $COD_{(Mn)}$ stabilizing at 90 - 100 ppm because decomposition resistant substances and reduction inorganic matter remain when treatment progresses and the BOD value becomes a low 40 to 50 ppm. Also, treated water slipped below the straight line when the $COD_{(Cr)}$ and BOD values were reversed. This is believed to be due to the BOD value becoming high because of nitrification of NH_4^+. It can be seen that the relationship of $COD_{(Cr)}$ to $COD_{(Mn)}$ is that both raw water and treated water tend to follow more or less a straight line. The empirical formula of T-N to $COD_{(Mn)}$ can be applied in the case of raw water but not to treated water. This is because organic matter is decomposed and the balance of carbon and nitrogen is upset.

2) Water Temperature of Aeration Tank
During the test period, this was maintained at 2 to 5℃, and at the low load of 0.2 kg-BOD/m^3/day, a water quality was obtained of $COD_{(Mn)}$ 90 to 100 ppm (removal rate 75 to 86%), and BOD 40 to 50 ppm (removal rate 96 to 98%). The results showed that water temperature did not have much effect on the treatment.

Also, there was an active growth of sludge, and there was no excessive interference with the growth due to low temperatures. However, the settlement property of the sludge became poorer. This is believed to be caused by excessive aeration due to the low BOD space loading rather than by thread-like bacteria.

3) Change in Form of Nitrogen (Refer to 7-(6))
Generally the nitrogen in organic matter is decomposed by microorganisms into aminoacids and then into NH_4^+. This is decomposed into NO_2^- and NO_3^- by nitrifying bacteria. If these were made anaerobic, denitrifying would take place and they would be discharged outside the system as N_2 gas. These tests revealed that practically all the T-N in the treated water was NH_4^+ and had not been oxidized into NO_2^- and NO_3^-.

4) The raw water resided in the raw water storage tank for five to six days during which time SS settled and collected on the bottom of the tank. There were cases where the SS was sucked up at which time the color of the effluent was a dark grey and COD and BOD were two to three times the normal levels. However, there was no deterioration of the treated water because of this, but as SS had collected at the bottom inlet when the tank was emptied of water after the tests were finished, removal of SS as a primary treatment should be performed when the activated sludge process is to be carried out.

5) There was severe foaming of the aeration tank particularly when the raw water became old (after residing in the raw water storage tank for four to five days).
There is also the foul odor that envelopes the entire facility and other problems.

6) Effect of Salt Water on Microorganisms
Experiments could not be performed this time, but from past experience the problem is the shock caused by subjecting the effluent to a sudden change in salt concentration rather than the salt concentration itself. Thus treatment is possible if adequate acclimatization is carried out.

9. Construction of an Actual Plant (as of March 1974)

1) Building Standards (primary treatment is not included)

i) Water Quality

	Raw Water quality (Aeration Tank Inlet)	Treated Water Quality (Daily Average)
pH	6.5 - 7.6	7.5 - 7.9
$COD_{(Mn)}$	500 ppm	120 ppm max.
BOD	2,000 ppm	120 ppm max.
SS	100 ppm	30 ppm max.

ii) BOD Space loading

BOD space loading: 0.4 kg-BOD/m^3/day

BOD sludge load: 0.05 kg-BOD/kg-sludge/day

iii) Aeration Tank

Air Requirement: 1 m^3/tank · m^3/hr

Residence Time: 5 days

Return Sludge: 100% 6,000 ppm

Aeration Tank MLSS: 4,000 ppm

iv) Settlement Tank

Residence Time: 6 hours

Water Surface Load: 10 m^3/m^2/day (not including foam breaking water)

(v) Surplus Sludge Concentrating Tank

Surplus sludge generated shall be 30% of inflow BOD.

Concentrating Time: About 3 days

Concentrated Sludge Density: 1.5%

vi) Raw Water Tank

Raw water tank shall not be considered other than the quantity to be activated sludge-treated.

2) Specifications of Equipment

Water Volume / Equipment Capacity	1,000 m³/day (125 m³/hr x 8 hr)	3,000 m³/day (375 m³/hr x 8 hr)	6,000 m³/day (750 m³/hr x 8 hr)
Raw Water Tank	150 m³ W L H 5 m x 10 m x 3 m	400 m³ W L H 8 m x 16 m x 3 m	800 m³ W L H 16 m x 16 m x 3 m
Aeration Tank	5,000 m³ W L H 25 m x 50 m x 4 m W L H (5 m x 25 m x 4 m 10 systems)	15,000 m³ W L H 75 m x 50 m x 4 m W L H (5 m x 25 m x 4 m 30 systems)	30,000 m³ W L H 100 m x 75 m x 4 m W L H (5 m x 25 m x 4 m 60 systems)
Settlement Tank	260 m³ φ H 11 m x 3.85 m	770 m³ φ H 19 m x 4.45 m	1,600 m³ φ H 28 m x 5.6 m
Sludge Concentrating Tank	400 m³ □ H 10 m x 4 m	1,000 m³ □ H 16 m x 4 m	2,000 m³ □ H 22 m x 4 m
Treated Water Tank	40 m³ W L H 5 m x 3 m x 2.6 m	20 m³ W L H 5 m x 8 m x 3 m	240 m³ W L H 15 m x 24 m x 3 m
Separation Fluid Tank	5 m³ W L H 1.2 m x 2 m x 2 m	12 m³ W L H 2 m x 3 m x 2 m	10 m³ W L H 1 m x 3 m x 3.5 m

3) Specifications of Dehydrating Facility

	1,000m³/day	3,000m³/day	6,000m³/day
Quantity of superfluous sludge generated	570 kg - DS/day (=24 kg - DS/hr)	1,710 kg - DS/day (=72 kg - DS/hr)	3,420 kg - DS/day (14 3kg - DS/hr)
Quantity withdrawn from settling tank	4 m³/hr	12 m³/hr	24 m³/hr
Quantity withdrawn from concentrating tank	40 m³/day(600 kg - DS/day) (5 m³/hr x 8 hr)	120 m³/day(1,800 kg - DS/day) (5 m³/hr x 24 hr)	240 m³/day(3,600 kg - DS/day) (10 m³/hr x 24 hr)
Quantity of dehydrated cake (moisture content 85%)	4 ton/day $40 \times \frac{100 - 98.5}{100 - 85}$	12 ton/day $120 \times \frac{100 - 98.5}{100 - 85}$	24 ton/day $240 \times \frac{100 - 98.5}{100 - 85}$

4) Flow chart

As per attached Figure 11.

5) Construction Costs

	1,000 m³/day	3,000 m³/day	6,000 m³/day
Including Building	JPY 390 million	JPY 630 million	JPY 1,110 million
Excluding Building	JPY 320 million	JPY 530 million	JPY 940 million

6) Running Costs

i) Cost of Electricity: JPY 10/kWH

ii) Cost of Water: JPY 40/m³

iii) Cost of Transportation: Truck (4-ton) for transporting dehydrated cake

1000 m³/day Once/day JPY 7,000

3000 m³/day・6000 m³/day

Cost of leasing for whole day: JPY 20,000

iv) Cost of Chemicals

a) For settlement sludge: Assuming that 5 ppm of cation-based high molecular coagulant will be added to the slurry. (Final Settlement Tank)

b) For dehydration: Assuming that 150 ppm, 1.0%/DS of cation-based high molecular coagulant will be added to the slurry.

Cation-based high molecular coagulant is used dissolved to 0.1%: 3,000 yen/kg

	1,.000 m^3/day	3,000 m^3/day	6,000 m^3/day
Power Requirement	4,039.2 kWH/day	11,278.8 kWH/day	22,262.2 kWH/day
Cost	40,392 yen	112,788 yen	222,622 yen
Water Requirement	11 m^3/day	34 m^3/day	78 m^3/day
Cost	440 yen	1,360 yen	2,720 yen
Transportation Cost	7,000 yen	20,000 yen	20,000 yen
Cost of Chemicals	32,100 yen	99,300 yen	198,600 yen
Total	79,932 yen	233,447 yen	443,942 yen

7) Area Requirement

	1,000 m^3/day	3,000 m^3/day	6,000 m^3/day
Area	3,120 m^2	7,650 m^2	16,500 m^2

8) Operating Personnel

	1,000 m^3/day	3,000 m^3/day	6,000 m^3/day
No. of Persons	2	2	2

Table-1 Result of Water Quality Analysis

Date	Raw Water									Treated Water								
	pH (-)	BOD (ppm)	COD(Cr) (ppm)	COD(Mn) (ppm)	SS (ppm)	N - Hex (ppm)	T - N (ppm)	Transparency (degrees)	Temperature (℃)	pH (-)	BOD (ppm)	COD(Cr) (ppm)	COD(Mn) (ppm)	SS (ppm)	N - Hex (ppm)	T - N (ppm)	Transparency (degrees)	Temperature (℃)
1.16	6.9	-	-	1181	800	-	-	-	4.5	7.2	-	-	462	-	-	-	-	1.0
17	7.1	2075	-	628	95	-	-	-	5.0	7.5	1344	-	344	-	-	-	-	2.0
18	7.5	-	1937	573	-	-	-	3.5	5.0	7.5	-	1462	371	-	-	-	4.0	1.0
19	7.3	1543	-	461	-	-	-	-	4.8	7.5	1019	-	309	-	-	-	-	0
20	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
21	7.4	-	2142	517	-	-	250	-	4.0	7.7	-	1444	339	-	-	188	5.0	0
22	7.4	2173	-	513	-	100	-	-	4.0	7.6	1523	-	294	-	47	-	-	0
23	7.4	-	1643	451	107	-	-	-	4.0	7.6	-	919	291	45	-	-	6.0	-1.0
	7.7	-	-	492	-	-	-	-	-	7.8	-	-	316	-	-	-	-	-
24	7.6	1489	-	446	-	-	-	4.0	4.0	7.8	1062	-	295	-	-	-	6.0	0
	7.7	-	-	451	-	-	-	-	4.0	7.9	-	-	279	-	-	-	-	0
25	7.4	-	1673	389	-	-	199	-	4.0	7.8	-	843	240	-	-	163	-	0
26	7.2	-	-	426	-	-	-	-	4.0	7.6	-	-	255	-	-	-	6.0	0
27	7.0	-	-	436	-	-	-	5.0	4.0	7.5	953	-	251	-	-	-	7.0	-2.0
28	7.2	-	1671	425	77	130	-	-	4.0	7.7	-	899	244	50	107	-	-	-2.0
29	7.0	-	-	523	-	-	-	-	3.7	7.6	-	-	233	-	-	-	-	-2.0
30	7.3	-	2220	550	-	-	-	-	9.0	7.6	-	808	213	-	-	--	7.0	-2.0
31	7.2	-	1470	543	-	-	-	-	4.0	7.7	-	689	199	-	-	-	-	-2.0
	7.3	-	-	1079	-	-	-	-	-	7.7	-	-	184	-	-	-	-	-

Date	Raw Water pH (-)	BOD (ppm)	$COD_{(Cr)}$ (ppm)	$COD_{(Mn)}$ (ppm)	SS (ppm)	N - Hex (ppm)	T - N (ppm)	Transparency (degrees)	Temperature (℃)	Treated Water pH (-)	BOD (ppm)	$COD_{(Cr)}$ (ppm)	$COD_{(Mn)}$ (ppm)	SS (ppm)	N - Hex (ppm)	T - N (ppm)	Transparency (degrees)	Temperature (℃)
2.1	7.5	2380	2890	717	-	-	355	-	2.5	7.7	702	587	190	-	-	219	7.0	0
2	7.5	-	2040	549	-	-	-	-	4.5	7.7	-	732	192	-	-	-	6.5	1.0
3	7.4	1780	2100	457	45.0	-	-	-	4.0	7.7	695	690	157	40.0	-	-	7.0	-0.5
4	7.2	-	2080	602	-	16.0	-	-	4.5	7.6	-	623	169	-	10.0	-	7.0	1.0
5	7.2	1640	2110	606	80.0	-	-	-	4.5	7.6	671	715	187	30.0	-	-	7.5	0.5
6	7.2	-	1920	545	-	-	282	-	4.0	7.7	-	683	196	-	-	250	7.5	-0.5
7	7.2	2000	1920	566	91.7	-	-	-	4.0	7.6	854	626	202	53.3	-	-	7.0	-1.0
8	7.1	1730	2240	527	-	-	NH_4^+ 98.4 T - N 281	-	4.0	7.5	972	929	201	-	-	NH_4^+ 242 T - N 259	8.0	-1.0
9	6.6	-	2590	517	-	16.0	-	-	4.5	7.5	-	921	192	-	< 5.0	-	7.0	0
10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
11	6.6	2730	3010	650	450	-	-	-	4.0	7.5	1040	894	196	13.3	-	-	12.0	-0.5
12	6.5	2430	2500	547	-	-	-	-	4.0	7.7	896	850	197	-	-	-	9.0	-0.5
13	6.5	2600	2520	497	123	-	-	-	4.0	7.7	888	774	181	12.0	-	-	10.0	-0.5
14	6.8	2000	2120	483	-	-	-	-	4.0	7.7	874	727	178	-	-	-	11.0	-1.0
15	6.9	1940	2150	531	-	-	287	-	4.5	7.7	808	709	174	-	-	266	12.0	-1.0
16	6.9	1970	2300	532	250	-	-	-	4.8	7.7	726	675	163	16.0	-	-	12.0	-0.5
17	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
18	6.5	2410	2690	525	-	-	-	-	4.8	7.7	480	511	138	-	-	-	17.0	-0.5
19	6.7	1440	1870	448	-	-	-	-	3.0	7.6	352	392	121	-	-	-	10.0	-1.0
20	6.9	1790	1860	493	-	20.0	-	-	4.2	7.8	318	349	94.5	-	< 5.0	-	12.0	0.5

Date	Raw Water pH (-)	BOD (ppm)	COD(Cr) (ppm)	COD(Mn) (ppm)	SS (ppm)	N - Hex (ppm)	T - N (ppm)	Transparency (degrees)	Temperature (℃)	Treated Water pH (-)	BOD (ppm)	$COD_{(Cr)}$ (ppm)	$COD_{(Mn)}$ (ppm)	SS (ppm)	N - Hex (ppm)	T - N (ppm)	Transparency (degrees)	Temperature (℃)
21	7.4	1760	2400	626	-	-	-	-	4.2	7.7	322	289	92.9	-	-	-	13.5	0.5
22	7.0	2620	2570	594	300	-	-	-	4.2	7.7	385	329	97.8	24.0	-	-	10.5	1.0
23	7.1	-	3190	774	-	-	-	<5	4.0	7.8	-	341	91.8	-	-	-	8.0	1.0
24	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
25	6.9	2250	2470	639	600	-	NH_4^+ 89.0 T - N 317	<5	4.2	7.6	177	278	90.4	30.0	-	NH_4^+ 245 T - N 247	8.0	1.0
26	7.2	3800	7480	1350	-	200	-	<5	5.2	7.8	60	284	87.8	-	18	-	9.0	1.8
27	7.5	-	1690	487	160	-	-	5	3.8	7.8	-	254	99.2	35	-	-	9.0	1.8
28	7.6	1630	1840	486	-	-	T - N 250 NH_4^+ 63	5	4.2	7.8	50	242	99.6	-	-	T - N 255 NH_4^+ 253	11.0	1.8
3/1	7.6	1700	1670	478	70	67	-	7	4.2	7.7	58	264	99.8	15	58	-	11.0	-1.0
2	7.4	1600	1920	447	-	-	-	5	4.0	7.7	94	234	90.4	-	-	-	13.0	1.0
3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
4	7.4	1160	1850	371	83	33	T - N 228 NH_4^+ 86.9	5	4.0	7.9	-	229	89.0	10	66	T - N 244 NH_4^+ 243	15.0	1.5
5	7.6	-	1830	433	-	-	-	6	4.0	7.9	-	224	83.7	-	-	-	18.0	1.8
6	7.1	1670	1740	414	60	-	-	5	4.0	7.6	42	223	88.1	30	-	-	17.0	1.2
7	7.1	1510	2190	451	-	-	T - N 240 NH_4^+ 134 NO_3^- 0.8 NO_2^- 0.1	-	4.0	7.7	36	231	85.7	-	-	T - N 232 NH_4^+ 224 NO_3^- trace NO_2^- 0.1	19.0	2.0
8	7.0	-	-	471	-	-	NO_3^- 0.8	-	3.8	7.7	-	-	88.1	-	-	NO_3^- trace NO_2^- 0.04	20.0	1.8

Phosphoric Acid Ion	Raw Water	Treated Water
3/7	125 ppm	110 ppm
3/8	115 ppm	107 ppm

Table 2 Equipment Operating Results (Aeration Tank)

Month/ Date	Sampling Time	Atm. Temp. (℃)	Aeration Tank Water Temp. (℃)	Flow Rate (m^3/day)	D.T (hrs)	Space loading (kg-BOD/m^3/day)	SV (-)	MLSS (ppm)	MLVSS (ppm)	VSS/MLSS (%)	SVI (cm^3/g)	Remarks
1/6	10:00	-	1.0	4.6	89		10	1140	960	84	87.7	Return Sludge 1.2 m^3/hr x 8 hr Seeding Sludge 3.3 m^3 put in
17	10:00	-	2.0	"	"		12	1580	1300	82	75.9	
18	13:30	-	2.0	"	"		20	1940	1460	75	103.7	Seeding Sludge 3.9 m^3 put in
19	10:30	-	2.0	5.2	78.5	0.6	20	1920	1380	72	104.2	Rate of settlement 1.64 m/hr
20	-	-	-	"	"	"	–	–	–	–	–	
21	10:00	-7.0	2.0	"	"	"	23	2220	1720	78	103.6	
22	10:30	-4.0	1.8	"	"	"	24	2380	1840	77	100.8	Return Sludge reduced 0.9 m^3/hr x 8 hr
23	9:30	-5.0	2.0	"	"	"	25	2320	1820	78	107.8	Return Sludge SV 95
24	10:30	-9.5	2.2	7.2	56.7	0.8	30	2260	1760	78	132.7	MLSS 6460 VSS 5000
25	10:00	-3.0	2.2	"	"	"	32	2420	1920	79	132.2	Rate of settlement 1.20 m/hr
26	9:30	-6.0	1.0	"	"	"	35	2560	-	-	136.7	
27	10:00	-5.5	2.0	"	"	"	41	2640	2040	77	155.3	Rate of settlement 0.77 m/hr
28	9:45	-6.8	2.2	"	"	"	39	2720	2160	79	143.4	Microscopic examination started
29	10:30	-4.0	2.5	"	"	"	39.5	2600	2060	79	151.9	
30	9:30	-6.0	2.5	"	"	"	75	2760	2240	81	271.7	
31	9:00	-4.0	2.5	"	"	"	45	3000	2500	83	50	DO 0.7 ppm
2/1	9:30	-6.0	2.0	"	"	"	48	3000	2520	84	160	DO 0.8 ppm
2	9:00	-3.0	2.5	"	"	"	52	3060	2560	84	170	
3	9:15	-4.5	3.0	"	"	"	57	3540	2860	81	161	
4	9:15	-5.0	3.5	"	"	"	58	3400	2860	84	171	Return Sludge 6,740 ppm
5	9:00	-8.2	3.5	"	"	"	70	3620	3040	84	193	
6	9:00	-12.5	3.0	"	"	"	71	3680	3060	83	193	DO 0.8 ppm
7	9:00	-15.0	3.0	"	"	"	70	3660	3220	87	191	Rate of settlement 0.29 m/hr
8	9:00	-10.0	3.0	7.2	56.7	0.8	67	3920	3220	82	171	
9	9:00	-5.5	3.5	3.6	11.3	0.4	67	3920	3180	81	171	
10	-	-	-	"	"	"	-	-	-	-	-	
11	10:00	-7.5	3.0	"	"	"	64	4200	3440	82	152	
12	9:00	-11.0	3.0	"	"	"	67	4060	3320	82	165	Return Sludge 7,560 ppm
13	9:15	-7.5	3.2	"	"	"	65	4300	3500	81	159	DO 2.5 ppm
14	9:00	-7.2	3.0	"	"	"	64	4220	3420	81	152	
15	9:15	-8.5	3.5	"	"	"	64	3880	3260	84	165	
16	9:15	-3.0	4.0	"	"	"	65	4160	3500	84	156	Rate of settlement 0.30 m/hr
17	-	-	-	"	"	"	-	-	-	-	-	
18	9:15	-3.2	4.5	"	"	"	88	4080	3400	83	216	↑ Aeration Tank foaming

Month/ Date	Sampling Time	Atm. Temp. (℃)	Aeration Tank Water Temp. (℃)	Flow Rate (m^3/day)	D.T (hrs)	Space loading (kg-BOD/m^3/day)	SV (-)	MLSS (ppm)	MLVSS (ppm)	VSS/MLSS (%)	SVI (cm^3/g)	Remarks
19	9:15	-12.2	4.0	3.6	113	0.4	93	4060	3360	83	229	Antifoaming Agent put in
20	9:15	0.8	4.8	"	"	"	92	4260	3580	84	216	
21	9:30	6.5	4.8	4.2	97.1	"	94	4300	3660	85	219	DO 3.2 ppm Return Sludge 6,760 ppm
22	9:30	5.5	4.5	"	"	"	96	4580	3620	83	219	
23	9:30	-7.2	4.5	"	"	"	90	4480	3760	84	201	DO 3.3 ppm
24	-	-	-	"	"	"	-	-	-	-	-	
25	9:30	-4.2	4.8	1.7	240	0.2	97	4640	3940	85	209	Foaming subsides a little
26	"	-5.2	4.8	"	"	"	97	4700	4020	86	206	DO 7.0 ppm
27	"	-5.0	4.2	"	"	"	98	4500	3840	84	215	Air volume reduced
28	"	-5.5	4.0	2.4	170	"	98	4480	3540	85	234	Return Sludge 5,360 ppm
3/1	"	-6.2	3.8	2.2	186	"	97	4400	3700	84	221	Air volume reduced DO 7.8 ppm
2	"	-2.8	3.8	1.7	240	"	97	4320	3600	83	225	
3	"	-6.1	-	1.7	240	"	-	-	-	-	-	
4	"	2.5	3.2	2.3	177	"	98	4220	3420	81	232	Rate of settlement 0.6 m/hr
5	"	-2.2	3.2	1.7	240	"	98	4280	3560	83	229	Return Sludge 5,840 ppm
6	"	-1.5	3.2	1.6	255	"	98	4540	3740	82	216	
7	"	-1.0	3.2	1.7	240	"	98	4380	3600	82	224	Microscopic examination finished
8	"	-4.0	3.2	2.2	186	"	98.5	-	-	-	-	

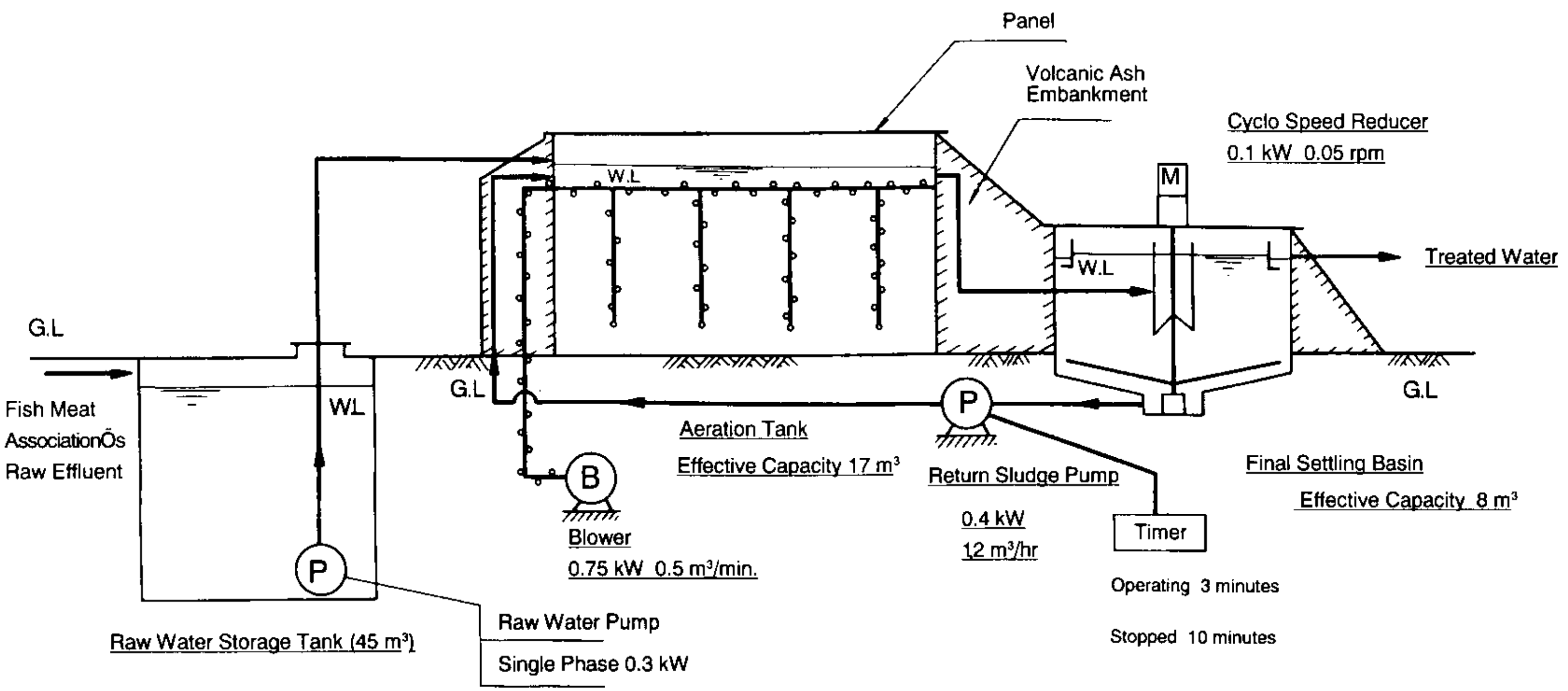


Figure 1 Outline and Flow Chart of Facility

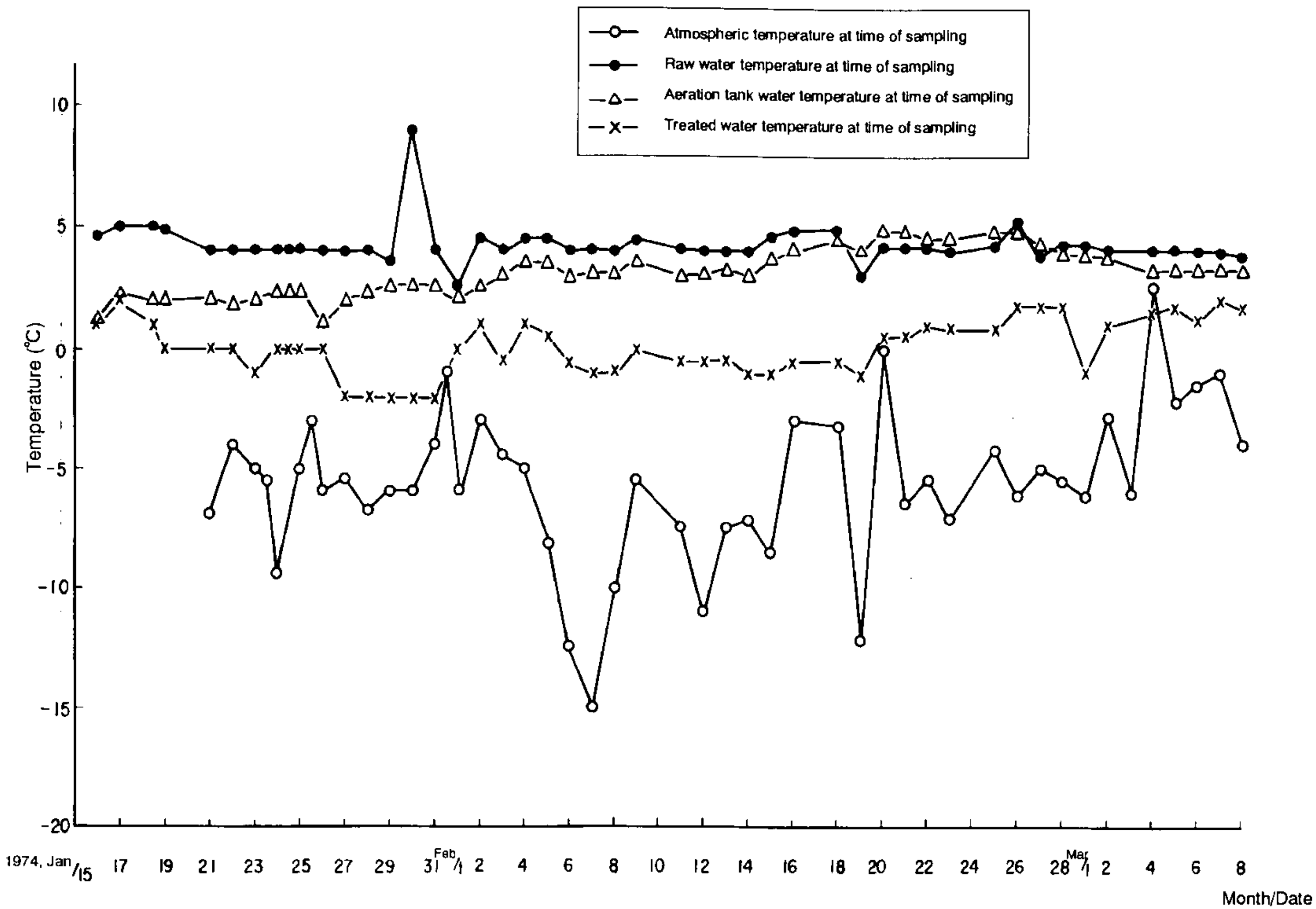


Figure 2 Daily Changes in Atmospheric and Water Temperatures at Time of Sampling

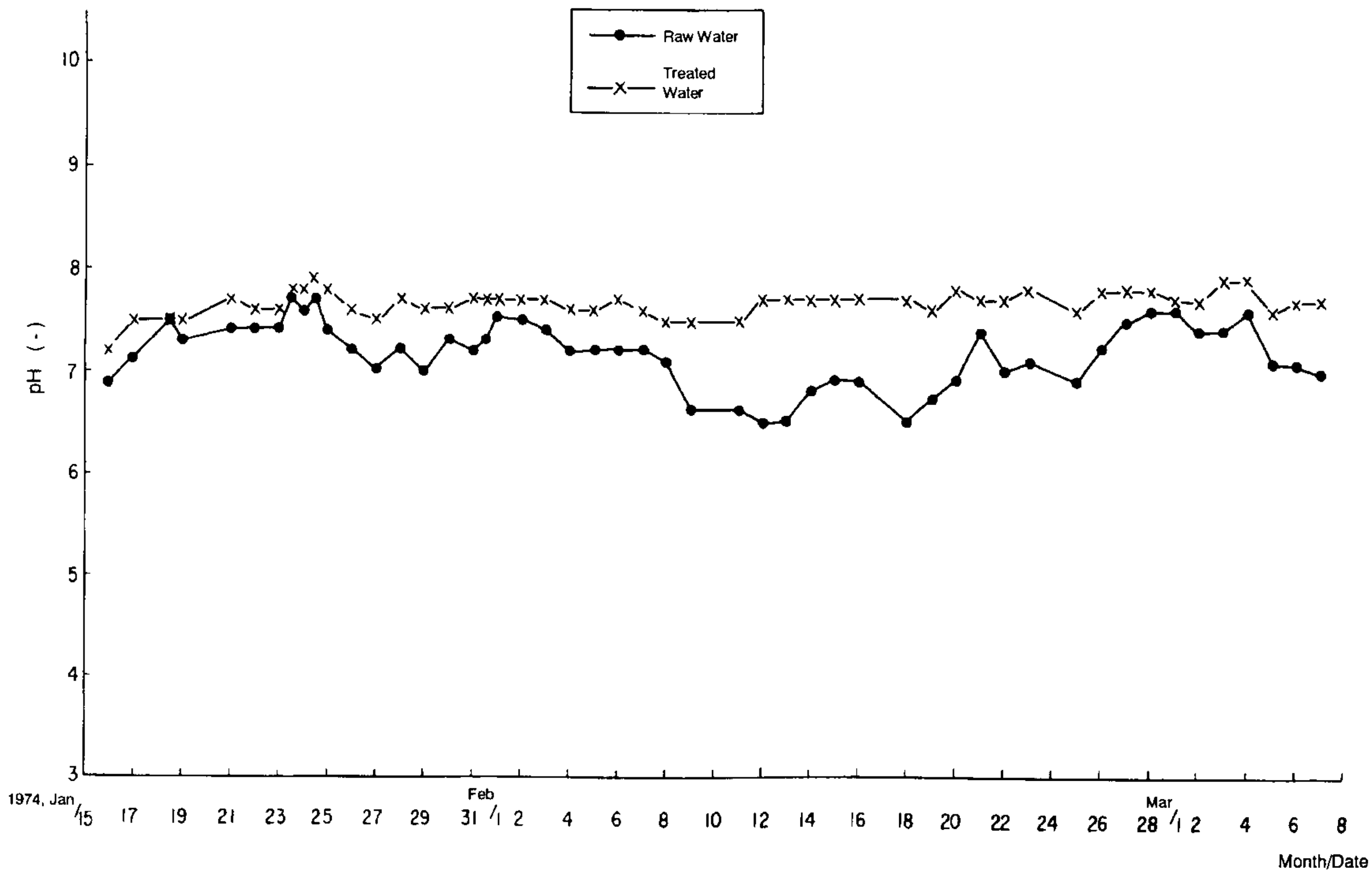
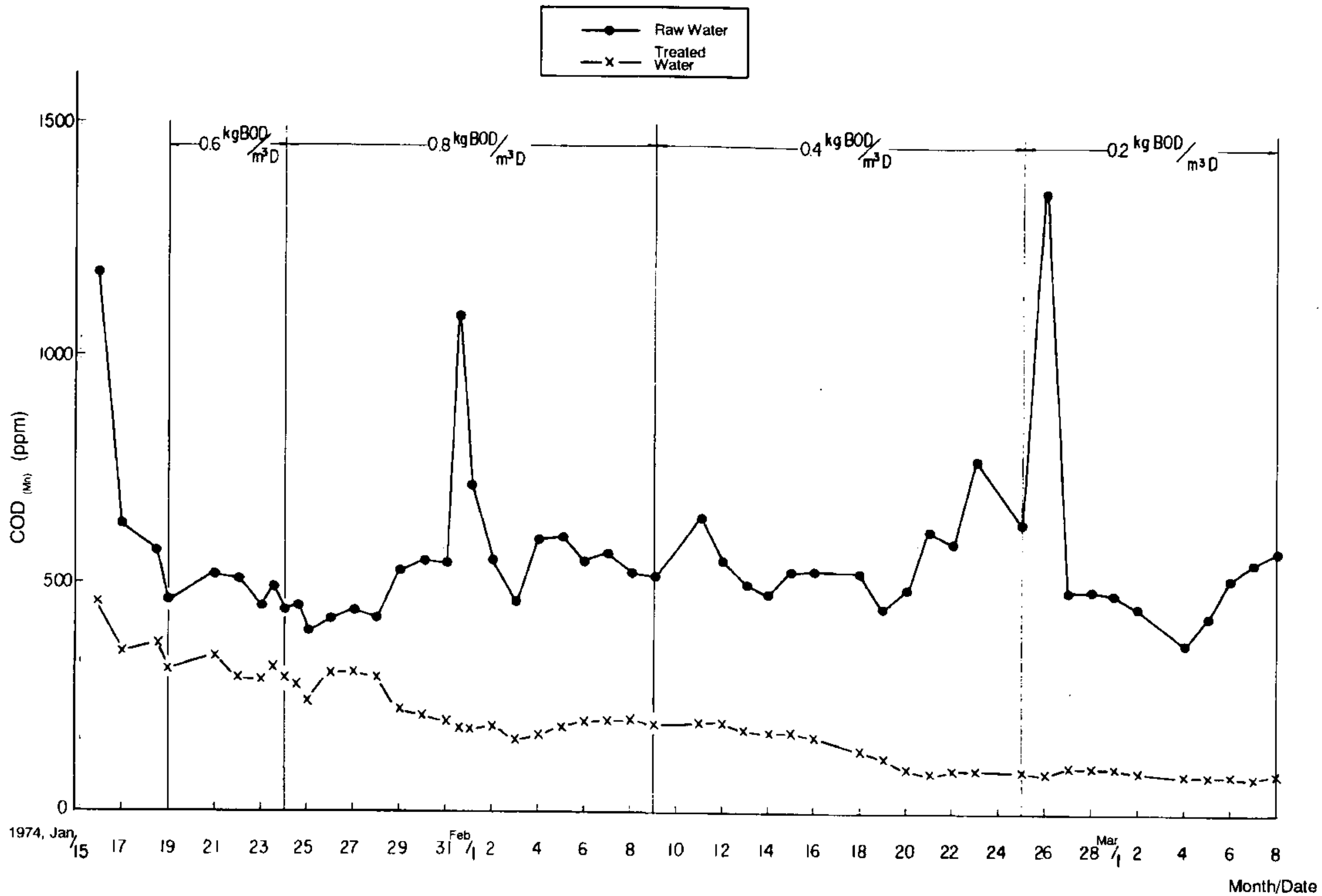


Figure 3 Daily Changes in pH


Raw Water
Treated Water
0.6 kgBOD/m³D
0.8 kgBOD/m³D
0.4 kgBOD/m³D
0.2 kgBOD/m³D
1500
1000
500
0
COD (Mn) (ppm)
1974, Jan/15
17
19
21
23
25
27
29
31
Feb/1
2
4
6
8
10
12
14
16
18
20
22
24
26
28
Mar/1
2
4
6
8
Month/Date

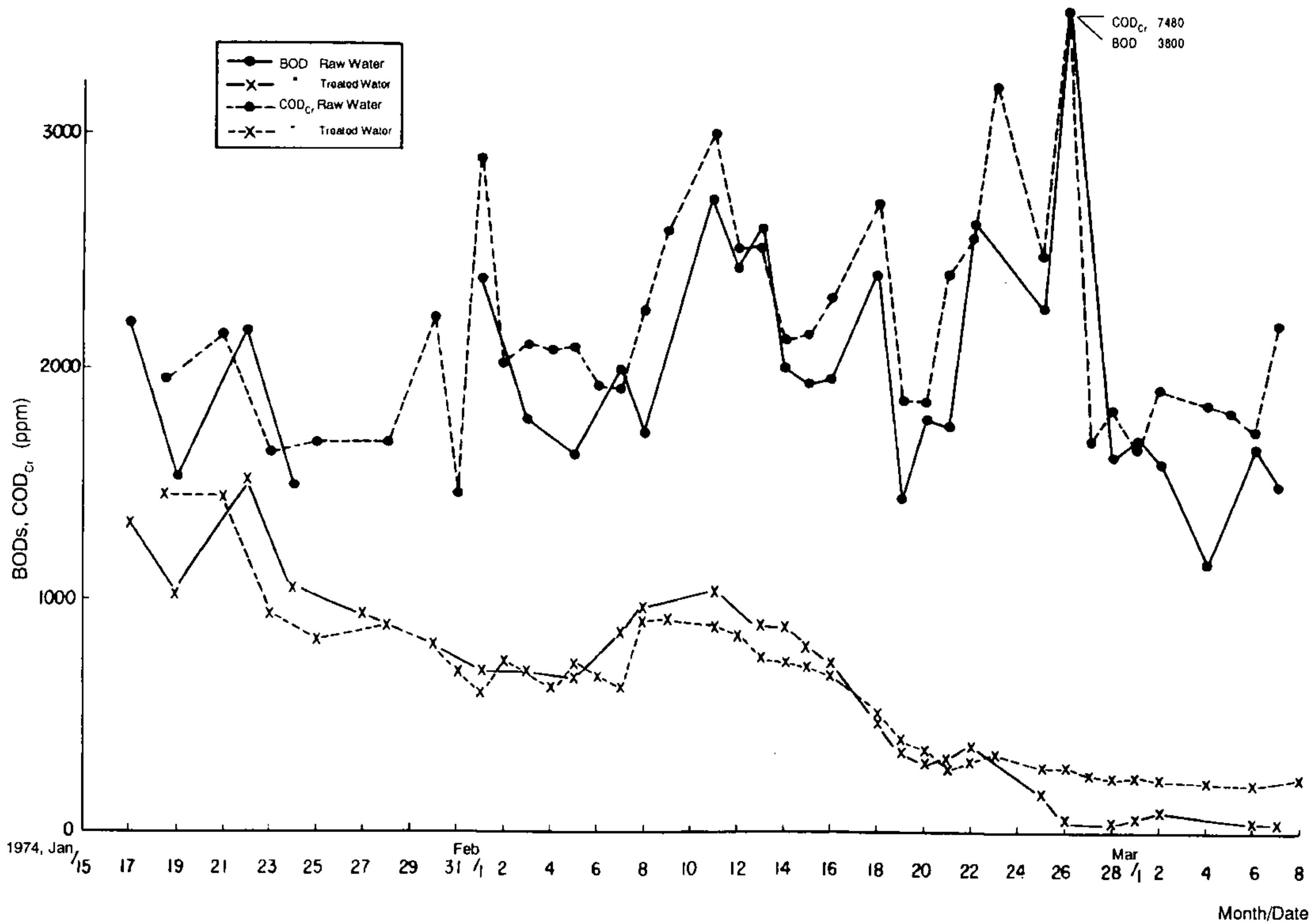


Figure 5 Daily Changes in BOD and COD_{Cr}

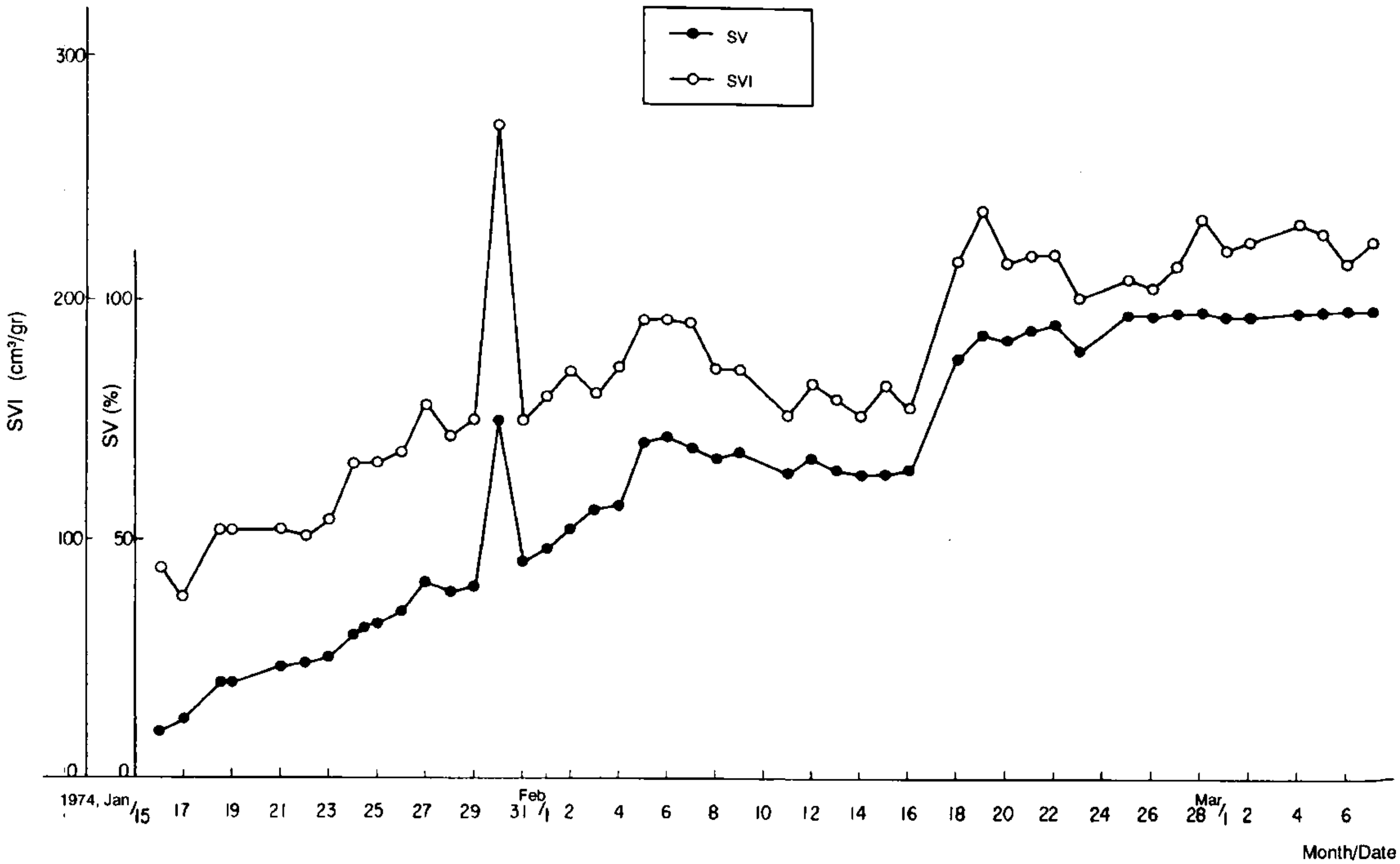


Figure 6 Daily Changes in SV and SVI

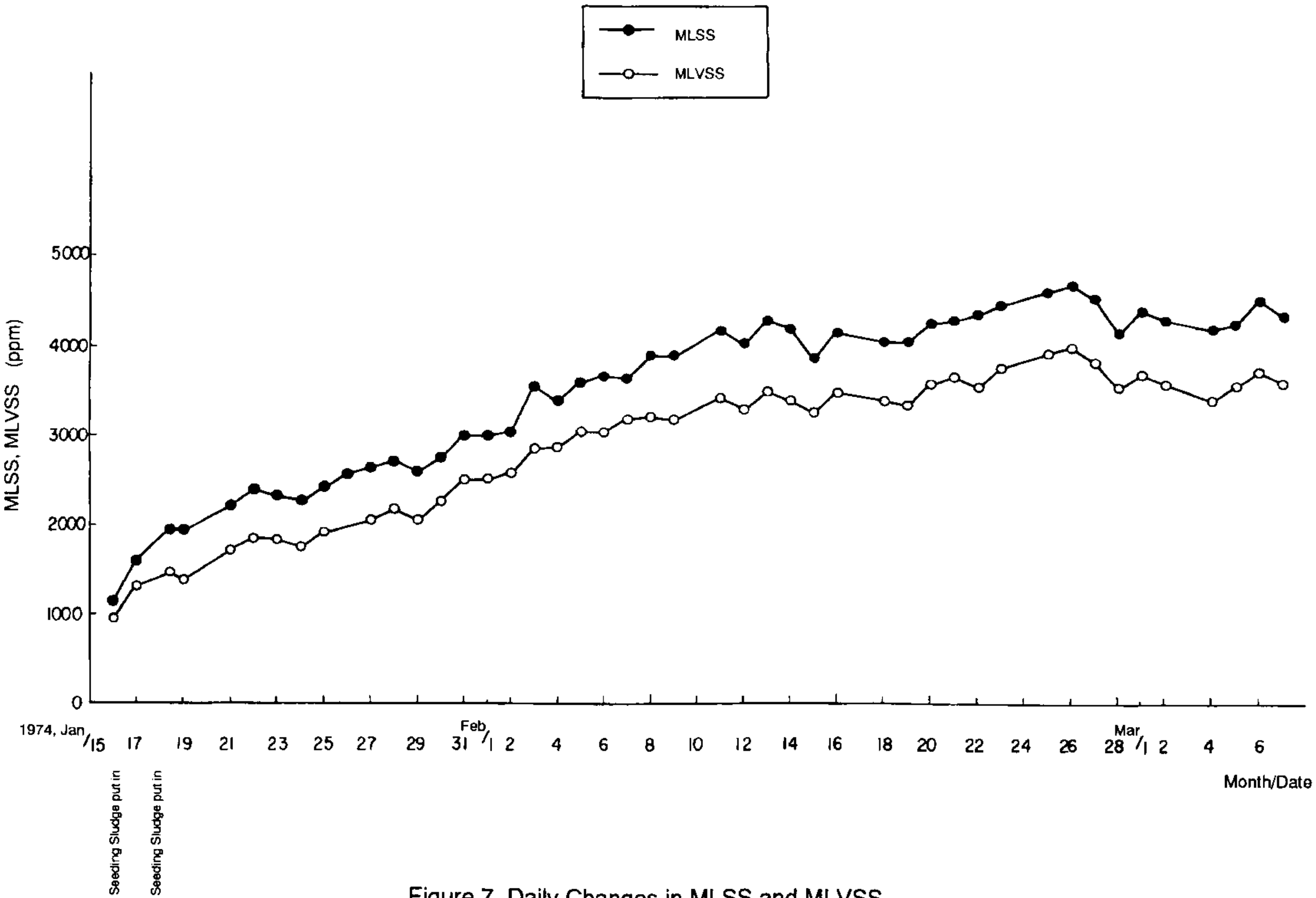
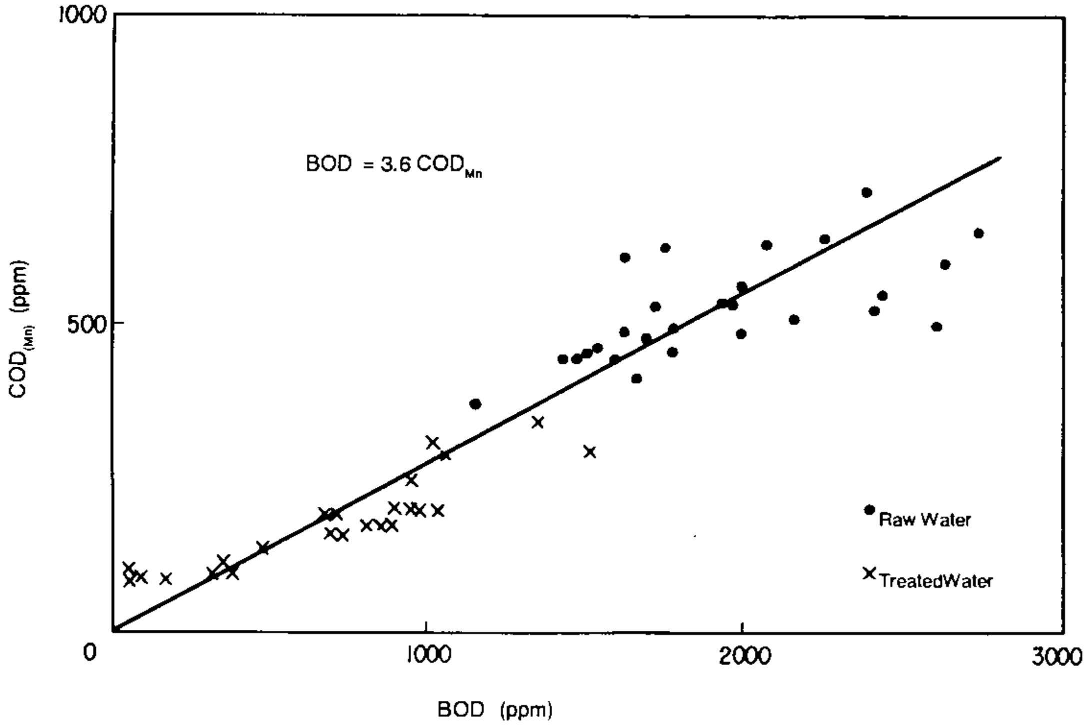


Figure 7 Daily Changes in MLSS and MLVSS



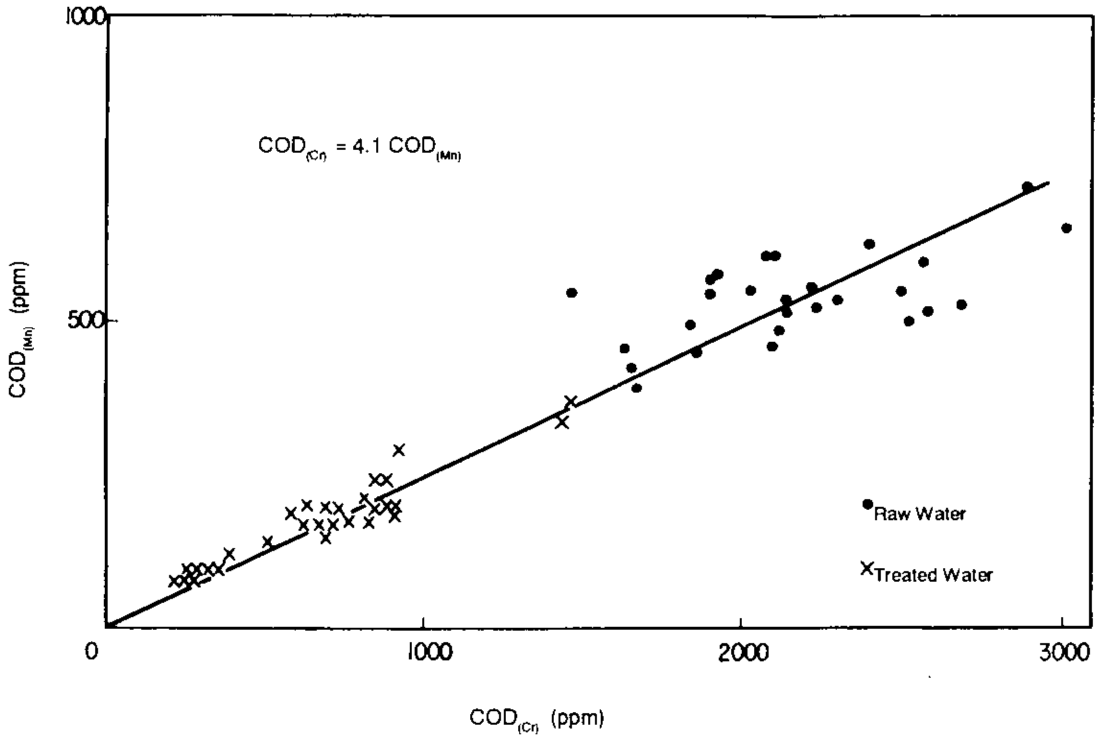


Figure 8 Relationship of $COD_{(Mn)}$ to BOD and $COD_{(Cr)}$

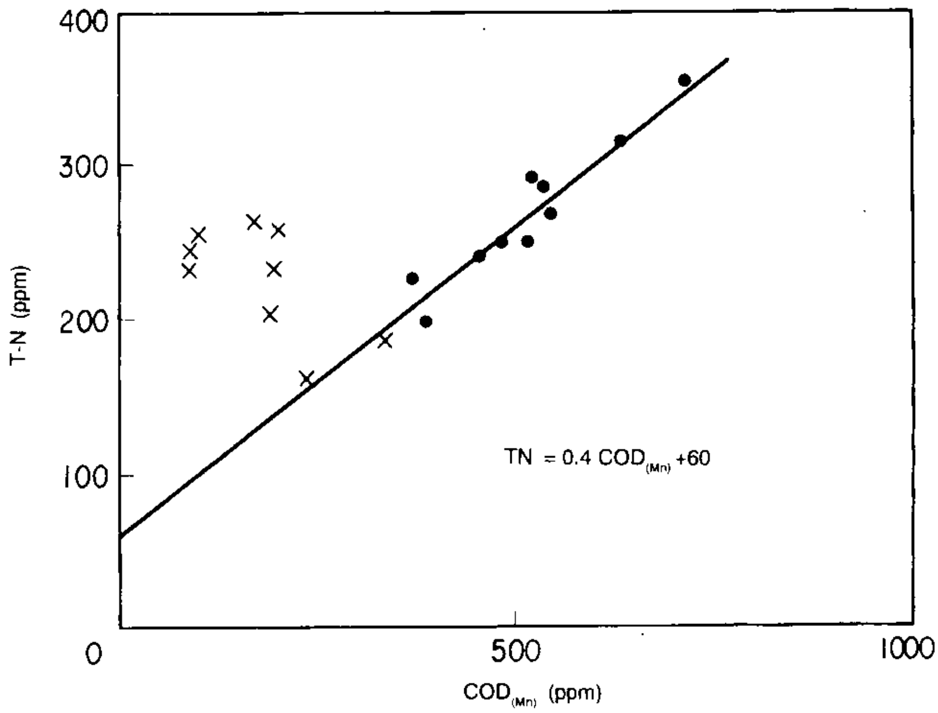


Figure 9 Relationship of $COD_{(Mn)}$ and T-N

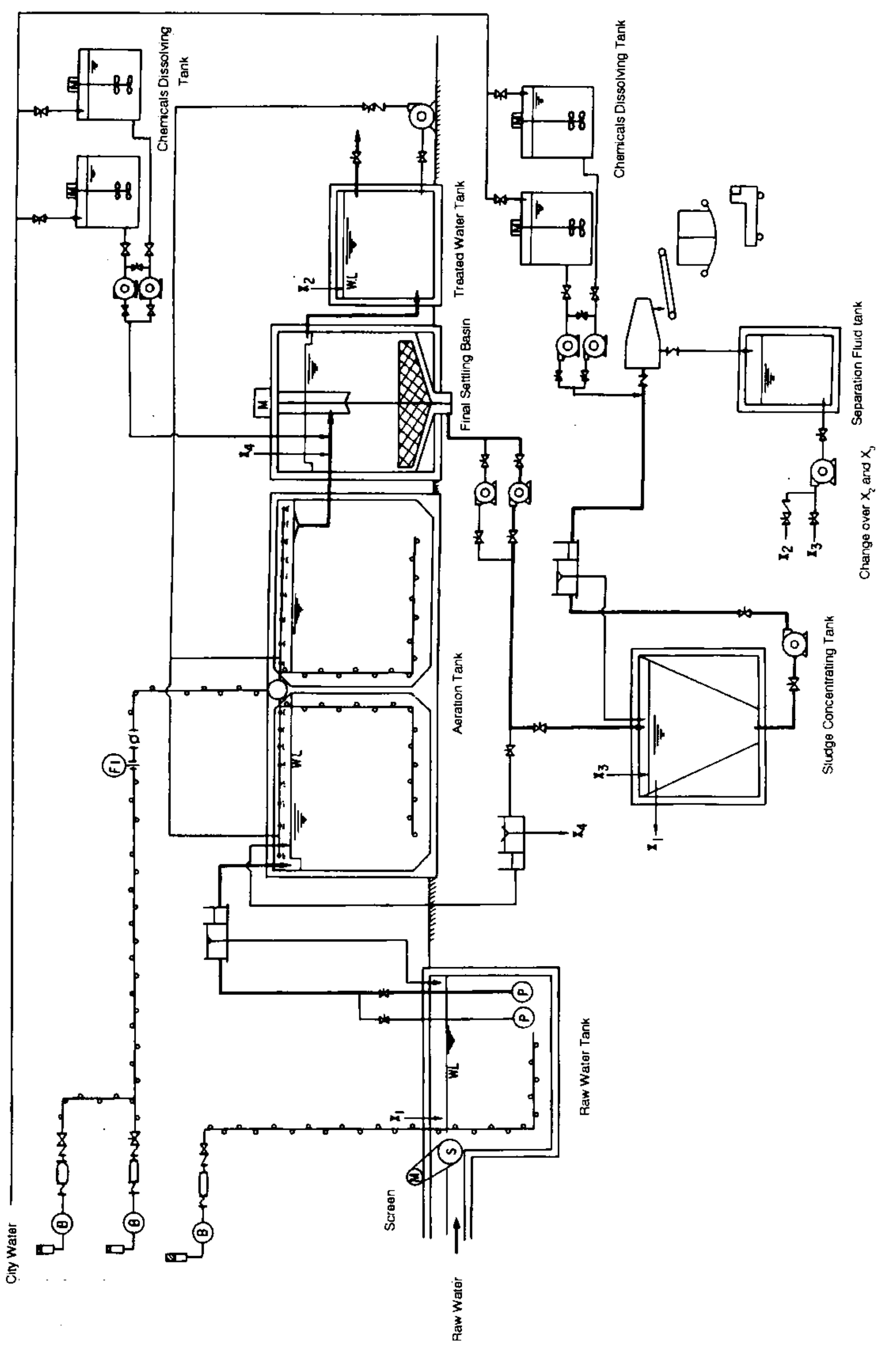


Figure 11 Flow Chart

C. Electric Coagulation Process

This research was conducted thanks to the cooperation of the National Frozen Fish Meat Association's Technical Research Laboratory. Some of the analysis was done by Morinaga Dairy Products Co., Ltd.

1. Outline of Research

As a method of treating marine product processing effluent in cold regions, physicochemical treatment tests, in parallel with biological treatment tests, were conducted to determine the effectiveness of the treatment. The tests were done under the following conditions, using waste water from the frozen ground fish meat process as the test effluent.

2. Outline of Research Facilities

Electric coagulation purifying facility (100 m^3/day) N.E.P. type

See attached figure.

3. Treatment Method

1) Preliminary Tests
Electric current, electrolysis time, and pH adjustment conditions were set for purifying effluent by the electrolytic process.

2) Electric Coagulation Treatment Tests with Actual Facility
Tests in accordance with the results of the preliminary tests were conducted with the NEP 10 Type (100 m^3/day) electrolytic facility installed at the National Frozen Fish Meat Association's Technical Research Laboratory.

4. Test Effluent

The same effluent as previously mentioned in A-4 was used.

5. Results of Research

1) Preliminary Tests (Refer to attached Table 1)

i) Pole Plates

a) Kind of pole plates: (+) aluminum (-) iron

b) Pole plates: (+) 4 plates (-) 5 plates Pole plate area 700 cm^2

c) Current density: 1.4 mA/cm^2 to 10 mA/cm^2

ii) Test Details

a) Electric current 1, 3, 5, 7 A
b) Electrolysis time 3, 5, 7, 9 minutes
c) PH adjustment 5.0, 4.5, 4.0
d) Electrolysis accelerating agent 1000 ppm (NaCl 0.1%)
e) Coagulant 15 ppm
f) Raw water 850 cc

Effectiveness of treatment was determined by various combinations of the above electric current, electrolysis time, and pH adjustment. The quantities of electrolysis accelerating agent and coagulant were kept the same. Upon completion of electrolysis, the treated water, after removing the froth floating on top, was used as the analysis sample.

iii) Results
As per attached Table 1, current density of 7.2 mA/cm^2 to 10 mA/cm^2, pH of 4.0 to 4.5, and electrolysis time of 7 to 9 minutes are considered to be the stable treatment conditions.

2) Electric Coagulation Treatment Tests with Actual Facility

i) Electrolytic Bath
Batch type F.R.P. electrolytic bath
Volume 980 x 914 x 1900 = 1.7 m^3
Actual Capacity 1.5 m^3

ii) Pole Plates and Construction
Anodes Aluminum
Cathodes Iron, No. of Pole Plates +80, - 80
Distance between pole plates 10 mm, tank agitator

iii) Electric voltage and current (DC) 40V to 100V - 100A to 700A
iv) Current density 1.4 mA/cm^2 to 10 mA/cm^2
v) Electrolysis time 5 to 7 minutes
vi) PH adjustment range 4.0 to 4.5
vii) Electrolysis accelerating agent NaCl concentration 0.11% of raw water
viii) Coagulant 15 ppm of electrolytically treated water
ix) Results

(1) With a current density range of 7.2 mA/cm^2 to 10 mA/cm^2, COD removal rate of 79 to 83% was obtained but there were large variations of 42 to 81% in the BOD removal rate. SS and N-Hex extracts and T-N are shown in the attached table.

2) Analysis of Water Treated by Electric Coagulation Process

a) Shown in Table 2.

b) BOD and COD removal rates were good compared to pressure flotation treated water

c) When pressure flotation treated water is subjected to electric coagulation treatment, the resultant treated water is close to electric coagulation treated water.

d) Electric coagulation treated water has an extremely low phosphorus acid ion content.

(Analysis by Morinaga Dairy Products Co., Ltd.)

	PO_4^{3-}	
	Raw Water	Treated Water
Mar. 16	396.4 ppm	4.0 (ppm)
Mar. 17	231.7	2.1
Mar. 19	323.2	1.4

Table 1 Preliminary Test Results

1) Test Current 1A, Current Density 1.4 mA/cm^2

Raw Water COD 927 ppm

Current	Voltage	Electrolysis Time (minutes)	Water Temperature℃		pH		ppm COD $_{(Mn)}$	Removal Rate (%)
			Before Treatment	After Treatment	Before Treatment	After Treatment		
1A	2.5V	3	6.0	7.0	7.2	8.69	395	57.3
"	"	5	"	8.5	"	8.30	371	60.0
"	"	7	"	9.0	"	8.70	286	69.1
"	"	9	"	10.5	"	9.05	277	70.1
1A	2.0 V	3	9.0	10.0	5.0	5.85	251	72.9
"	"	5	"	10.3	"	6.25	233	74.9
"	"	7	"	10.8	"	6.70	208	77.6
"	"	9	"	11.5	"	6.90	200	78.4
1A	1.5 V	3	9.0	9.5	4.5	5.60	268	76.1
"	"	5	"	10.0	"	5.80	230	75.2
"	"	7	"	10.3	"	6.25	215	76.8
"	"	9	"	11.1	"	6.50	190	79.5
1A	1.2 V	3	10.0	10.5	4.0	4.80	312	66.3
"	"	5	"	11.0	"	5.20	206	77.8
"	"	7	"	11.7	"	5.57	176	81.0
"	"	9	"	12.2	"	5.60	195	79.0

2) Test Current 3A, Current Density 4.3 mA/cm^2

Raw Water COD 927 ppm

Current	Voltage	Electrolysis Time (minutes)	Water Temperature℃		pH		ppm COD (Mn)	Removal Rate (%)
			Before Treatment	After Treatment	Before Treatment	After Treatment		
3A	3.2 V	3	8.0	9.0	7.20	9.20	429	53.7
"	"	5	"	11.0	"	9.20	352	62.0
"	"	7	"	12.0	"	9.50	236	74.5
"	"	9	"	13.0	"	9.50	174	81.2
3A	3.0 V	3	8.5	9.0	5.0	8.00	385	58.5
"	"	5	"	10	"	7.95	308	66.8
"	"	7	"	11.0	"	8.20	270	70.9
"	"	9	"	14.0	"	8.00	227	75.5
3A	2.8 V	3	9.0	11.5	4.5	7.10	269	71.0
"	"	5	"	14.5	"	6.70	195	79.0
"	"	7	"	15.0	"	7.35	194	79.1
"	"	9	"	18.5	"	7.20	201	78.3
3 A	2.5 V	3	12.0	14.0	4.0	5.60	314	66.1
"	"	5	"	14.5	"	6.10	202	78.2
"	"	7	"	19.0	"	6.60	175	81.1
"	"	9	"	20.5	"	7.06	187	79.8

3) Test Current 5A, Current Density 7.2 mA/cm^2

Raw Water COD 927 ppm

Current	Voltage	Electrolysis Time (minutes)	Water Temperature℃		pH		ppm COD $_{(Mn)}$	Removal Rate (%)
			Before Treatment	After Treatment	Before Treatment	After Treatment		
5 A	4.5 V	3	11.0	12.5	7.20	9.75	247	73.4
"	"	5	"	14.0	"	9.15	222	76.1
"	"	7	"	17.0	"	9.28	202	78.2
"	"	9	"	19.0	"	8.60	222	76.1
5 A	3.8 V	3	13.0	15.0	5.0	7.20	294	68.3
"	"	5	"	16.0	"	7.42	197	78.7
"	"	7	"	19.0	"	8.00	154	83.4
"	"	9	"	21.0	"	6.00	161	82.6
5 A	3.5 V	3	15.0	19.0	4.5	6.50	213	77.0
"	"	5	"	20.0	"	6.60	182	80.4
"	"	7	"	21.5	"	7.30	159	82.8
"	"	9	"	23.0	"	8.20	160	82.7
5 A	3.5 V	3	14.0	16.0	4.0	6.95	194	79.1
"	"	5	"	17.5	"	6.20	170	81.7
"	"	7	"	21.0	"	6.10	146	84.3
"	"	9	"	22.0	"	6.30	162	82.5

4) Test Current 7A, Current Density 10 mA/cm^2

Raw Water COD 927 ppm

Current	Voltage	Electrolysis Time (minutes)	Water Temperature℃		pH		ppm $COD_{(Mn)}$	Removal Rate (%)
			Before Treatment	After Treatment	Before Treatment	After Treatment		
7 A	5.5 - 8.0 V	3	8.0	14.0	7.20	9.50	353	61.9
"	"	5	"	17.0	"	8.25	212	77.1
"	"	7	"	20.0	"	8.10	172	81.4
"	"	9	"	29.0	"	5.50	133	85.7
7 A	5.0 - 80 V	3	14.0	19.0	5.0	6.50	179	80.7
"	"	5	"	23.5	"	6.62	181	80.5
"	"	7	"	28.0	"	5.81	153	83.5
"	"	9	"	28.0	"	5.62	142	84.7
7 A	5.5 - 7.5 V	3	11.0	15.0	4.5	6.50	172	81.4
"	"	5	"	19.5	"	6.62	153	83.5
"	"	7	"	22.0	"	5.81	124	86.6
"	"	9	"	27.0	"	5.62	119	87.2
7 A	5.5 - 70 V	3	12.0	16.0	4.0	5.50	195	79.0
"	"	5	"	20.0	"	5.70	149	83.9
"	"	7	"	23.0	"	5.35	125	86.5
"	"	9	"	27.0	"	5.05	138	85.1

Table 2 Results of Electrolytic Treatment (1)

Month/ Day	Time	Water Temperature (℃)		pH		$COD_{(Mn)}$ ppm		Removal Rate (%)	BOD ppm		Removal Rate (%)	SS ppm		N-Hex Extracts (ppm)		T-N ppm		Electrolytic Conditions
		Raw Water	Treated Water	Raw Water	Treated Water	Raw Water	Treated Water		Raw Water	Treated Water		Raw Water	Treated Water	Raw Water	Treated Water	Raw Water	Treated Water	
3.9	9.30	-	-	7.00	7.10	783	164	79.1	1280	720	43.8	900	113	123	68	380	127	Current density 4.3 mA/cm²
"	10.30	-	-	7.30	6.62	1009	173	82.9	2922	671	77.0	800	140	-	-	396	136	" 7.2 mA/cm²
"	13.00	8.0	9.5	7.15	7.27	561	134	76.1	1565	613	60.8	650	75	-	-	242	86	" 4.3 mA/cm²
"	14.00	8.0	10.0	7.20	7.38	688	140	79.7	1752	618	64.7	550	30	400	60	306	110	" 7.2 mA/cm²
"	15.00	8.0	10.0	7.20	7.35	587	140	76.1	1092	635	41.8	650	45	-	-	335	118	" 4.3 mA/cm²
"	16.00	6.0	11.5	7.39	8.20	2175	410	81.1	6945	1316	81.1	2000	43	-	-	950	118	" 7.2 mA/cm²
"	17.00	-	-	-	-	352	-	-	-	-	-	-	-	-	-	-	-	
3.11	9.30	7.0	9.0	-	-	934	175	81.3	-	-	-	1067	67	-	-	-	-	Current density 10 mA/cm²
"	10.30	8.0	8.0	7.20	8.70	889	170	80.9	-	-	-	933	154	389	6	403	176	" 10 mA/cm²
"	11.30	7.0	9.5	7.40	8.35	819	217	73.5	-	-	-	1400	83	-	-	-	-	" 4.3 mA/cm²
"	13.00	9.0	-	7.12	6.90	785	115	85.4	-	-	-	-	-	-	-	-	-	" 10 mA/cm²
"	14.00	7.0	6.0	7.00	7.40	839	198	76.4	2225	942	57.6	667	40	62	4	400	171	" 7.2 mA/cm²
"	15.00	7.5	10.0	7.05	7.03	810	156	80.7	-	-	-	467	90	-	-	-	-	" 7.2 mA/cm²
"	16.00	9.0	9.0	7.10	-	1188	145	87.8	-	-	-	800	133	-	-	-	-	" 10 mA/cm²
3.12	14.00	7.0	9.0	7.20	-	805	166	79.4	2280	821	63.9	833	97	-	-	-	-	Current density 10 mA/cm²
3.13	14.00	7.5	6.0	7.38	8.54	887	178	79.9	-	-	-	750	27	145	24	398	174	Current density 7.2 mA/cm²
"	15.00	6.0	8.0	7.55	7.25	815	214	73.7	-	-	-	867	40	-	-	409	152	" 7.2 mA/cm²
3.14	10.00	4.5	8.0	7.42	7.92	723	114	84.2	-	-	-	933	-	-	-	-	-	Current density 10 mA/cm²
"	11.00	6.0	8.0	7.35	7.15	686	133	80.6	-	-	-	822	50	-	-	-	-	" 10 mA/cm²
"	13.30	7.0	7.0	7.21	6.98	771	106	86.3	-	-	-	733	10	-	-	-	-	" 10 mA/cm²
"	14.30	6.0	8.0	7.42	7.42	622	118	81.0	-	-	-	600	13	130	12	-	-	" 10 mA/cm²
"	15.30	7.5	8.0	7.30	8.05	1020	174	82.9	-	-	-	-	-	-	-	-	-	" 10 mA/cm²
"	16.00	7.5	8.0	7.25	8.15	908	157	82.7	-	-	-	-	-	-	-	-	-	" 10 mA/cm²
3.15	9.30	6.0	7.5	7.40	8.02	883	179	79.7	-	-	-	1200	75	300	132	444	220	Current density 7.2 mA/cm²

Table 2 Results of Electrolytic Treatment (2)

Month/ Day	Time	Water Temperature (℃)		pH		$COD_{(Mn)}$ ppm		Removal Rate (%)	BOD ppm		Removal Rate (%)	SS ppm		N-Hex Extracts (ppm)		T-N ppm		Electrolytic Conditions
		Raw Water	Treated Water	Raw Water	Treated Water	Raw Water	Treated Water		Raw Water	Treated Water		Raw Water	Treated Water	Raw Water	Treated Water	Raw Water	Treated Water	
3.15	10.30	8.0	10.0	7.27	7.60	969	158	83.6	-	-	-	1133	64	-	-	-	-	Current density 7.2 mA/cm²
"	11.30	7.0	9.0	7.38	8.21	779	148	81.0	-	-	-	1310	78	-	-	406	137	" 7.2 mA/cm²
"	13.00	6.0	9.5	6.68	7.41	926	167	81.9	-	-	-	1400	60	-	-	-	-	" 7.2 mA/cm²
"	14.00	7.0	10.0	7.03	7.75	773	138	82.1	-	-	-	1000	50	541	20	475	197	" 7.2 mA/cm²
"	15.00	6.5	8.0	7.39	7.93	1095	225	79.5	-	-	-	1600	58	-	-	-	-	" 7.2 mA/cm²
3.16	9.30	6.0	9.0	7.40	7.83	755	142	81.1	-	-	-	882	30	110	78	358	155	Current density 10 mA/cm²
"	10.30	6.0	9.5	7.32	7.20	769	137	82.2	-	-	-	1400	50	219	15.6	422	156	" 10 mA/cm²
"	11.30	6.5	10.5	7.30	8.13	787	153	80.5	-	-	-	1500	38	-	-	-	-	" 10 mA/cm²
"	13.00	6.5	9.5	7.38	7.70	1098	208	81.0	-	-	-	1400	73	-	-	-	-	" 10 mA/cm²
"	14.00	7.0	9.5	7.27	7.22	683	150	78.0	-	-	-	1200	63	-	-	318	136	" 10 mA/cm²
"	15.00	6.0	10.0	7.30	7.21	734	137	81.3	-	-	-	2300	60	-	-	-	-	" 10 mA/cm²
3.18	14.00	6.0	8.5	7.21	7.07	626	118	81.1	-	-	-	400	60	-	-	-	-	Current density 10 mA/cm²
3.19	11.00	6.0	8.5	7.43	8.12	1008	179	82.2	-	-	-	900	-	-	-	-	-	Current density 10 mA/cm²
3.20	13.30	6.0	8.0	7.28	7.43	1047	132	87.4	-	-	-	800	20	-	-	-	-	Current density 10 mA/cm²

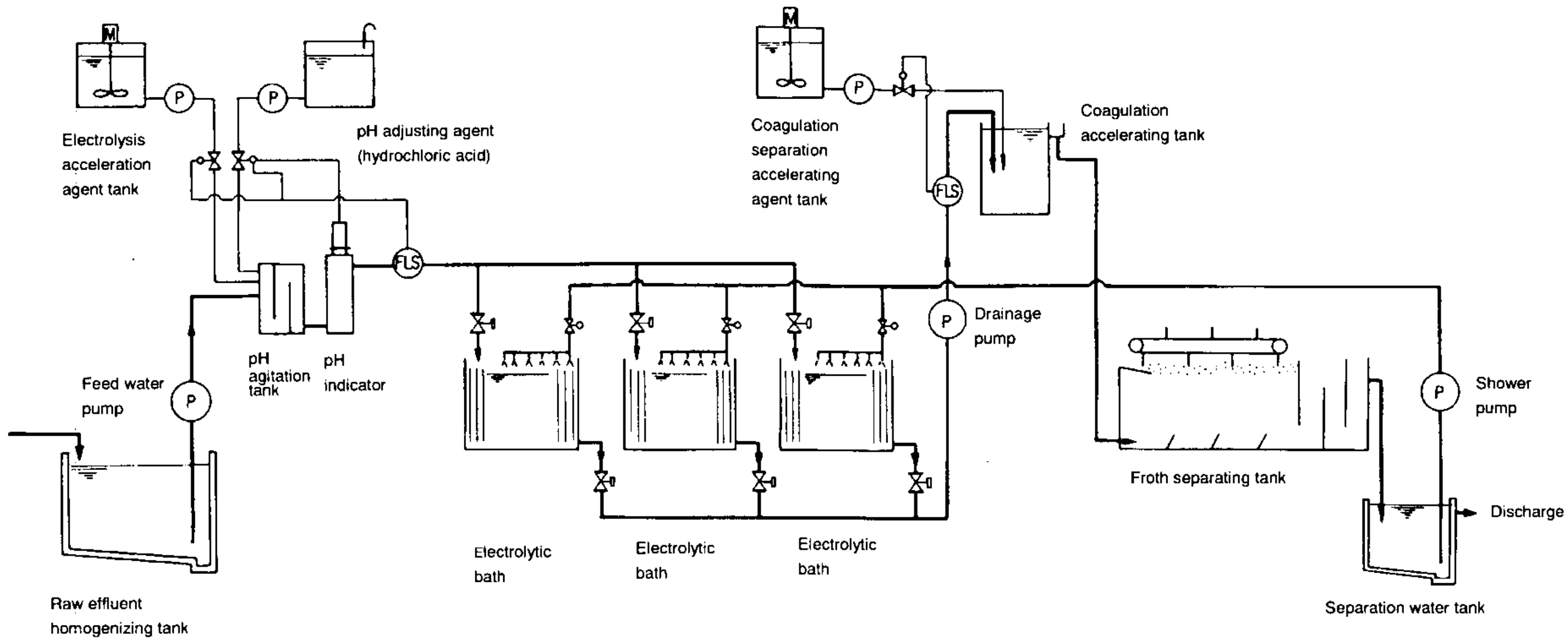


Figure Electrolysis Flow Chart

D. Pressure Flotation Process

This research was conducted thanks to the cooperation of the National Frozen Fish Meat Association's Technical Research Laboratory. Some of the analysis was done by Morinaga Dairy Products Co., Ltd.

1. Outline of Research

As a method of treating marine product processing effluent in cold regions, physicochemical treatment tests, in parallel with biological treatment tests, were conducted to determine the effectiveness of the treatment. The tests were done with the existing facilities, using waste water from the frozen ground fish meat process as the test effluent.

2. Outline of Research Facilities

Pressure flotation treatment facility (100 tons/day) made by Kurita Kogyo Co., Ltd., as per attached figure.

3. Treatment Method

(1) Raw water volume	8 to 14 m^3/hr
(2) Set pH	5.3 to 5.7
(3) Amount of hydrochloric acid added	150 to 200 ppm (conversion 100%)
(4) Coagulant aid	35 to 60 ppm
(5) Applied pressure	2.0 to 2.5 kg/cm^2
(6) Pressurizing water	Treated water used
(7) Circulating water	3 to 5 m^3/hr

Tests were performed based on the above set conditions.

4. Test Effluent

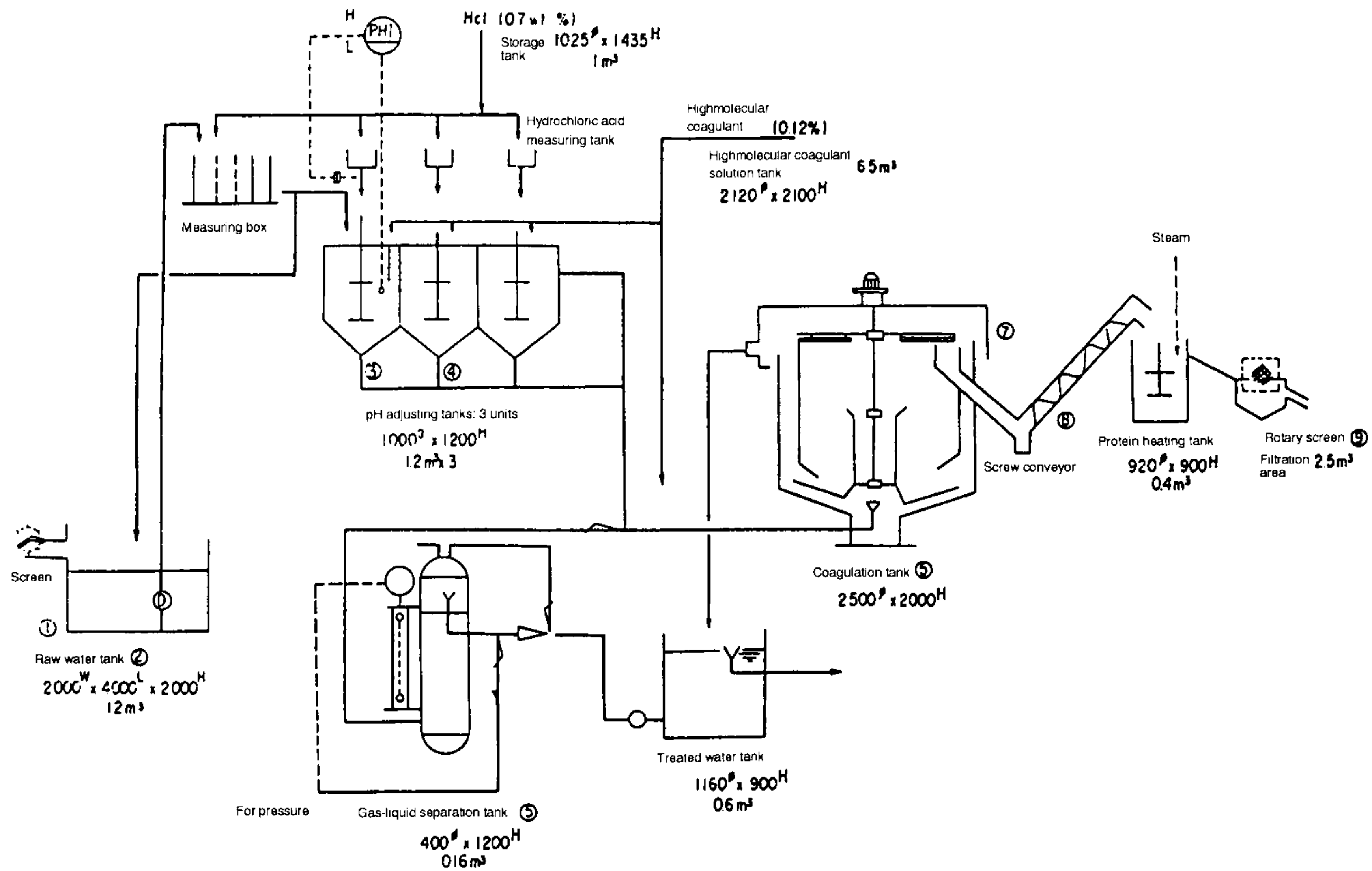
The same effluent as previously mentioned in A-4.

5. Results of Research (Refer to attached Table)

According to the test results obtained from the facility that was used, the removal rates of COD, BOD and SS did not meet the general standards, being 50 to 80%, 35 to 70% and 60 to 95% respectively. Effectiveness of treatment was not too good because of the ground fish meat effluent and its light water quality concentrations.

Table 1 Results of Pressure Flotation Treatment

Month/Day	Raw Water				Treated Water			
	pH	COD ppm	BOD ppm	SS ppm	pH	COD ppm	BOD ppm	SS ppm
2. 26	5.42	798	3495	1700	5.3	373	1476	200
27	7.52	475	1660	500		399	1435	175
28	7.30	1739	4305	740	5.2	641	2454	100
3. 1	7.80	643	1410	367				
2	7.53	500	1428	650				
4	7.54	485	846	450	5.55	198		100
5	7.60	521	1560	419		348		
6								
7	7.42	813	2520	650				
8	7.20	1146	3240	1067		492		240
9	7.20	587	1092	650		294		
10								
11	7.00	839	2225	667		356	1288	261
12		805	2280	833		250	764	221
13	7.38	887	2622	750		272		45
14	7.21	622	2390	600	5.3	177		70
15	7.03	773	1712	1000	5.4	257		200
16	7.38	1098	3234	1400	5.2	418		150
18	7.21	626	1720	400	5.7	324	1102	133
19	7.28	1043	2490	800	5.45	314	1062	160
20	7.28	1208	2988	1700	5.35	298	978	150



Pressure Flotation Flow Chart

Reference 1.

Effectiveness of Electrolytic Treatment of Highly Contaminated Effluent Occurring When Producing Ground Fish Meat

Ground fish meat is usually produced by frozen ground fish meat makers from fish with heads. The degree of contamination of the effluent differs considerably depending on the freshness of the raw material fish. Except for walleye pollack caught in coastal waters, the freshness of the raw material is particularly poor. Destruction of the meat fibers due to the fish meat quality becoming fragile, the degree of advancement of the dissolution of the entrails, and other factors, generally cause highly contaminated effluent to be produced when ground fish meat is processed.

Examples of measurements made of the effectiveness of purification with the electrolytic treatment facilities installed at frozen ground fish meat factories in Abashiri City are as follows. The raw water was the integrated effluent used when making frozen ground fish meat.

1. Nature and Volume of Effluent When Ground Fish Meat Is Made and of Effluent by Processes

The usual manufacturing processes and the effluent system currently being employed to produce ground fish meat are as shown in Table 1. An example of the nature of the effluent produced by each manufacturing process is shown in Table 2.

The volume of effluent and integrated effluent produced in each time period by a standard manufacturing plant processing 70 tons of raw material into 20 tons of product per day is shown in Table 3.

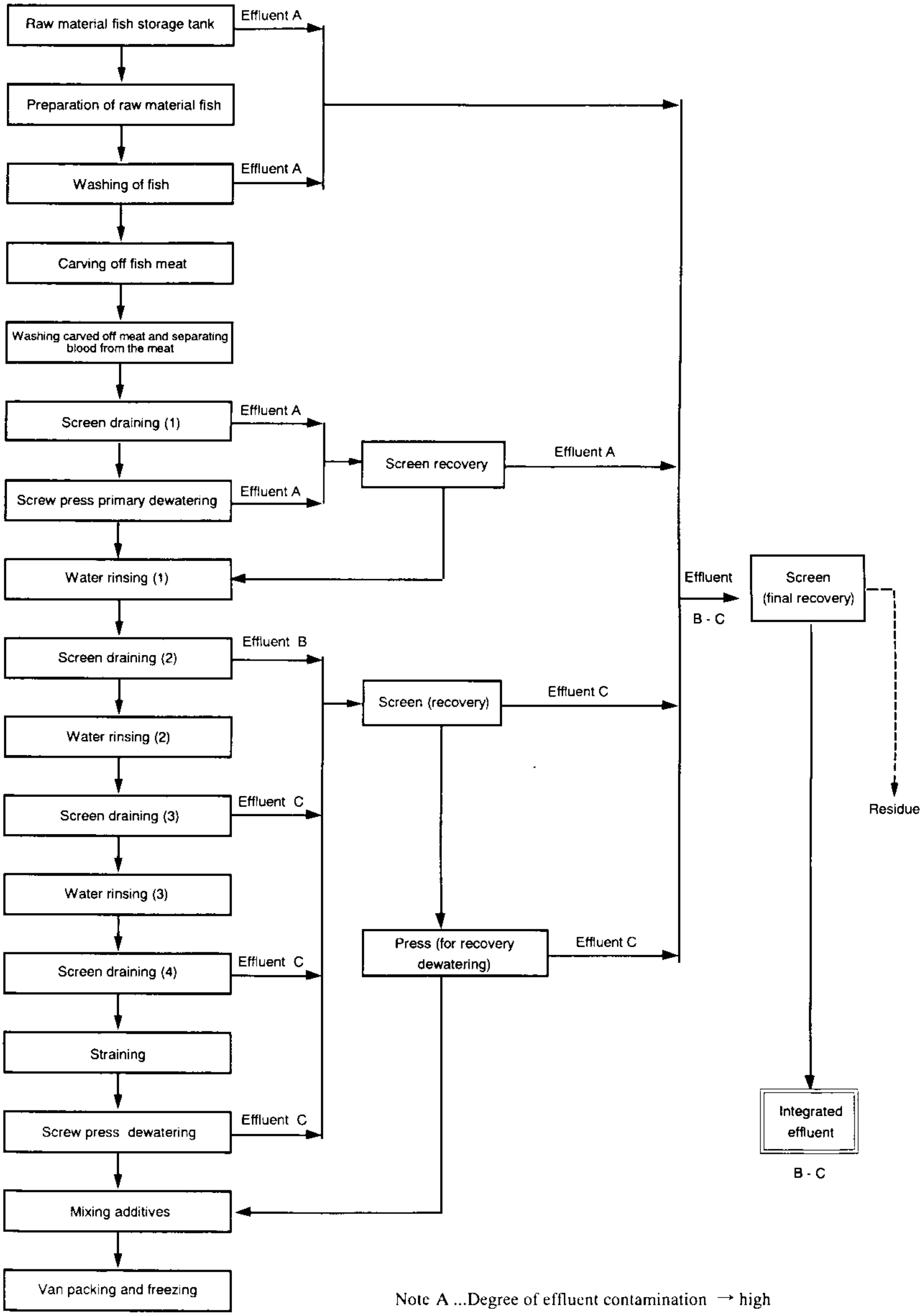
2. Raw Material Walleye Pollack

The results of measurements made of the effectiveness of electrolytic treatment carried out on raw material from various fishing grounds between June 1973 and March 1974 are as shown in Table 4. Generally, the freshness of most Hokuten walleye pollack, cod, cuttlefish, walleye pollack, and 52 degrees north latitude (N-52) walleye, had deteriorated, whereas that of coastal walleye pollack was good.

3. Electrolytic Treatment Conditions

(1) Pole Plates and Construction	
One tank: Anodes:	Aluminum, 80 plates
Cathodes:	Iron, 80 plates combined
(2) Electric Voltage and Current:	80V - 600A to 1,500A
(3) Current Density:	1.4 mA/cm^2 to 10 mA/cm^2
(4) Electrolysis time:	5 to 7 minutes
(5) pH adjustment range:	4.0 to 4.5
(6) Electrolysis accelerating agent:	NaCl 0.1% of raw water
(7) Coagulant:	15 to 20 ppm of treated water

Table 1 Frozen Ground Fish Meat Making Processes and Effluent System (Factory A)



Note A ...Degree of effluent contamination → high
B ...Degree of effluent contamination → fairly high
C ...Degree of effluent contamination → low

Table 2 Nature of Effluent by Frozen Ground Fish Meat Making Processes (In case of Factory A)

No.	Process	pH	Transparency	External Appearance	COD (Mn) ppm	COD (Cr) ppm	SS ppm	N-Hex Extracts (ppm)	T - N ppm	Volume of effluent in one day (tons)
1	Fish tank	7.1	1.0	Brown	2,420	11,500	3,390	1,190	570	40
2	Fish washing machine	7.1	1.5	Light brown	1,180	6,800	3,200	740	666	40
3	No.1 screen	7.2	1.0	Brown	6,380	26,600	6,900	420	2,750	90
4	Primary dewatering	7.2	1.0	Reddish brown	5,690	24,100	1,240	400	2,730	1.5
5	No.2 screen	7.4	2.0	Pale turbid yellow	3,320	4,490	1,500	450	516	69
6	No.3 screen	7.4	2.0	Pale turbid yellow	3,320	4,490	1,500	450	516	69
7	No.4 screen	7.1	2.0	Same as above	1,140	13,700	1,400	30	433	69
8	Secondary dewatering	7.2	1.0 or less	Greyish white	10,800	37,200	23,400	90	4,340	1.5
9	Recovery screen (1)	7.3	1.0	Reddish brown	5,420	18,700	3,700	390	2,120	
10	Recovery screen (2)	7.3	2.0	Pale turbid yellow	1,110	4,200	950	60	375	
11	Integrated effluent	7.1	1.0	Faint yellowish brown	2,180	10,550	2,310	640	939	380

Remarks: In addition to 380 tons of effluent, about 20 tons of miscellaneous water, total 400 tons
Average values of effluent at 1030 hours and 1430 hours on November 17, 1973.
Raw material: Hokuten walleye pollack - Freshness: Rather poor

Table 3 Times and Effluent Volumes of Ground Fish Meat Factory (In case of Factory A)

	Process \ Time	7 - 8	8 - 9	9 - 10	10 - 11	11 - 12	12 - 13	13 - 14	14 - 15	15 - 16	16 - 17	17 - 18	18 -	Volume of Effluent	Hours of operation	Volume of effluent per one hour
○	Fish tank													40		(4.4)
	Preparation of raw material fish														9	
○	Washing of fish													40	9	4.4
	Carving off fish meat															
	Washing carved off meat and separating blood from the meat															
○	Screen draining (1)													90	7.5	12
○	Press primary dewatering													1.5	7.5	0.2
	Water rinsing (1)															
○	Screen draining (2)													69	7.5	9.2
	Water rinsing (2)															
○	Screen draining (3)													69	7.5	9.2
	Water rinsing (3)															
○	Screen draining (4)													69	7.5	9.2
	Straining															
○	Screen press dewatering													1.5	8.0	0.19
	Mixing additives															
○	Miscellaneous water													20	0.5	
	Volume of effluent	15	42	49	49	49		49	49	44	34		20	400		48.79

Remarks: Raw material used: 70 tons; product produced: 20 tons.
Processes marked with a circle are effluent-discharging locations.
Example taken of one day of full operation.

Table 4-(1) Examples of Electrolytic Treatment of Ground Fish Meat Processing Effluent

Factory	Month/Day	Water Temp. (℃)		pH		COD ppm		Removal Rate (%)	BOD ppm		Removal Rate (%)	SS ppm		N-Hex Extracts (ppm)		T-N ppm		Remarks
		Raw Water	Treated Water	Raw Water	Treated Water	Raw Water	Treated Water		Raw Water	Treated Water		Raw Water	Treated Water	Raw Water	Treated Water	Raw Water	Treated Water	
Association	47. 12. 9	7.5	8.8	7.25	7.50	1534	175	88.6	-	-	-	730	25	210	45	350	110	Hokuten walleye pollack
"	48. 6. 13	8.0	10.0	7.10	7.20	1138	150	86.8	3357	712	78.8	950	37	550	70	370	112	Coastal walleye pollack
"	20	7.8	10.8	7.30	7.75	1096	202	81.6	-	-	-	1210	55	-	-	-	-	"
"	23	7.5	11.0	7.10	7.25	1185	207	82.5	4290	978	77.2	750	33	320	30	400	118	"
"	29	8.3	9.8	7.50	7.60	2099	386	81.6	-	-	-	1600	140	1220	92	977	230	"
"	29	9.0	9.0	7.05	7.55	1942	391	79.8	6500	2097	67.7	1400	280	432	10	730	381	"
"	30	7.7	11.0	7.00	7.21	1994	178	90.1	-	-	-	1280	45	-	-	-	-	"
A	7. 10	8.0	11.5	7.28	7.05	1353	231	82.9	-	-	-	1320	51	-	-	-	-	Cod, cuttlefish, walleye pollack
"	20	8.0	11.5	7.00	7.50	1568	104	93.4	-	-	-	995	80	630	50	470	232	"
"	8. 8	7.5	9.0	7.10	8.40	2109	501	76.2	6640	1500	77.4	2500	40	559	67	1028	452	"
"	23	7.7	11.0	7.03	7.70	1702	382	77.5	5600	1820	67.5	811	25	-	-	-	-	"
"	24	8.2	10.8	7.00	8.15	1941	419	78.4	-	-	-	1050	75	721	85	445	141	"
"	25	8.0	9.5	6.96	8.21	1105	247	77.6	-	-	-	880	35	435	7	321	153	N-52 walleye pollack
"	27	9.0	10.5	7.15	8.30	1337	278	79.2	5480	1700	69.0	1210	70	1015	30	722	280	"
"	28	8.0	10.7	7.20	8.80	1110	243	78.1	-	-	-	920	25	232	42	665	284	"
"	29	8.1	10.0	6.40	7.80	1823	305	83.3	-	-	-	2100	78	-	-	-	-	Hokuten walleye pollack
"	30	7.9	12.0	5.86	7.84	1407	333	76.3	3790	1660	56.2	1115	31	318	13	752	137	"
"	31	8.3	11.8	6.32	6.91	1743	263	84.9	-	-	-	1330	85	1390	97	889	311	"
"	9. 1	8.0	9.5	6.78	7.22	1339	244	81.8	-	-	-	815	27	-	-	-	-	"
"	3	8.0	8.5	7.22	8.31	1596	281	52.4	4229	1370	67.6	1043	62	533	27	555	288	"
"	4	7.9	10.0	7.02	7.32	1612	186	88.5	-	-	-	975	38	-	-	-	-	Cod, cuttlefish, walleye pollack
"	5	8.0	12.5	6.16	8.32	1526	259	83.0	4190	1191	71.6	1200	65	552	18	775	279	"
"	10. 4	7.8	10.8	7.08	7.70	1294	206	84.1	3290	620	81.2	786	80	666	53	590	210	Coastal walleye pollack

Table 4-(2) Examples of Electrolytic Treatment of Ground Fish Meat Processing Effluent

Factory	Month/ Day	Water Temp. (℃)		pH		COD ppm		Removal Rate (%)	BOD ppm		Removal Rate (%)	SS ppm		N-Hex Extracts (ppm)		T-N ppm		Remarks
		Raw Water	Treated Water	Raw Water	Treated Water	Raw Water	Treated Water		Raw Water	Treated Water		Raw Water	Treated Water	Raw Water	Treated Water	Raw Water	Treated Water	
B	48.10. 20	8.0	11.5	5.72	6.70	1951	257	86.8	-	-	-	1500	90	-	-	-	-	Hokuten walleye pollack
"	22	8.2	9.8	7.00	8.10	1387	237	82.9	3890	1330	65.8	900	15	399	45	953	428	Coastal walleye pollack
"	23	7.8	10.0	6.00	7.40	1590	369	76.8	4452	1395	68.6	1600	20	1440	88	858	377	Hokuten walleye pollack
"	23	8.0	10.0	5.05	6.70	1295	279	78.5	-	-	-	2400	33	-	-	-	-	"
"	23	8.0	9.5	4.85	6.47	1432	326	77.2	3180	1016	68.0	1867	42	633	19	663	246	"
"	24	7.5	8.8	5.98	7.22	1752	409	76.7	-	-	-	2300	40	-	-	-	-	"
C	11. 5	8.0	9.5	6.72	7.21	1868	316	83.1	-	-	-	2100	55	-	-	-	-	"
B	7	7.8	9.8	4.78	6.60	1528	331	78.3	-	-	-	750	35	435	58	634	274	"
C	9	7.5	10.0	6.94	7.00	1412	203	85.6	3720	950	74.5	2583	105	871	85	840	309	"
"	24	7.5	8.5	7.05	7.33	2460	307	87.5	-	-	-	2250	55	775	37	998	351	"
"	24	8.0	9.5	7.21	7.31	1904	250	86.9	-	-	-	1850	68	-	-	-	-	"
"	29	7.5	10.0	7.00	6.70	1534	332	78.4	4580	1595	65.2	3067	33	1600	98	1210	355	"
D	12. 24	7.5	9.8	7.23	7.10	1442	154	89.3	-	-	-	1255	77	-	-	-	-	"
E	24	8.0	8.8	6.70	7.50	1445	175	87.9	-	-	-	1050	52	662	27	674	271	"
F	49. 1. 22	7.5	9.0	7.07	7.40	1262	229	81.8	3407	1035	69.6	1770	60	720	53	747	231	Hokuten gara walleye pollack
G	2. 8	6.6	8.8	7.22	7.05	1042	104	90.0	-	-	-	720	25	-	-	-	-	"
Assn.	28	6.5	9.2	7.30	8.37	1739	234	86.5	4305	1212	71.8	740	60	328	33	540	188	"
F	3. 1	7.0	8.7	7.04	7.93	1500	254	83.1	4457	1303	70.8	1800	95	1010	62	937	227	"
"	1	7.2	8.5	7.19	7.55	1524	263	82.7	-	-	-	1970	42	-	-	-	-	"
"	7	-	-	6.52	6.45	1388	206	85.1	-	-	-	1050	38	551	26	552	200	"

Reference 2.

Treatment Test of Primary Effluent of Processing Mackerel (Under Conditions of Seawater and Low Water Temperature)

1. Purpose

To see to what degree effluent generated by using seawater for primary fish washing could be treated by the biological treatment process under low temperature conditions.

2. Test Method

1) Raw Effluent: The bloody water obtained when was dressed and washed mackerel was used.

BOD_5	4360 ppm
$COD_{(Mn)}$	1431 ppm

2) BOD space loading and residence time: BOD space loading 0.2 kg-BOD/m^3/day
A mixture consisting of 140 ml of bloody water and 160 ml of seawater was poured into a 3 liter aeration tank, and by batch type, 300 ml was discharged from the aeration tank and considered to be the treated water.
The number of days of residence was 10 days.

3) Water Temperature: The water temperature was regulated at 4℃ by placing the aeration tank in a constant temperature water bath set at 4℃.

4) Acclimatization: The load was gradually raised in 10 days from 0.1 kg-BOD/m^3/day to 0.2 kg-BOD/m^3/day, and then samples for analysis began to be taken.

3. Test Results

Treated water with BOD, COD, and SS values that could fully meet the general standards was obtained.

Low Temperature Treatment Tests of Mackerel Effluent (Seawater)

No. of Days	pH	SV_{30} %	MLSS ppm	SVI (Sludge Volume Index)	COD ppm	BOD ppm	SS ppm
1	8.1	7.0	1240	56.5	35.5	15.1	10.1
3	7.8	8.0	1852	43.2	33.7	14.9	34.2
5	8.0	7.6	1710	43.0	36.5	15.0	42.3
7	8.2	6.6	1554	42.5	39.6	15.1	-
9	8.2	7.3	1660	44.1	40.0	14.8	35.6
11	8.3	8.0	1769	45.2	40.8	15.3	-
13	7.7	9.0	1617	55.7	37.6	15.2	-
15	7.8	8.9	1665	53.8	35.1	15.3	38.4
17	-	-	-	-	32.4	15.5	-
19	8.1	8.9	1934	46.1	34.5	151.1	-
21	8.3	6.5	1660	39.2	36.4	15.1	-
23	8.3	9.0	2120	42.5	43.4	25.7	44.1
25	8.1	8.0	1984	40.3	45.2	24.7	-

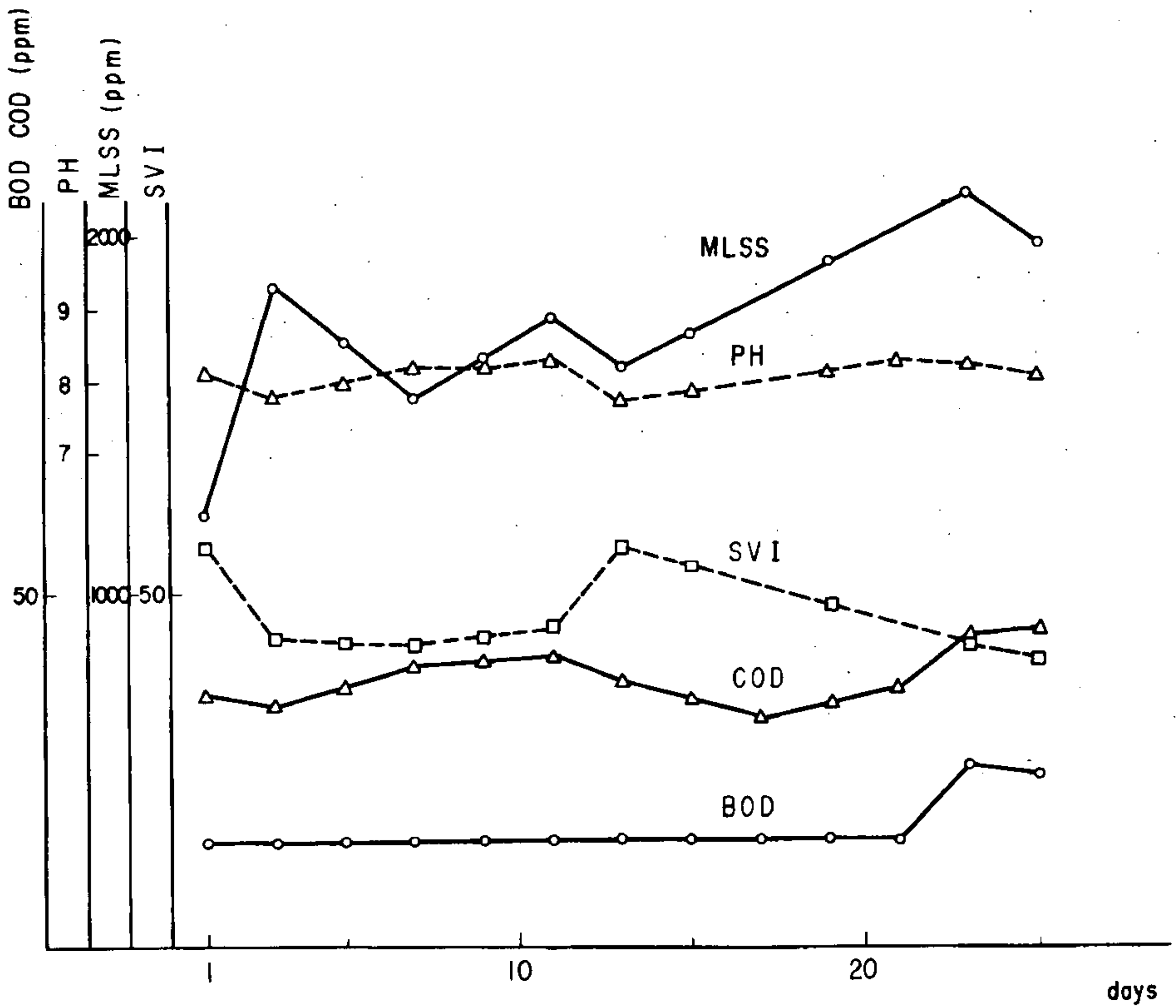


Figure Low Temperature Treatment Tests of Mackerel Effluent

V Conclusion

The working team of this investigation and research earnestly studied, the establishment of advanced technology for the treatment of marine product processing effluent in cold regions for use by small and medium size enterprises from the technical, economical and other standpoints. Based on our Interim Report, two private companies were commissioned through the Environmental Pollution Control Service Corporation (the former name of JEC) to carry out the necessary research.

In addition, thanks to the cooperation of the National Frozen Fish Meat Association's Technical Research Laboratory, comparison research was done on the electric coagulation process and the pressure flotation process. Therefore, studies were made of four reports, including reports on these latter processes, from which the following results were obtained.

1. Lagoon Process

The temperature in the tank was practically all minus(-) 0.5 to 0℃. There were some slight differences in treated water quality depending on the temperature in the tank, but at a load of 0.2 kg-BOD/m^3/day or less, removal rates of 85% for $COD_{(Mn)}$ 60 to 80 ppm and 85% for BOD around 100 ppm were obtained. Thus, this treatment can be expected to be fully effective in cold regions.

2. Activated Sludge Process

During the period of the tests, the water temperature in the aeration tank was kept at 2 to 5℃. At a load of 0.2 kg-BOD/m^3/day, considerably good results on treated water quality were obtained. $COD_{(Mn)}$ was lowered to 90 to 100 ppm for a removal rate of 75 to 86%, and BOD to 40 to 60 ppm for a removal rate of 96 to 98%. Thus, if the load is low, the activated sludge process can provided adequate treatment in cold regions. However, when the BOD space loading exceeds 0.4 kg-BOD/m^3/day, there is a tendency for the effectiveness of the treatment to deteriorate.

3. Electric Coagulation Process

BOD was relatively difficult to remove and COD was sometimes seen to exceed the general standards for effluent of 120 ppm.

4. Pressure Flotation Process

The removal rates on average were not necessarily good because the raw water quality was only effluent related to ground fish processing and so was thin. Treatment by the pressure flotation process produced treated water that in many cases exceeded the general effluent standards.

5. Two-Stage Treatment by Pressure Flotation / Electric Coagulation Process

As an effluent with a low contamination was used, the treated water quality was close to that of the electric coagulation process.

6. Results of Tests with 20-liter Water Tank (Lagoon Process)

Generally, a stable set of data was obtained because the external conditions were more uniform than in the case of the pilot plant. Therefore, steady results of treated water quality of $COD_{(Mn)}$ 30 to 50 ppm were obtained at a BOD space loading of 0.12 kg-BOD/m^3/day, and 50 to 90 ppm at a BOD space loading of 0.3 to 0.4g/liter/day. When biological treatment was carried out as secondary treatment after electric coagulation process and pressure flotation process were performed as primary treatment, even more extremely steady results than the above were obtained.

7. Others

1) Removal of Nitrogen
In all cases, a high removal rate cannot be expected. However, 40 to 60% was removed by physicochemical treatment. The nitrogen was transformed into an ammonia state by biological treatment.

2) Removal of Phosphorous
The electric coagulation process is an extremely effective method of removing phosphorous, a removal rate of 99% or better being obtained. In the case of biological treatment, almost no effect could be seen.

3) Removal of N-Hex Extracts
Considerable removal was seen in the case of the electric coagulation process but there still were cases in which the general standard for effluent of 30 ppm was exceeded. It is not clear what will happen in the case of other treatment methods because of insufficient data, but not too great a removal rate can be expected.

4) Sludge Generation and SVI
   i) In the case of the electric coagulation process and the pressure flotation process, froth is generated. In the case of biological treatment, not much superfluous sludge generation is seen when the BOD space loading is in the range of 0.2 kg/m^3/day or less.

   ii) In the case of biological treatment with a low BOD space loading of 0.4 kg/m^3/day, SVI was 200 to 300.

From the above results of study, the following can be said.

1. Only the electric coagulation process and the pressure flotation process are sometimes not necessarily adequate enough to produce treated water that conforms to the general effluent standards.
2. Even in cold regions, biological treatment is possible and will conform to the general effluent standards if the BOD space loading is held down to 0.4 kg/m^3/ day or less, although there may be some differences depending on temperature conditions.
3. As the SVI of sludge is high, careful consideration should be given to how water area load is taken when designing a settling tank.
4. Although not much can be expected of nitrogen removal, it was seen by these tests that the electric coagulation process was effective in removing phosphorous. Removal was also possible by the pressure flotation process depending on conditions.
5. Removal of N-Hex extracts sometimes did not conform to the general effluent standard when one treatment process alone was used.
6. The following treatment is desirable in order to cope with the changes in effluent water quality, including the primary treated water of fish carcass, the removal of suspended matter, and other factors, so that treated water which conforms to the general effluent standards can be obtained. First, either the electric coagulation process or the pressure flotation process should be carried out as a primary treatment, and then a biological treatment should be performed as the secondary treatment.
7. When the BOD space loading is low, not much difference can be seen in the results of the biological treatment of the activated sludge process and lagoon process. So the decision on which system to employ should be made by a comprehensive consideration of construction costs, land area, ease of maintenance, running costs, and other factors.

Finally,

With the present studies and research on advanced technology for the treatment of marine product processing effluent in cold regions, it was seen that by carrying out a biological process as a secondary treatment, it would be possible to produce treated water that conformed to the general standards for effluent. However, because a low BOD space loading is an essential condition for biological treatment in cold regions, a generally higher construction cost for facilities than in warm areas is unavoidable.

From this standpoint, we believe some sort of measures are required to be taken.

Also, further research is required on matters accompanying the primary treatment on which adequate studies could not be made during the present research, such as the disposal of the scum and sludge that are generated, the removal of nitrogen, etc.

Attachment 1.

Biological Treatment Process in Cold Regions

1) Lagoon (Morinaga Type) Process

This process is an aeration type lagoon treatment in which a long period (of about 10 days) is taken for residence time and the BOD space loading is set at about 0.3 kg-BOD/m^3/day or less. It is a type of activated sludge process.

a) Case of Treatment of Marine Product Processing Effluent in Ishinomaki
Raw water is BOD 3000 to 5000 ppm and treated water is BOD 40 to 100 ppm. The temperature of the effluent is 3 to 7℃.

b) Case of Treatment of Dairy Product Factory Effluent in Sapporo
Raw water is BOD 400 to 500 ppm and treated water is BOD 4 to 8 ppm. The temperature of the effluent is about 6℃.

2) Case of Treatment of Shiogama Marine Product Processing Factory Apartment Effluent

This treatment process is an activated sludge process consisting of a pressure flotation process and a two-stage aeration process.

The raw water average BOD is 1000 ppm and the treated water average BOD is 40 ppm.

Attachment 2.

Procedure for Investigation and Research

1. Treatment Processes

1-1. Biological Treatment

1) Activated Sludge Process

This process is the most usual of biological treatment processes and there are cases of it being carried out in warm areas for the treatment of marine product processing effluent. The research is to determine whether or not this process is technically and economically viable in cold regions, and, if so, what treatment processes are conceivable.

a. Outline of Research

1. Scale of Experimental Plant
   (a) Capacity $10\ m^3/day$
   (b) Area required $100\ m^2$

2. Test Method (details will be discussed)

3. Test Period: From December 1, 1973 to February 28, 1974

b. Layout of Facility (Refer to attached Figure 1)

2) Lagoon Process (Low Load Activated Sludge Process)

This process is in operation in the cold regions for the treatment of some industrial effluent. On treatment of marine product processing effluent, there is a report from an experimental plant in Ishinomaki. The present planned experiment calls for research on marine product processing effluent to be conducted outdoors and moreover in a severely cold area. Up to now, this sort of experiment has never been carried out. In this experiment, research will be conducted on what sort of results can be obtained under conditions of outdoors and low BOD space loading.

a. Outline of Research

1. Scale of Experimental Plant
   (a) Capacity $48\ m^3/day$ (when raw water BOD is 2000 ppm)
   (b) Tank capacity $320\ m^3$
   (c) Required area $375\ m^2$
   (d) Oxygen supply 360 kg/day

2. Test Method (details will be discussed)

3. Test Period: From December 1, 1973 to February 28, 1974

b Layout of Facility (Refer to attached Figure 2)

1-2. Physicochemical Treatment

1) Pressure Flotation Process

This process, similar to the electric coagulation process, is effective for the pretreatment of marine product processing effluent. This research is to see whether it is suitable as the final treatment process for obtaining treated water that meets the national effluent standards.

a. Outline of Research

The plant is being used as a normal effluent treatment facility, so data will be obtained while normal operations are being carried out.

1. Capacity of Facility 150 t/day

2. Test Method (details will be discussed)

3. Test Period: From December 1, 1973 to February 28, 1974

b. Flow Chart (Refer to attached Figure 3)

2) Electric Coagulation Process

Similar to the pressure flotation process mentioned in (1) above, this process is effective for the pretreatment of marine product processing effluent, but more is expected of it than the pressure flotation process. Research is to be carried to see whether or not it is suitable as the final treatment process for obtaining treated water that meets the national effluent standards.

a. Outline of Research

As with the pressure flotation facility mentioned in (1) above, this plant is being used as a normal effluent treatment facility, so data will be obtained while normal operations are being carried out.

1. Capacity of Facility 300 t/day

2. Test Method (details will be discussed)

3. Test Period: From December 1, 1973 to February 28, 1974

b Flow Chart (Refer to attached Figure 4)

2. Outline of Test Site

Test Site: Higashi 1-Chome. Kita 8 Jo, Abashiri City, Hokkaido (Map of vicinity of location is shown in attached Figure 5)

Abashiri has recorded a minimum atmospheric temperature in the winter of minus(-) 29.2℃ (in 1902), but the average temperature of the coldest month of the year, February, is minus(-) 11℃. In the winter, ice floes press in on the coast of the Sea of Okhotsk and the port is sealed off, making it impossible for fishing boats to call there. During this period, the marine product processors of Abashiri obtain their raw material fish by land transportation from the Kunashiro area. The fish transported to Abashiri are mainly without head and entrails. The marine product processing effluent in the winter has a BOD of 2,000 to 4,000 ppm and so is considerably better than the summertime effluent.

For the current test site, a vacant plot of land nearby the National Frozen Fish Meat Association was made available through the courtesy of that Association. The actual facilities already installed by the Association are scheduled to be used for the pressure flotation process and the electric coagulation process.

3. Contents of Research

This research will entail studies on the research items of 3-2 based on the investigations of 3-1. Effluent will be assumed to be 1,000 m^3/day, 3,000m^3/day, and 6,000 m^3/day and the following data will be submitted (applies only to biological treatment processes).

1) Flow Chart
2) Construction Costs
3) Running Costs
4) Construction Area
5) Operating Personnel
6) Others

3-1. Common Investigation Items

1) Types and quantities of raw material fish of subject factory
2) Work processes and quantities of effluent by processes
3) Properties of raw water quality and water temperature
4) Water quality and water temperature of treated water
5) Atmospheric temperature and other weather conditions during the tests
6) Other necessary matters

3-2. Outline of Research Items

a. Biological Treatment

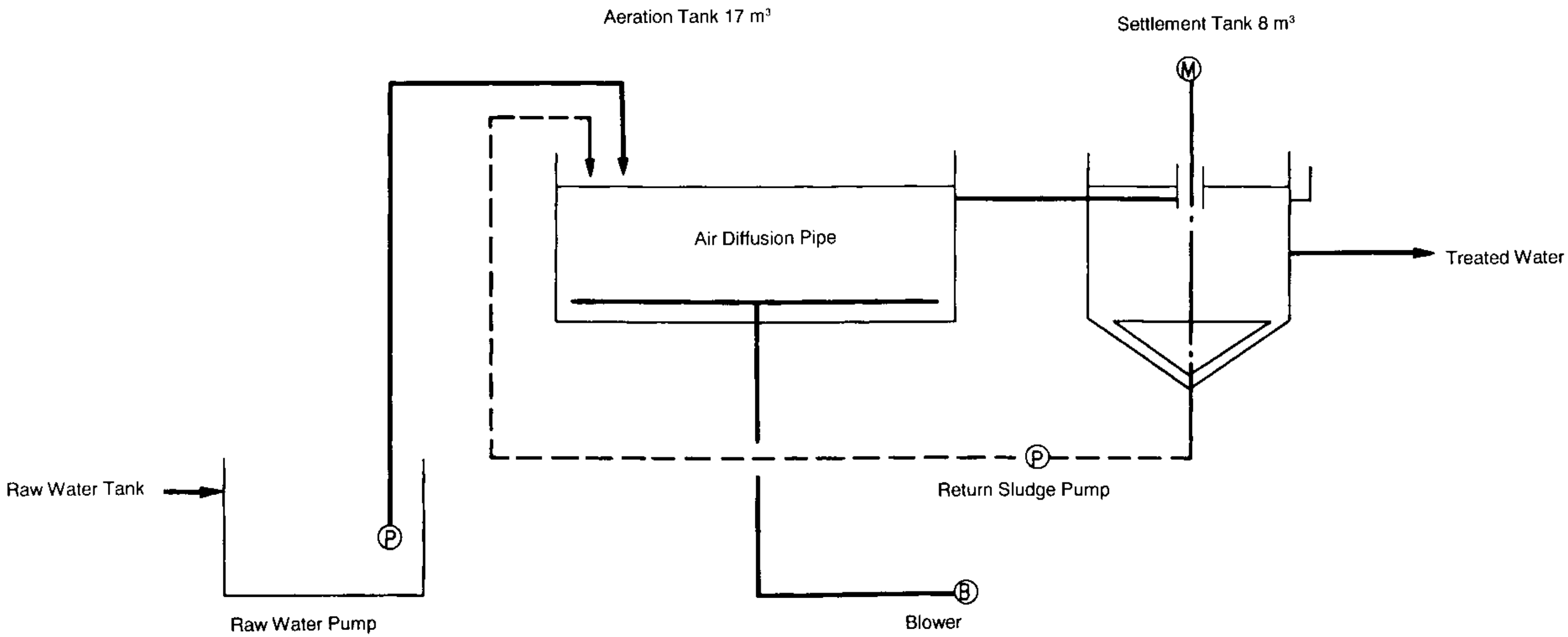
1) Obtain removal rates of COD, BOD, etc. using effluent water temperatures and BOD space loading as parameters.
2) Report on quantity of superfluous sludge generated.
3) Report on foul odor, appearance, etc.
4) Report on effectiveness of removal of nitrogen and phosphorous
5) Other matters that are deemed necessary.

b. Physicochemical treatment

1) Report on coagulating conditions (effectiveness of treatment)
2) Report on quantity of superfluous sludge generated.
3) Report on foul odor, appearance, etc.
4) Report on effectiveness of removal of nitrogen and phosphorous
5) Other matters that are deemed necessary.

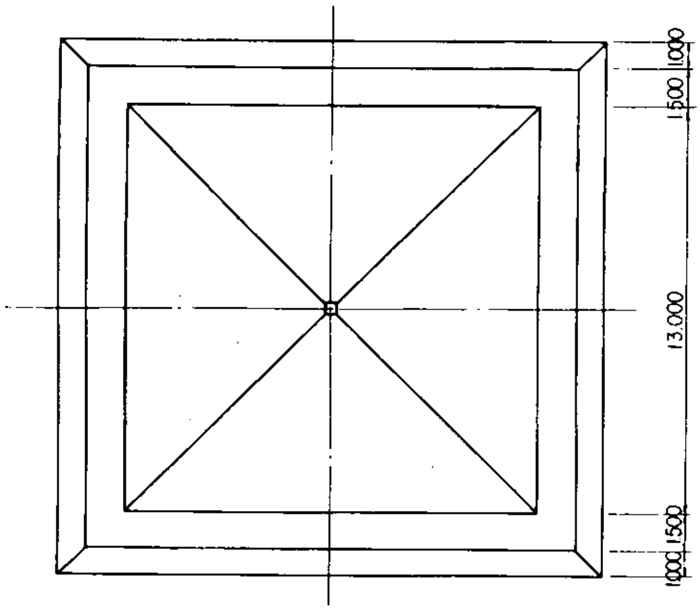
4. Working Party

1) Activated sludge process	Kurita Kogyo Co., Ltd.
2) Lagoon (low load activated sludge process)	Morinaga Dairy Products Co., Ltd.
3) Pressure flotation process	National Frozen Fish Meat Association's Technical Research Laboratory
4) Electric coagulation process	National Frozen Fish Meat Association's Technical Research Laboratory

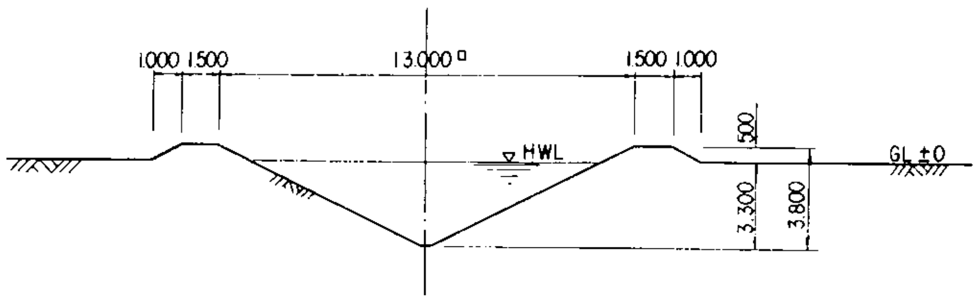


Continuous Activated Sludge Process

(Attached Figure 1)



(Plan View)

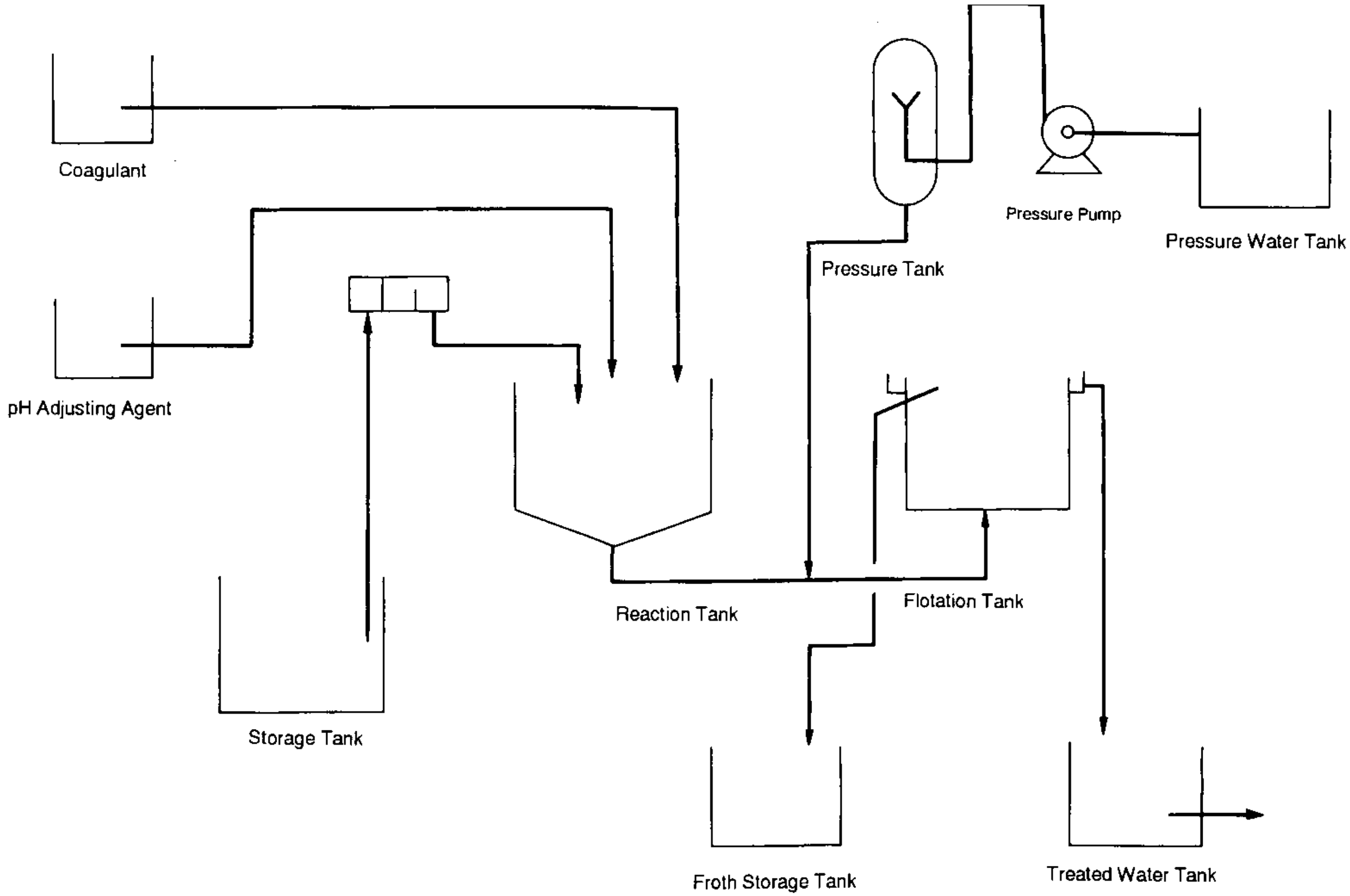


(Sectional View)

Tank Capacity 320 m^3
Oxygen supplied to aerator 360 kg/day

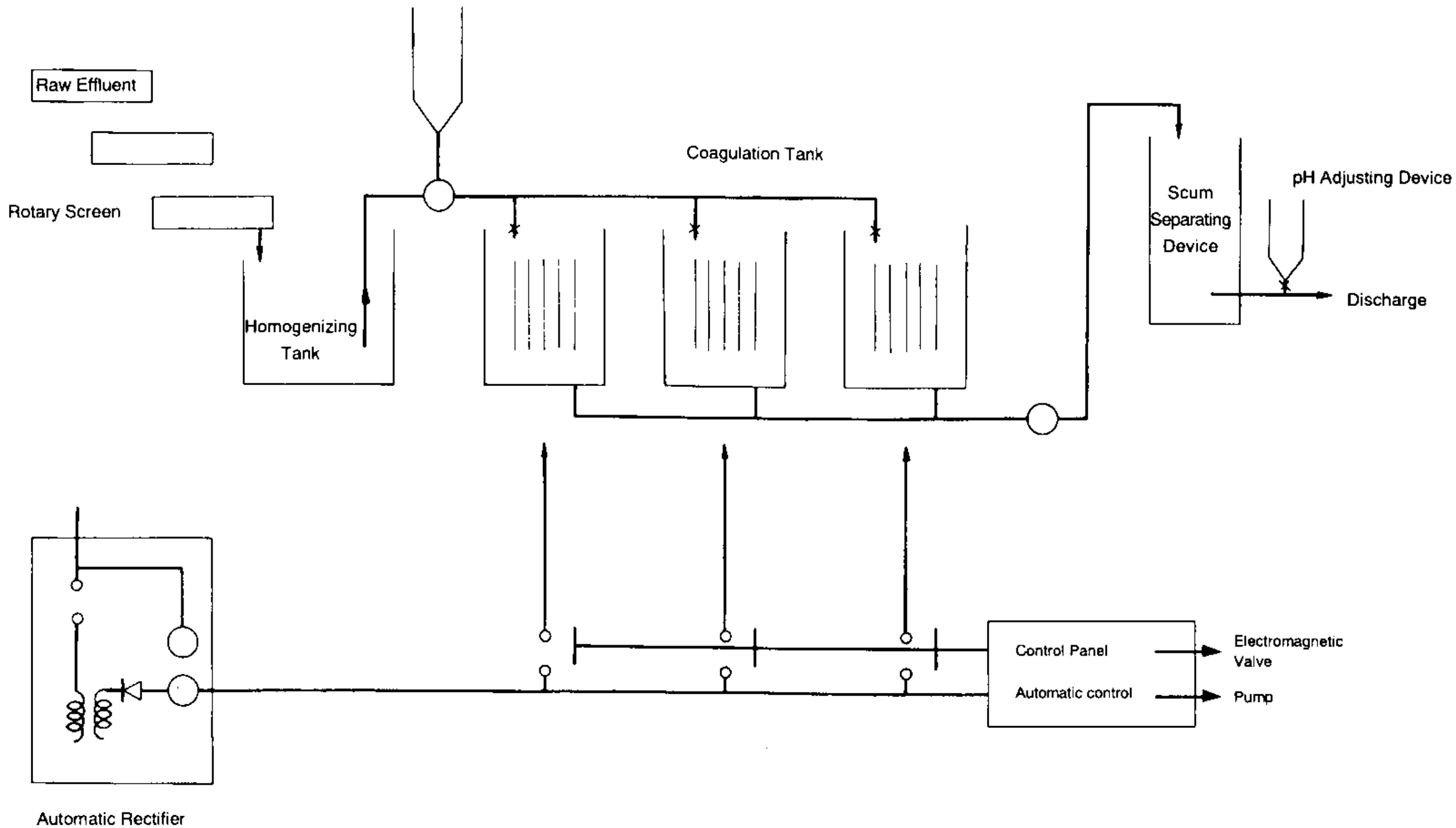
Lagoon Process (Low Load Activated Sludge Process) Batch Type

(Attached Figure 2)



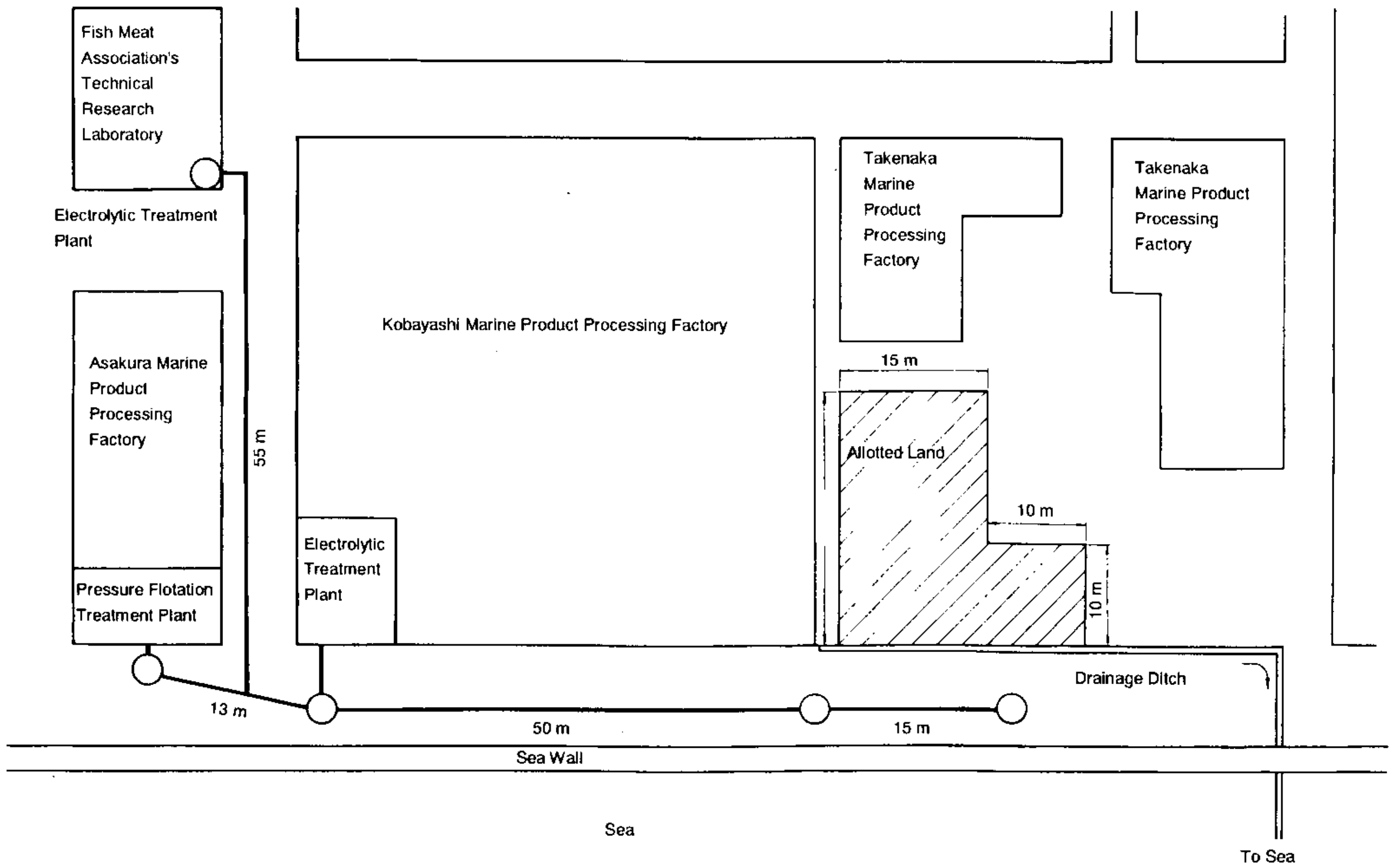
Pressure Flotation Process

(Attachment Figure 3)



Electric Coagulation Process

(Attached Figure 4)



Map of Test Site Vicinity

(Attached Figure 5)