III. Dyeing Industrial Estate

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1. Condition of the Industrial Estate

1.1 Outline of the Industrial Estate

This shows industrial estate location, size, organization and located companies.

(1) Industrial estate location and size

B Industrial Estate is located 40km southwest of Seoul City, and belongs to Ansan City, Kyonki-Dou. B Industrial Estate has a total of 1,116 factories of dyeing, foodstuff process, paper-pulp and, metal process industries in the site of 15,180,000m^2.

Recent research object is the dyeing estate, consisting of 61 factories, of which wastewater is jointly treated by B Dyeing Industrial Cooperative. The layout of the dyeing estate is shown in Figure 1.1.1.

An outline of the dyeing estate is as follows.

Total area	:	588,074 m^2
Investment	:	300 billion won
Main products	:	Dipping, printing
Total production capacity	:	Yarn: 140,000,000 kgs/year Textile: 600,000,000 yards/year
Industrial water consumption	:	60,000 m^3/day
Living water consumption	:	5,000 m^3/day
Steam consumption	:	440 t/day
Electricity consumption	:	38,000 kw/h
LNG consumption	:	2,440 m^3/h
Number of factories	:	61 factories in total
Total workers	:	10,500 workers

(2) Outline of B Dyeing industrial Estate Cooperative

Construction of B Industrial Estate started upon the Korean government's approval as an exclusive dyeing estate in 1979. At

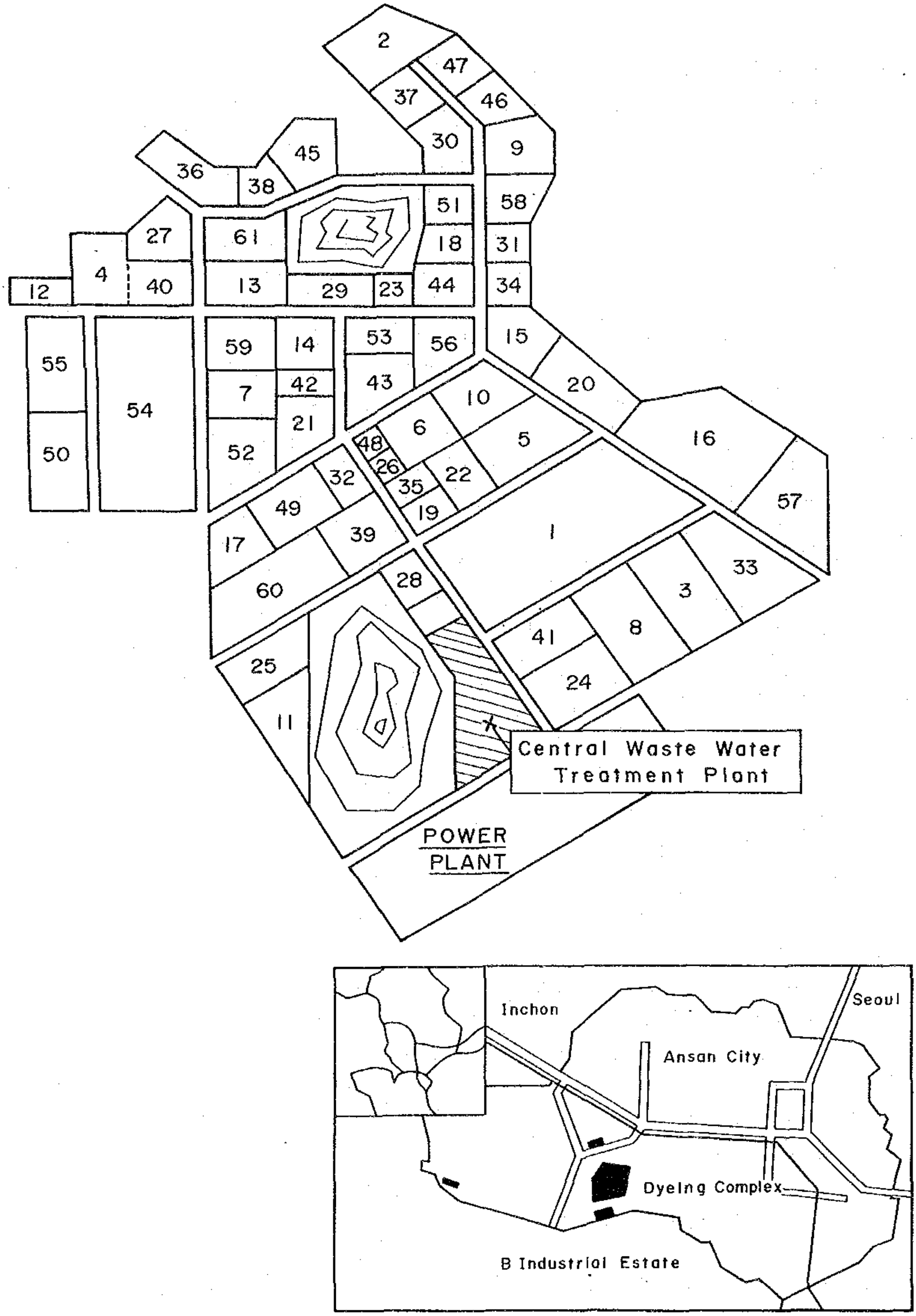


Fig. 1.1.1 Layout of Dyeing Estate

the start, Seoul Central Dyeing Cooperative took charge of construction work for a central wastewater treatment plant (capacity 35,000 m^3/day), which came into operation in May, 1983. Later, for the main purpose of the operation and management of this central wastewater treatment plant, B Industrial Cooperative broke off from Seoul Dyeing Cooperative and became an independent organization in December, 1986. Subsequently, the cooperative embarked on construction to increase the central wastewater treatment plants' capacity, and the treatment capacity has been 70,000 m^3/day since September, 1989.

B Dyeing Industrial Cooperative consists of 61 dyeing companies within B Industrial Estate. Main products of the member companies are shown in Table 1.1.1. More than 70% of the whole factories dye cotton, synthetic fibers, or mixed yarns of these materials.

The organization of the cooperative is as per Fig. 1.1.2 Directors are represented individually by the cooperative member companies.

Table 1.1.1 Main Products of Member Companies

Factory No.	Main Products
1	Cotton yarn, P/C mixed yarn dyeing
2	Polyester yarn, Cotton yarn, P/C mixed yarn dyeing
3	Acrylic and P/C mixed yarn, Polyester textile dyein
4	Polyester yarn dyeing
5	Polyester textile printing
6	Silk printing
7	Polyester textile dyeing
8	Polyester textile & knit dyeing
9	Cotton textile、P/C textile dyeing
10	Polyester textile dyeing
11	Acatate textile dyeing
12	Acetate textile dyeing
13	Cotton knit, P/C knit dyeing
14	Polyester textile & yarn dyeing
15	Fur tanning
16	Cotton textile dyeing
17	Wool yarn dyeing
18	Synthetic fiber yarn & knit dyeing
19	P/C knit dyeing
20	Synthetic fiber knit dyeing
21	Cotton yarn dyeing
22	Synthetic fiber textile & knit dyeing
23	Wool yarn、Synthetic fiber yarn dyeing
24	Synthetic fiber textile dyeing
25	Cotton textile dyeing
26	Silk printed
27	Synthetic fiber textile dyeing

Table 1.1.1 Main Products of Member Companies (continue)

Factory No.	Main Products
28	Yarn dyeing
29	Synthetic fiber yarn dyeing
30	Yarn dyeing
31	Synthetic fiber knit dyeing
32	Printing
33	Synthetic fiber textile & knit dyeing
34	Yarn dyeing
35	Silk printing
36	Synthetic fiber textile dyeing
37	Synthetic fiber dyeing
38	Silk printing
39	Knit dyeing
40	Synthetic fiber yarn、P/C mixed yarn dyeing
41	Synthetic fiber textile dyeing
42	Silk printing dyeing
43	Synthetic fiber textile dyeing
44	Synthetic fiber textile & knit dyeing
45	Synthetic fiber yarn dyeing
46	Synthetic fiber textile & knit dyeing
47	Synthetic fiber knit dyeing
48	Yarn dyeing
49	Cotton textile dyeing
50	Cotton yarn、P/C mixed yarn & knit dyeing
51	Synthetic fiber textile dyeing
52	Synthetic fiber knit dyeing
53	Cotton textile dyeing
54	Cotton textile dyeing

Table 1.1.1 Main Products of Member Companies (continue)

Factory No.	Main Products
55	Printing
56	Printing
57	Synthetic fiber yarn、P/C mixed yarn dyeing
58	Cotton textile、Silk textile dyeing
59	Synthetic fiber yarn dyeing
60	Synthetic fiber textile dyeing
61	Cotton textile dyeing

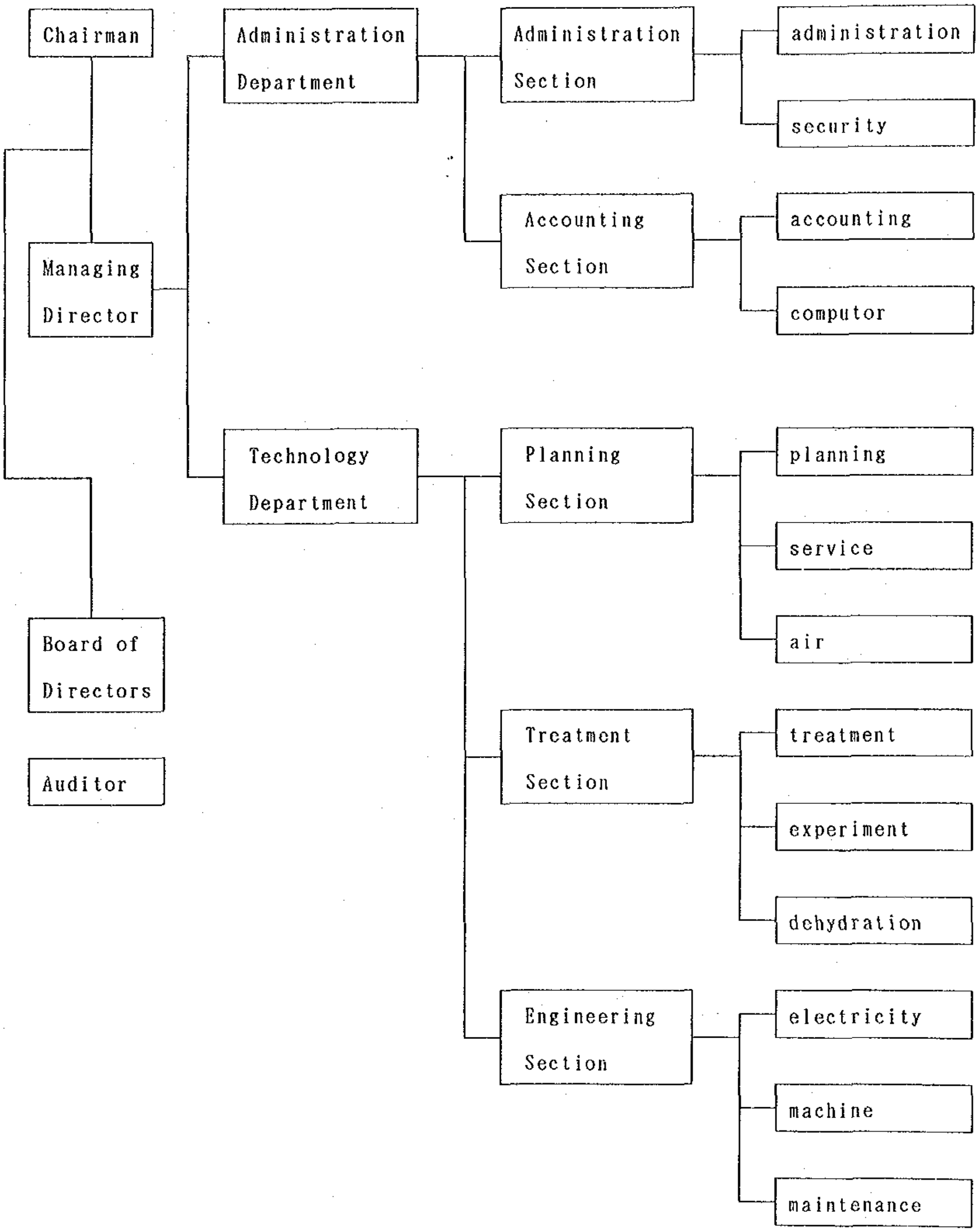


Fig. 1. 1. 2 Organization of Banwol Dyeing Industrial Cooperative

1.2 The State of Wastewater, Wastewater Treatment and Reclamation

This covers the situation of wastewater volume/quantity, wastewater treatment, and reclamation.

(1) Wastewater volume

Wastewater inflow drained to the central wastewater treatment plant consists of both process drainage (including steam condensed water) from individual factories and general drainage, excluding rain-water inflow. Some factories recover sodium hydroxide from condensed drainage from mercerizing process, within their factories by themselves, or through consignment to specialty firms.

Wastewater flows in from Monday to Saturday, never on Sundays, when factories do no operate. Fig. 1.2.1 shows monthly variation in wastewater inflow and Table 1.2.1 shows monthly total water consumption and waste- water treatment volume of Dyeing Industrial Estate. The difference between water consumption and wastewater treatment volume is due to the water storage tank owned by each factory. Variations in wastewater volume is 55,000 - 73,000 m^3/day. Wastewater volume is expected to increase, and approximately 100,000 m^3/day volume is estimated for 1996. Wastewater flows in continuously for 24 hours as factories operate all day long, but its volume decreases at night. Inflow reaches the minimum of about 1,400 m^3/h from 2:00 to 6:00 am, while reaching the maximum of about 4,500 m^3/h from 1 to 6pm due to rapid volume increase starting around 10am. Fig. 1.2.2. shows daily inflow variation example.

(2) Waste water quality

Quality of both wastewater and treated water (designed criteia) is shown in Table 1.2.2. And individual daily variation examples of pH, BOD and SS are indicated in Fig. 1.2.3 - 6 pH changes in a range of 9.9 - 10.9, while BOD does 220 - 280 mg/l, COD 220 - 350 mg/l, and SS 80 - 110 mg/l, respectively. Quality

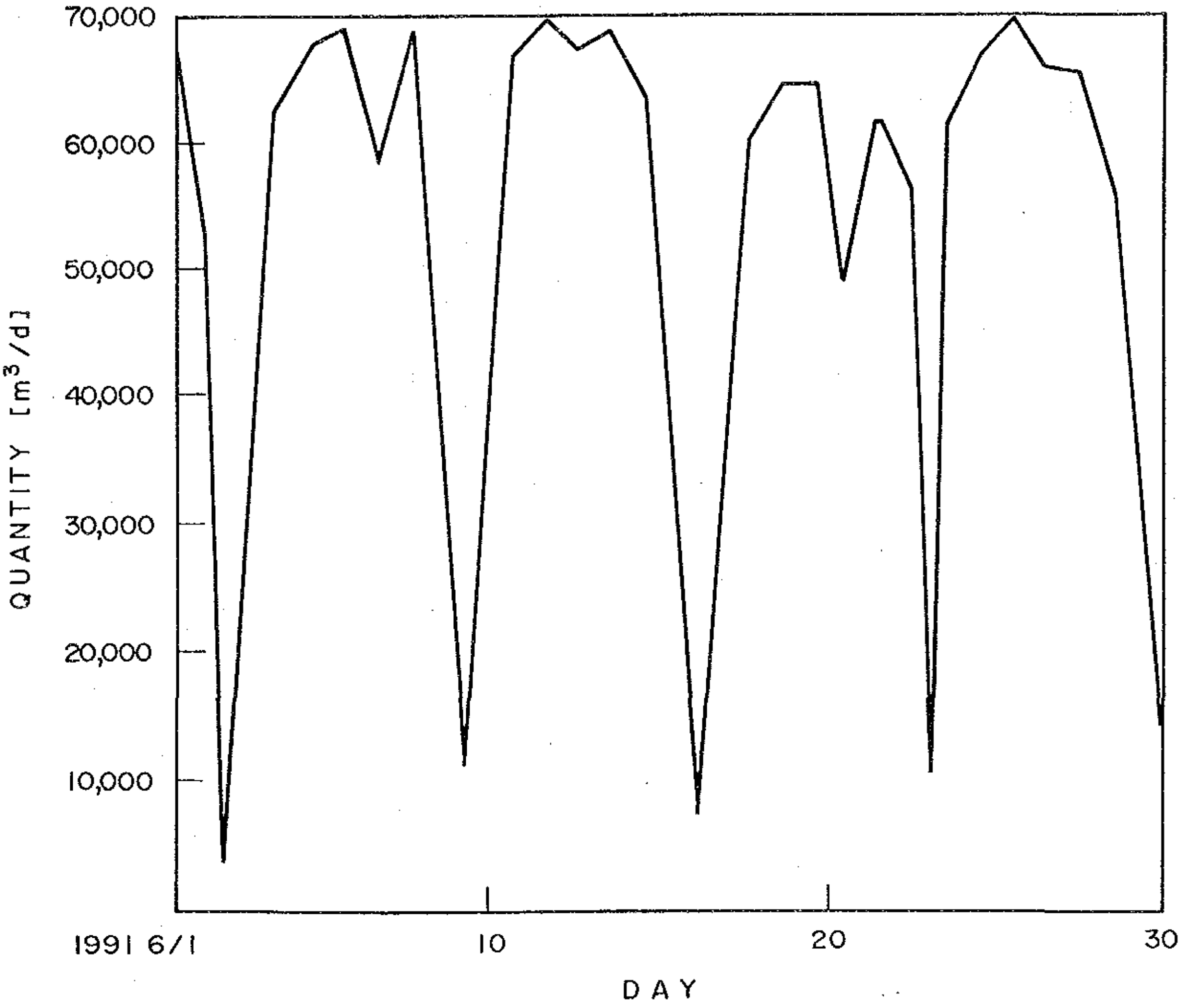


Fig. 1. 2. 1 Monthly Change of Waste Water Inflow

Table 1.2.1 Monthly Total Water Consumption and Effluent Volume of Dyeing Industrial Estate

Month	Water Usage [m^3]	Steam Drain [m^3]	Effluent [m^3]
Jan.	1,214,019	111,515	1,371,970
Feb.	1,118,999	92,839	1,100,150
Mar.	1,194,780	113,542	1,345,980
Apr.	1,336,968	107,619	1,516,920
May	1,388,644	104,979	1,739,830
Jun.	1,243,476	93,340	1,649,300
Jul.	1,355,300	98,070	1,832,170
Aug.	1,303,528	87,752	1,613,300
Sep.	1,265,571	83,970	1,435,410
Oct.	1,326,656	108,409	1,698,440
Nov.	1,326,111	111,481	1,462,340
Dec.	1,311,281	116,275	1,322,250
Total	15,385,333	1,229,791	18,058,060

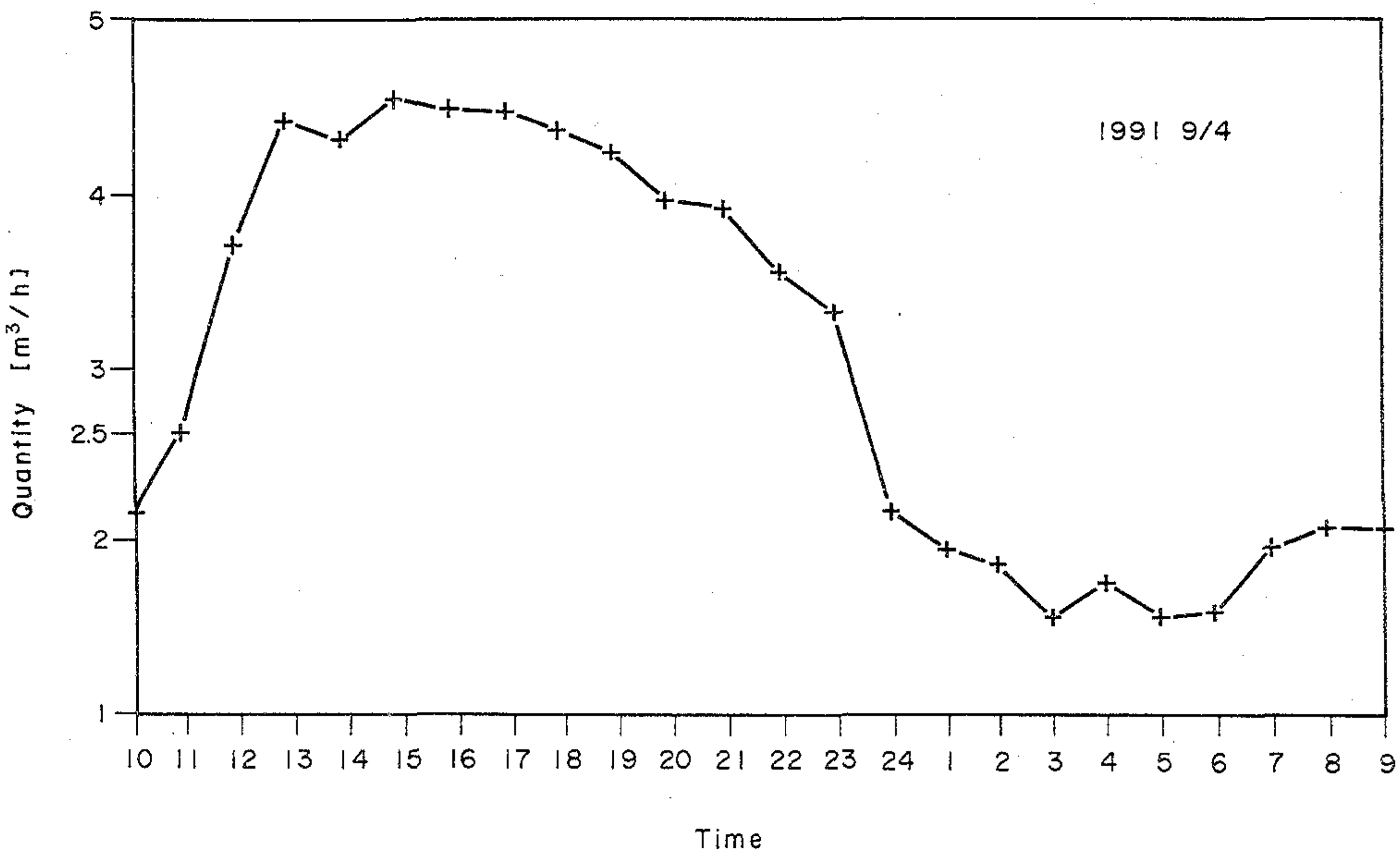


Fig. 1. 2. 2 Daily Change of Waste Water Inflow

Table 1.2.2 Quality of Raw Water and Treated Water in Central Waste Water Treatment Plant (Design Criteria)

Items		Influent	Effluent
pH	[-]	11.5	5.8 - 8.6
BOD	[mg/ℓ]	300	70
COD	[mg/ℓ]	450	85
SS	[mg/ℓ]	150	30
N-Hex	[mg/ℓ]	20	2
Color	[deg.]	400	200
Temp.	[°C]	46 - 30	35 - 23

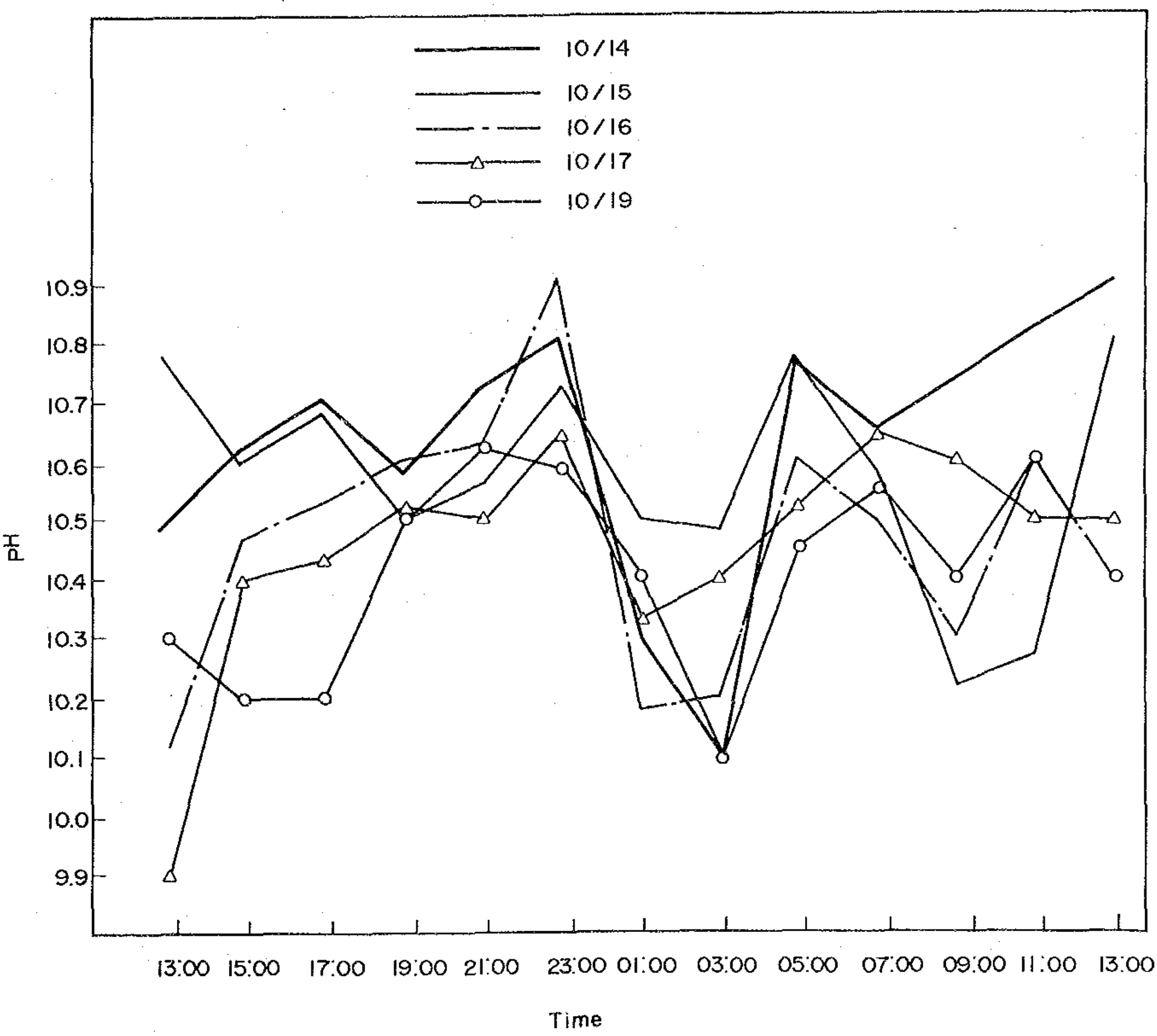


Fig. 1. 2. 3 Daily pH Change of Waste Water

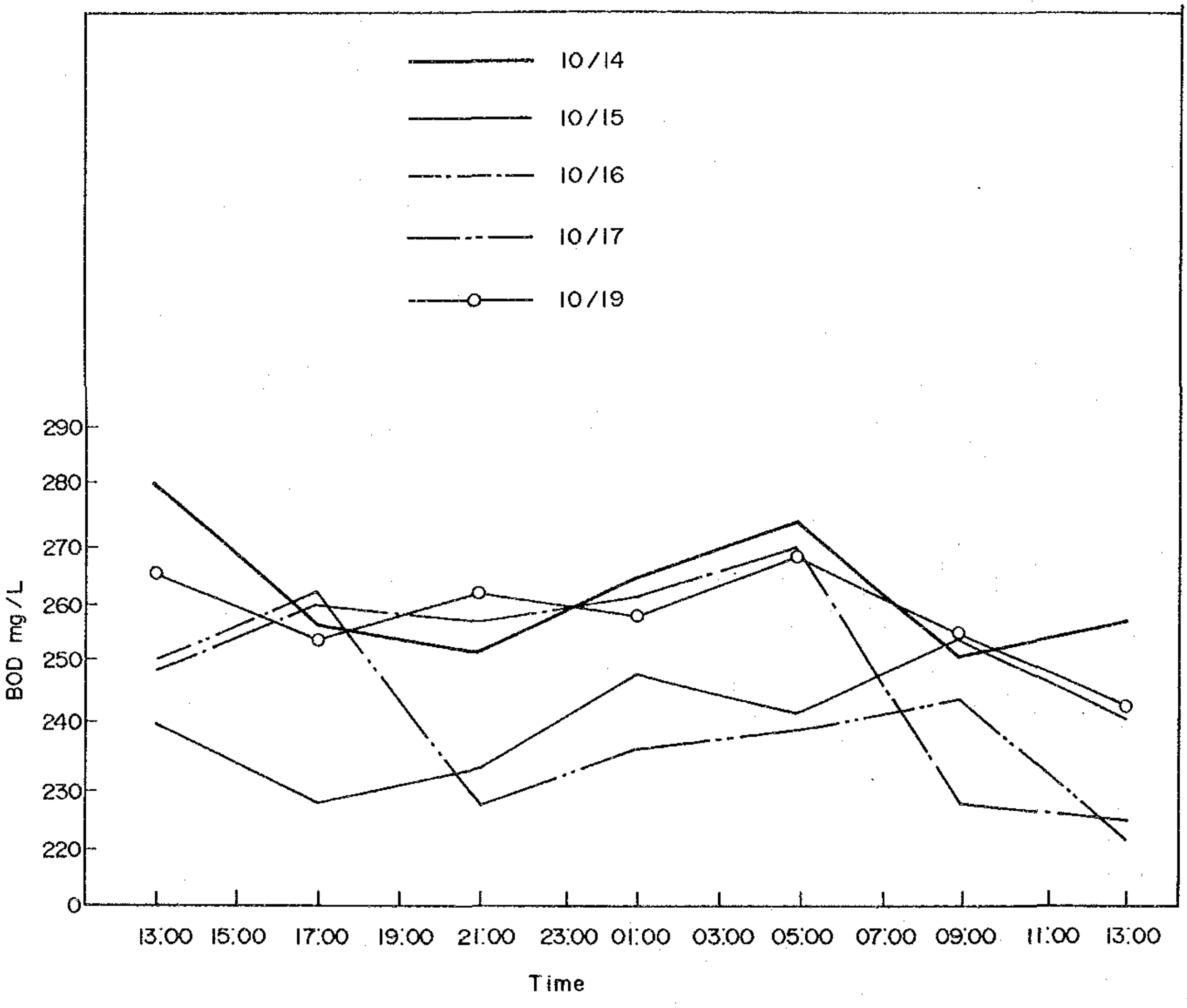


Fig. 1. 2. 4 Daily BOD Change of Waste Water

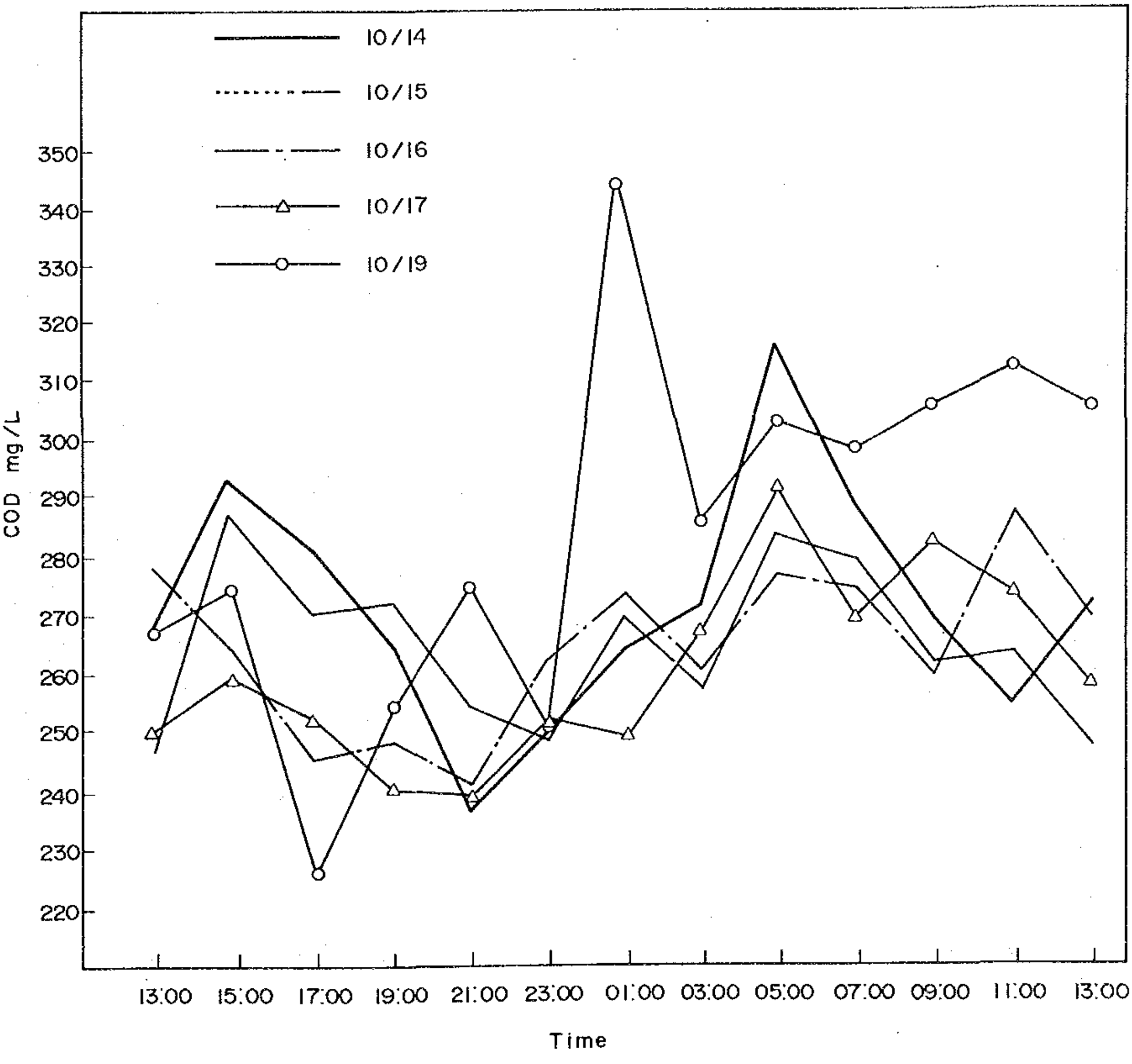


Fig. 1. 2. 5 Daily COD Change of Waste Water

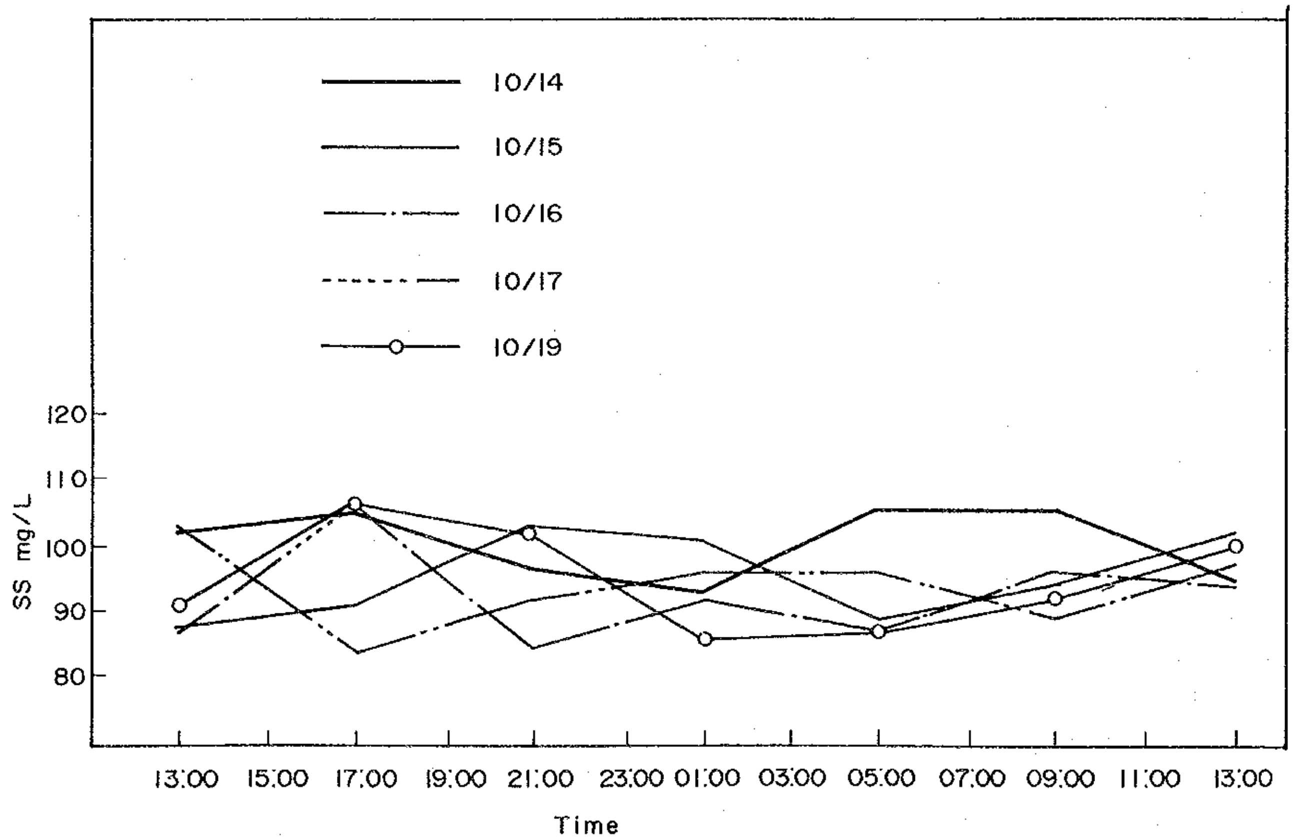


Fig. 1. 2. 6 Daily SS Change of Waste Water

of wastewater does not vary remarkably, and is kept stable throughout the year generally.

At the central wastewater treatment plant, quality of wastewater outflow from each factory is not particularly checked but pH is measured at random. Additionally one factory alone discharging chromium-contained wastewater is instructed to conduct pretreatment within the factory.

(3) Size of wastewater treatment plant

This treatment plant started with 35,000 m^3/day treatment capacity first and increased its capacity in 1989. Current treatment capacity of the central wastewater treatment plant is 70,000 m^3/day with treatment through an old line and a new one.
An outline of the treatment plant is mentioned below.

Treatment capacity	:	70,000 m^3/day
an old line	:	35,000 m^3/day
a new line	:	35,000 m^3/day
Area	:	20,149 m^2
Construction fee	:	6 billion won
an old line	:	3.2 billion won
a new line	:	2.8 billion won
Contractor	:	Kolon Construction Co., Ltd. Kolon Engineering Co., Ltd.
Reserve area	:	3,318 m^3 (secured)

(4) Wastewater treatment process

Inflow wastewater from factories, after heavy metals chlate formation, is distributed to the old line and the new line to be treated and discharged into the Ansan city sewage treatment plant. Distribution volume of wastewater to the two lines shall be even in principle, but is controlled depending on water quality treated. Fig. 1.2.7 shows treatment process of each line. pH value and COD value of treated water are continuously measured at the outlet of the central wastewater treatment plant. Excess sludge therein is dehydrated to be transported to the Government terminal treatment plant for reclamation process.

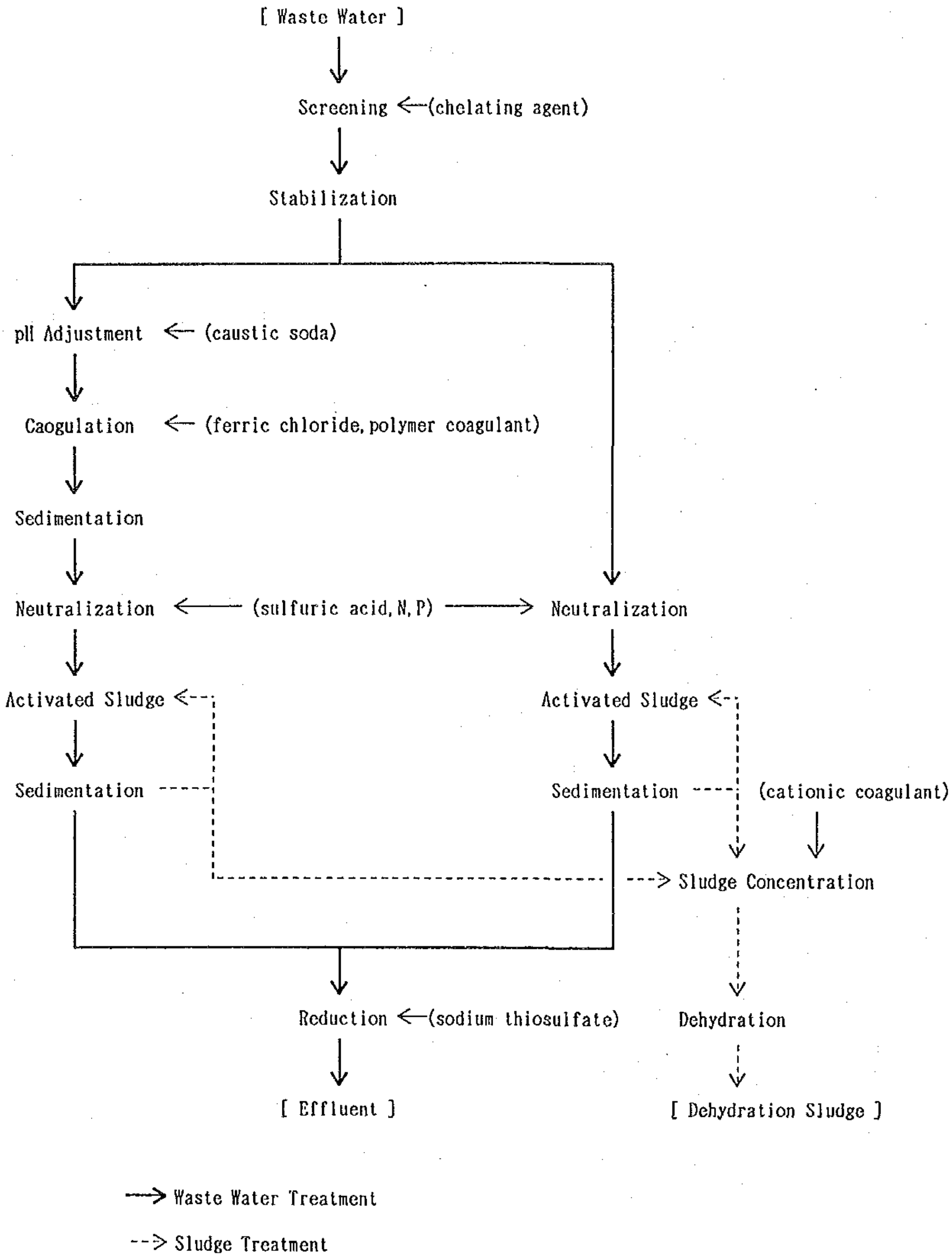


Fig. 1. 2. 7 Flow Diagram of Treatment in Central Waste Water Treatment Plant

(5) General condition of reclamation

Treated water is discharged into the sewage terminal treatment plant in Ansan City and is not particularly reclaimed. The sewage terminal treatment plant treats both living drainage amounting to 60,000 m^3/day in Ansan City and discharged water reaching 60,000 m^3/day from the central wastewater treatment plant. Fig. 1.2.8 shows the treatment process of the sewage treatment plant.

Table 1.2.3 shows inflow water into the sewage terminal treatment plant and quality of treated water. This flowchart indicates that as present facilities are only for physical/chemical treatment, but not for biological treatment, inflow water from the central wastewater treatment plant therefore keeps better water quality in comparison with treated water at the sewage terminal treatment plant.

From another point of view, it may be said that discharged water from the central wastewater treatment plant is utilized to dilute living drainage from Ansan City. At present, reinforcement work for better facilities is planned and being carried out at the sewage terminal treatment plant, including the addition of a second-stage treatment facility.

[Waste Water]

↓

Pump pit

↓

Screen

↓

Sedimentation Basin (with Aeration)

↓

Sedimation Tank

↓

[Effluent]

Fig. 1. 2. 8 Flow Diagram of Treatment in Sewage Terminal Treatment Plant in Ansan City

Table 1.2.3 Quality of Inflow Water and Treated Water in Sewage Terminal Treatment Plant in Ansan City (Design Criteria)

Items		Influent	Effluent
BOD	[mg/ℓ]	216 - 219	143 - 144
COD	[mg/ℓ]	430 - 438	241 - 249

1.3 Wastewater Sources

This section covers, based on the result of visiting survey and questionnairing at factories, the state of production process, pollutant, and chemicals usage at the factories that discharge wastewater.

1.3.1 Result of Factory Survey

Regarding production process, water/wastewater condition and water quality, visiting survey was conducted at 15 factories chosen out of 61 factories in B Dyeing Industrial Estate. The selection of the factories was made referring to sorts of dyeing object materials (shape difference of yarns and cloths, and materials), and differences of dyeing methods (dyeing, printing). Table 1.3.1 shows the factories visited. The result of the survey is as follows.

(1) Factory No.1

A. Business

Cotton yarn hank dyeing	1,404 t/year
Cotton yarn cheese dyeing	1,678 t/year
Cotton/synthetic fiber-mixed yarn cheese dyeing	524 t/year

B. Dyeing machine

Winch (for hank dyeing use)
Jetdyeing machine (for cheese dyeing use)

C. Production process

* Hank yard dyeing process
  (desizing) —> (marcerizing) —> (pre-treatment or bleaching) —> (dyeing) —> (finishing)
* Cheese yarn dyeing process
  (marcerizing) —> (pre-treatment or bleaching) —> (dyeing) —> (finishing)

Table 1.3.1 List of Visiting Survey Factory

No.	Workers	Area	Quantity of Water					Products
			①	②	③	④	⑤	
	[persons]	[m²]	[m³/D]	[m³/D]	[m³/D]	[t/D]	[m³/D]	
1	220	53,722	1,500	100		90	1,690	yarn dyeing
2	200	12,790	800	50		75	925	yarn dyeing
3	160		2,000	30		200	2,230	yarn & textile dyeing
4	120	16,613	1,800	12		100	1,912	yarn dyeing
5	155	13,084	350	10		70	430	textile printing
6	180	6,303	630	20		70	720	textile printing & dyeing
7	134	6,608	1,000	30		90	1,120	textile dyeing
8	214	14,988	2,000	3		200	2,203	knit printing & dyeing
9	250	10,583	2,500	10		320	2,830	textile printing & dyeing
10	120	11,795	1,000	30		75	1,105	textile dyeing
11	135	8,307	1,000	2		120	1,122	textile dyeing
12	134	5,010	700	7		30	737	textile dyeing
13	130	17,029	2,400	6		150	2,556	knit dyeing
14	230	7,862	580	20	130	84	814	yarn & textile dyeing
15	60	2,292	140	10		30	180	fur tanning and dyeing, laundry

① ; Industrial water ② ; City water ③ ; Ground water ④ ; Steam ⑤ ; Total

D. Water/wastewater condition

1) Water consumption

Industrial water	:	1,500 m^3/day
City water	:	100 m^3/day
Steam	:	90 t/day

2) Water consumption ratio in each process

Marcerizing	:	80 m^3/day
Scouring/bleaching	:	630 m^3/day
Dyeing	:	750 m^3/day

E. Sample and analysis

1) Sample
   a. Concentrated waste from marcerizing process (Cotton yarn)
   b. Waste washing water from marcerizing process (Cotton yarn)
   c. Total effluent
2) Analysis
   See Table 1.3.2

F. Other hearing information

1) Caustic soda is collected from marcerizing process concentrated waste water.
2) Liquor ratio in hank dyeing is 16 - 17 times, and that of cheese dyeing is about 8 times.
3) Both living wastewater and factory wastewater are discharged together into the central treatment plant.
4) Steam costs Won 5,250/t. (same to other factories)
5) This factory pays 25 billion won/month for wastewater treatment charges to the central treatment plant.
6) Hot wastewater is discharged after heat exchange.
7) Rain water is discharged through a rain water pipe.

(2) Factory No.2

A. Business

Embroidery hank and cheese dyeing
Polyester 57 t/year

Table 1.3.2 Analytical Value of Effluent Quality (Factory No.1)

(1) Sample

a. Concentrated waste from marcerizing process (Cotton yarn)

b. Waste washing water from marcerizing process (Cotton yarn)

c. Total effluent

(2) Analytical Value

Items		Samples		
		a	b	c
pH	[-]			10.7
SS	[mg/ℓ]	395.0	72.5	21.0
COD_{Mn}	[mg/ℓ]	2805.6	821.6	334.0
BOD_5	[mg/ℓ]		221.0	157.5
n-Hex	[mg/ℓ]			28.7
T-P	[mg/ℓ]			3.5
T-N	[mg/ℓ]			0.2
Color	[deg.]			810
Temparature	[°C]			50

P/C mixed yarn	10 t/year
Cotton	4 t/year
Viscose rayon	47 t/year

B. Dyeing machine

Winch (for hank dyeing use)	6 sets
Jet dyeing machine (for cheese dyeing use)	30 sets

C. Production process

(scouring) —> (dyeing) —> (finishing)

D. Water/waste water condition

1) Water consumption

Industrial water	: 800 m^3/day
City water	: 50 m^3/day
Steam	: 75 t/day

2) Water consumption ratio in each process

Scouring	: 50 m^3/day
Dyeing	: 650 m^3/day
Finishing	: 80 m^3/day

E. Sample and analysis

1) Sample
   a. Waste washing water from dyeing process (Viscose Rayon yarn)
   b. Total effluent

2) Analysis
   See Table 1.3.3

F. Other hearing information

1) Drainage volume increases soon after shifting on 7:00-14:00, 14:00-22:00, 22:00-7:00 shifts.

Table 1.3.3 Analytical Value of Effluent Quality (Factory No. 2)

(1) Sample

a. Waste washing water from dyeing process (Viscose Rayon yarn)

b. Total effluent

(2) Analytical Value

Items		Samples	
		a	b
pH	[-]		
SS	[mg/ℓ]	49.5	19.5
COD_{Mn}	[mg/ℓ]	8.8	102.7
BOD_5	[mg/ℓ]	2.3	78.0
n-Hex	[mg/ℓ]	2.0	21.3
T-P	[mg/ℓ]		0.3
T-N	[mg/ℓ]		1.0
Color	[deg.]	21	415
Temparature	[°C]		35

2) Softening treatment of industrial water is made for the purpose of eliminating hardness (original water is 50-70mg/l, and treatment water 8 - 10 mg/l). Process system follows; sand filtration —> activated carbon adsorption —> ion exchange (cation resin).

3) Hot waste water is discharged after heat exchange, while cooling water is recycled for cleaning water.

4) Steam is purchased from cooperative facilities; however,its own boiler is also equipped for an emergency.

(3) Factory No.3

A. Business

Acryl yarn hank dyeing	4,000 t/year
Cotton yarn and P/C mixed yarn cheese dying	1,600 t/year
Polyester textile dyeing	1,500 t/year

B. Dyeing machine

Winch (for hank dyeing use)
Jet dyeing machine (for cheese dyeing use)
Jet dyeing machine (for textile dyeing use)

C. Production process

(scouring or bleaching) —> (dyeing) —> (finishing)

D. Water/waste water condition

Industrial water	:	2,000 m^3/day
Tap water	:	30 m^3/day
Steam	:	200 t/day

E. Sample and analysis

1) Sample

a. Waste washing water from dyeing process (P/C textile)

b. Waste washing water from dyeing process (Cotton textile)

c. Total effluent

2) Analysis

See Table 1.3.4

F. Other hearing information

1) The production lines are divided into the following 3 divisions.

* Production I Division

Acryl yarn dyeing

Direct dyeing without pretreatment process of scouring and bleaching.

Soaping water after dyeing is not much required, so that water consumption is only a little.

* Production II Division

Cheese yarn dyeing

Much water consumption with scouring or bleaching process. No marcerizing done. Dyeing process follows;

dyeing —> water cleaning —> soaping

—> water cleaning twice.

* Production III Division

Polyester textile dyeing

Comparatively much water consumption. No marcerizing.

2) Approximately 10,000 m^3 of cooling water is consumed in a month. About 20% of industrial water is used for cooling water. No cooling tower is utilized.

3) Dyeing takes about 5 hours from beginning preparations to finishing process.

4) City water is solely for drinking. And steam condensed water is utilized for living water, too.

(4) Factory No.4

Table 1.3.4 Analytical Value of Effluent Quality (Factory No. 3)

(1) Sample

a. Waste washing water from dyeing process (P/C textile)

b. Waste washing water from dyeing process (Cotton textile)

c. Total effluent

(2) Analytical Value

Items		Samples		
		a	b	c
pH	[-]	9.6	9.6	9.8
SS	[mg/ℓ]	5.5	10.0	24.5
COD_{Mn}	[mg/ℓ]	10.5	34.5	258.0
BOD_5	[mg/ℓ]	12.5	36.8	162.0
n-Hex	[mg/ℓ]	3.3	4.5	22.7
T-P	[mg/ℓ]			4.0
T-N	[mg/ℓ]			1.5
Color	[deg.]	262	508	4870
Temparature	[°C]			31

A. Business

Dyeing of synthetic fibers (acryl, polyester, nylon), natural yarns (cotton, wool, ramie) and mixed yarns (polyester/cotton, acryl/cotton, acryl/wool)

Main products;

Cotton yarn cheese dyeing	2,640 t/year
Acryl yarn hank dyeing	3,360 t/year

B. Dyeing machine

Winch (for hank dyeing use ... acryl yarn)

Jet dyeing machine (for cheese dyeing ... cotton yarn)

C. Production process

* Cotton yarn dyeing process
  (scouring) —> (bleaching) —> (dyeing) —> (finishing)
* Acryl yarn dyeing process
  (dyeing) —> (finishing)

D. Water/wastewater condition

1) Water consumption

Industrial water	:	1,800 m^3/day
City water	:	12 m^3/day
Steam	:	unknown

2) Water consumption ratio in each process

Scouring/bleaching	:	250 m^3/day
Dyeing	:	670 m^3/day
Soaping	:	1,000 m^3/day

E. Sample and analysis

1) Sample

a. Waste washing water from dyeing process (A/C yarn, red)
b. Waste washing water from dyeing process (Cotton yarn, red)
c. Waste washing water from dyeing process (A/C yarn, blue)
d. Waste washing water from dyeing process (Cotton yarn, blue)

e. Total effluent

2) Analysis
   See Table 1.3.5

F. Other hearing information

1) Factory No.4 has two separate factories situated adjacent to each other. The above values are the ones obtained from one of them.
2) Regarding cotton yarn, scouring is always carried out, and bleaching is made only in case of light colour dyeing.
3) If it is acryl pretreatment is not required due to direct dye.Utilizing efficiency of dyestuff (cation dyestuff)is high and the wastewater contamination level is low.
4) Cotton yarn dyeing needs much water due to scouring, and, therefore, the wastewater contamination level is high.

(5) Factory No. 5

A. Business

Acryl yarn hank dyeing	3,360 t/year
Polyester knit printing	width 44 inches x 9.6 million yards/year

B. Dyeing machine

Automatic printing machine	5 sets

C. Production process

(printing) ——> (finishing)

D. Water/wastewater condition

1) Water consumption

Industrial water	:	350 m^3/day
City water	:	10 m^3/day
Steam	:	70 t/day

Table 1.3.5 Analytical Value of Effluent Quality (Factory No.4)

(1) Sample

a. Waste washing water from dyeing process (A/C yarn , red)

b. Waste washing water from dyeing process (Cotton yarn , red)

c. Waste washing water from dyeing process (A/C yarn , blue)

d. Waste washing water from dyeing process (Cotton yarn , blue)

e. Total effluent

(2) Analytical Value

Items		Samples				
		a	b	c	d	e
pH	[-]	10.1	8.6	9.9	9.9	9.6
SS	[mg/ℓ]	18.5	64.0	10.5	5.0	6.0
COD_{Mn}	[mg/ℓ]	303.9	455.9	233.0	303.9	126.9
BOD_5	[mg/ℓ]	128.6	282.0	83.3		138.0
n-Hex	[mg/ℓ]	0.7	4.7		3.0	4.7
T-P	[mg/ℓ]					1.8
T-N	[mg/ℓ]					1.9
Color	[deg.]	1660	2500	4100	3810	3700
Temparature	[°C]					56

2) Water consumption ratio in each process

Plate making	:	8 m^3/day
Combination	:	30 m^3/day
Print	:	100 m^3/day
Water cleaning	:	200 m^3/day

E. Sample and analysis

1) Sample
   a. Effluent from mixing room
   b. Waste washing water from printing frames
   c. Waste washing water from printing process (Polyester textile)
   d. Total effluent

2) Analysis
   See Table 1.3.6.

F. Other hearing information

1) Only direct dyeing is done at Factory No.5 since pre-treatments such as scouring, etc. are already done at another factory.
2) In printing process, water in used for the washing of the conveyer belt conveying knit.
3) Water is also used for frame soaping and dyestuff adjustment process.
4) Natural gas is mainly utilized as dryer, and steam is used to produce hot water. Steam condensed water is mixed with industrial water and is used.
5) A lot change is made for every 300 yards - 100,000 yards. (av. 3,000 yards)
6) Processing cost is about 6 billion won (processing charge only).

(6) Factory No. 6

A. Business

Silk textile printing and dyeing (small volume)
width 44 inches x 8 million yards/year

B. Dyeing machine

Table 1.3.6 Analytical Value of Effluent Quality (Factory No. 5)

(1) Sample

a. Effluent from mixing room

b. Waste washing water for printing frames

c. Waste washing water from printing process (Polyester textile)

d. Total effluent

(2) Analytical Value

Items		Samples			
		a	b	c	d
pH	[-]	3.9	3.2	11.5	11.3
SS	[mg/ℓ]		772.7	126.7	255.0
COD_{Mn}	[mg/ℓ]	5678.0	1523.0	801.6	1077.2
BOD_5	[mg/ℓ]	2625.0	630.0	270.0	337.5
n-Hex	[mg/ℓ]			5.0	33.3
T-P	[mg/ℓ]				2.7
T-N	[mg/ℓ]				0.3
Color	[deg.]	9500	6900	2940	3650
Temparature	[°C]				34

Printing use	automatic printing machine
Dyeing use	jet dyeing machine

C. Production process

* Printing process
(scouring) ---> (tentering) ---> (printing)
---> (tentering) ---> finishing

* Dyeing process
(scouring) ---> (tentering) ---> (dyeing) ---> (tentering)
---> (finishing)

D. Water/wastewater condition

1) Water consumption

Industrial water	:	630 m^3/day
City water	:	20 m^3/day
Steam	:	70 t/day

2) Water consumption ratio in each process

Scouring	:	300 m^3/day
Dyeing	:	200 m^3/day
Printing	:	50 m^3/day
Water washing	:	100 m^3/day

E. Sample and analysis

1) Sample
a. Waste washing water from dyeing process (Silk textile)
b. Waste washing water from printing process (Silk textile)
c. Effluent from mixing room for printing
d. Total effluent

2) Analysis
See Table 1.3.7

F. Other hearing information

1) Raw textile is first scoured.

Table 1.3.7 Analytical Value of Effluent Quality (Factory No. 6)

(1) Sample

a. Waste washing water from dyeing process (Silk textile)

b. Waste washing water from printing process (Silk textile)

c. Effluent from mixing room for printing

d. Total effluent

(2) Analytical Value

Items		Samples			
		a	b	c	d
pH	[-]	5.4	7.5	7.2	6.7
SS	[mg/ℓ]	3.5	66.0		44.3
COD_{Mn}	[mg/ℓ]	841.7	425.9	5060.1	574.5
BOD_5	[mg/ℓ]	228.0	270.0	2040.0	330.0
n-Hex	[mg/ℓ]	6.0	35.3		16.0
T-P	[mg/ℓ]				4.7
T-N	[mg/ℓ]				0.2
Color	[deg.]	511	570	27600	1530
Temparature	[°C]				23

2) This factory has a processing department and on international department in the site. The above values are from the former.
3) Water is not reused. Steam condensed water is mixed with industrial water for reclamation.
4) Heat is not specially recovered.

(7) No. 7 factory

A. Business

Dyeing of nylon textile (95% of processing) for underwear.
Dyeing of cotton textile and polyester/cotton textile.
Processing volume ... Width 10 mm - 84 inches x 14 miilion yards/year

B. Dyeing machine

Beam	4 sets
Rapid	6 sets
Circular	3 sets
Winch	4 sets
Jigger	3 sets

C. Production process

* Nylon textile dyeing process
(scouring) —> (dyeing) —> (finishing)

* Cotton textile dyeing process
(desizing) —> (scouring) —> (dyeing) —> (finishing)

* P/C textile dyeing
(scouring) —> (presetting) —> (dyeing)
—> (water washing) —> (finishing)

D. Water/waste water condition
1) Water consumption

Industrial water	:	1,000 m^3/day
City water	:	30 m^3/day

Steam : 90 t/day

2) Water consumption ratio in each process

Scouring	:	100 m^3/day
Dyeing	:	350 m^3/day
Cooling tower	:	500 m^3/day (cleaning water)

E. Sample and analysis

1) Sample

a. Waste washing water from scouring process (Nylon textile)

b. Waste washing water from dyeing process (Nylon textile)

c. Total effluent

2) Analysis

See Table 1.3.8

F. Other hearing information

1) The most water consuming process is nylon dyeing (including water washing process after dyeing).

2) Washing water once used in light colour dyeing process is sometimes re-used for dark colour dyeing.
Reclaimed water is about 50 - 100 m^3/day.
No heat is recovered.

3) Light colour dyeing does not need much washing water, while dark colour dyeing requires much water.

4) They have 2 dyeing machines named "Himerit", which operate when it is nylon or polyester with cotton yarn embroidery which requires double dyeing work.

5) They have filter and activated carbon equipment for industrial water treatment.

6) Colouring was hardly found in general drainage.
It seems to be due to mainly light colour dyeing performed at the factory.

(8) Factory No. 8

A. Business

Table 1.3.8 Analytical Value of Effluent Quality (Factory No.7)

(1) Sample

a. Waste washing water from scouring process (Nylon textile)

b. Waste washing water from dyeing process (Nylon textile)

c. Total effluent

(2) Analytical Value

Items		Samples		
		a	b	c
pH	[-]	8.0	7.3	8.0
SS	[mg/ℓ]	113.5	6.5	22.0
COD_{Mn}	[mg/ℓ]	111.7	184.4	152.3
BOD_5	[mg/ℓ]	105.0	50.0	210.0
n-Hex	[mg/ℓ]	117.3	4.6	22.7
T-P	[mg/ℓ]			2.6
T-N	[mg/ℓ]			0.7
Color	[deg.]		88	141
Temparature	[°C]			45

Mainly knit (cotton and P/C).

Printing has just begun.

Processing quantity

Dyeing ... 2,540 t/year

(cotton: 1,160 t/year, P/C: 1,380/year)

Printing .. 0.48 million yards/years

B. Dyeing machine

Jet dyeing machine	9 sets
Winch	18 sets
Printing machine	4 sets

C. Production process

* Cotton knit dyeing process

(desizing) —> (scouring) —> (bleaching)

—> (marcerizing) —> (dyeing or printing)

—> (finishing)

D. Water/wastewater condition

1) Water consumption

Industrial water : 2,000 m^3/day

(dyeing ... 1,700 m^3/day,

printing .. 300 m^3/day0

City water : 3 m^3/day

(for dining room use only)

Steam : 200 t/day

2) Water consumption ratio in each process

Scouring	: 315 m^3/day
Bleaching	: 300 m^3/day
Marcerizing	: 1,300 m^3/day
Water washing	: 450 m^3/day

E. Sample and analysis

1) Sample

a. Total effluent from circular type dyeing machines (Knit)

b. Total effluent from wince type dyeing machines (Knit)

c. Total effluent

2) Analysis
See Table 1.3.9

F. Other hearing information

1) Heat recovery is made, and water heated up around at 60°C is utilized for bath dyeing liquor.
2) Industrial water is treated; sand filtration —> activated carbon adsorption —> ion exchange.

(9) Factory No. 9

A. Business

Knit dipping	150,000 yards/day
Knit dyeing	30,000 yards/day

The materials are P/C (60%), cotton (30%) and others (10%).

B. Dyeing machine

Continuous dyeing machine	1 set (cap. 100,000 yards/day
Jigger	8 sets
Jet dyeing machine	3 sets
Printing machine	3 sets

C. Production process

(desizing) —> (scouring) —> (bleaching)
—> (marcerizing) —> (dyeing or printing)
—> (finishing)

D. Water/wastewater condition

1) Water consumption
Industrial water : 2,500 m^3/day
(dyeing 1,700 m^3/day,
printing 300 m^3/day)

Table 1.3.9. Analytical Value of Effluent Quality (Factory No.8)

(1) Sample

a. Total effluent from circular type dyeing machines (knit)

b. Total effluent from wince type dyeing machines (knit)

c. Total effluent

(2) Analytical Value

Items		Samples		
		a	b	c
pH	[-]	9.7	10.4	10.2
SS	[mg/ℓ]	9.0	18.0	14.5
COD_{Mn}	[mg/ℓ]	334.0	350.7	303.9
BOD_5	[mg/ℓ]	105.0	101.3	108.0
n-Hex	[mg/ℓ]	10.0	9.3	10.7
T-P	[mg/ℓ]			2.5
T-N	[mg/ℓ]			1.9
Color	[deg.]	10.0	9.3	10.7
Temparature	[°C]			44

City water : 10 m^3/day
(for dining room use only)
Steam : 320 t/day

2) Water consumption ratio in each process

Scouring	:	50 m^3/day
Bleaching	:	130 m^3/day
Dyeing	:	750 m^3/day
Water washing	:	1,500 m^3/day

E. Sample and analysis

1) Sample
   a. Total effluent from pretreatment process of the continuous dyeing machine (P/C textile)
   b. Waste washing water from marcerizing process of the continuous dyeing machine (P/C textile)
   c. Waste washing water from dyeing process of the continuous dyeing machine (P/C textile)

2) Analysis
   See Table 1.3.10

F. Other hearing information

1) Industrial water is utilized after filtration and softening.
2) Wastewater reclamation is difficult, but countercurrent soaping water and cooling water are effectively reused for washing water or dyeing process water.

3) NaOH concentrated wastewater in marcerizing process of continuous dyeing machine is sold to a collector. The condensed liquid in the dyeing bath is exchanged at each lot.

(10) Factory No. 10

A. Business

Dyeing of polyester (jacket materials) knit processing 1.6 million yards/year x 44 inches

Table 1.3.10 Analytical Value of Effluent Quality (Factory No. 9)

(1) Sample

a. Total effluent from pretreatment process of the continuous dyeing machine (P/C textile)

b. Waste washing water from marcerizing process of the continuous dyeing machine (P/C textile)

c. Waste washing Water from dyeing process of the continuous dyeing machine (P/C textile)

d. Total effluent

(2) Analytical Value

Items		Samples			
		a	b	c	d
pH	[-]	11.0	12.7	12.0	11.3
SS	[mg/ℓ]	28.0	179.0	44.5	27.0
COD_{Mn}	[mg/ℓ]	225.5	150.3	96.2	390.8
BOD_5	[mg/ℓ]	175.0	46.0	35.0	105.0
n-Hex	[mg/ℓ]	63.3	19.3	35.3	22.0
T-P	[mg/ℓ]				1.7
T-N	[mg/ℓ]				0.8
Color	[deg.]			2010	8300
Temparature	[°C]				50

B. Dyeing machine

Low liquor ratio dyeing machine 2 sets and others

This factory has unique finishing process followed by dyeing, but hardly uses water for finishing.

C. Production process

(desizing) —> (scouring) —> (dyeing) —> (finishing)

D. Water/wastewater condition

1) Water consumption

Industrial water	:	1,000 m^3/day
City water	:	30 m^3/day
Steam	:	75 t/day

2) Water consumption ratio in each process

Desizing	:	140 m^3/day
Scouring	:	143 m^3/day
Dyeing	:	290 m^3/day
Water washing	:	380 m^3/day

E. Sample and analysis

1) Sample
   a. Total effluent
2) Analysis
   See Table 1.3.11

F. Other hearing information

1) Water is used after activated carbon process.
   The purpose of this treatment is to eliminate chlorine; however, details are unknown.
2) At present, over 50% of the whole dyeing is performed by low liquor ratio dyeing machines.
   Purchasing another machine is scheduled in November this year.
   Liquor ratio is 1:3.
3) This factory is saving water by the introduction of a high-frequency scouring machine and a low liquor ratio type dyeing machine, and is also saving energy by installing a heat exchanger in the dyeing ma-

Table 1.3.11 Analytical Value of Effluent Quality (Factory No.10)

(1) Sample

a. Total effluent

(2) Analytical Value

Items		Samples
		a
pH	[-]	10.2
SS	[mg/ℓ]	38.0
COD_{Mn}	[mg/ℓ]	143.6
BOD_5	[mg/ℓ]	55.0
n-Hex	[mg/ℓ]	52.2
T-P	[mg/ℓ]	0.5
T-N	[mg/ℓ]	1.1
Color	[deg.]	274
Temparature	[°C]	45

chine.

(11) Factory No. 11

A. Business

Dyeing of acetate knit
44 inches x 20 million yards/year
Dyeing of rayon & nylon textile
44 inches x 0.5 million yards/year

B. Dyeing machine

Jigger, jet dyeing machine

C. Production process

(desizing) —> (scouring) —> (bleaching) —> (dyeing) —> (finishing)

D. Water/wastewater condition

1) Water consumption

Industrial water	:	1,000 m^3/day
City water	:	2 m^3/day
Steam	:	120 m^3/day

2) Water consumption ratio in each process

Scouring	:	300 m^3/day
Dyeing	:	200 m^3/day
Water washing	:	500 m^3/day

E. Sample and analysis

1) Sample
   a. Total effluent
2) Analysis
   See Table 1.3.12

F. Other hearing information

1) Industrial water is not treated, but chemical treatment is done in case

Table 1.3.12 Analytical Value of Effluent Quality (Factory No. 11)

(1) Sample

a. Total effluent

(2) Analytical Value

Items		Samples
		a
pH	[-]	6.9
SS	[mg/ℓ]	232.0
COD_{Mn}	[mg/ℓ]	2014.2
BOD_5	[mg/ℓ]	860.0
n-Hex	[mg/ℓ]	174.0
T-P	[mg/ℓ]	5.3
T-N	[mg/ℓ]	4.3
Color	[deg.]	7400
Temparature	[°C]	43

of cation dye application.

2) This factory is saving water & energy by heating steam condensed water and cooling water drainage to be utilized as hot water.

3) The final products of acetate are mostly used for clothes linings.

(12) Factory No. 12

A. Business

Dyeing of acetate & polyester textile processing 70 million yards/year x 44, 48, 54 inches (80% ... acetate)

B. Dyeing machine

Jigger	24 sets (high pressure ... 2 sets, normal pressure ... 22 sets)
Beam	2 sets
Winch	1 set
Jet dyeing machine	1 set

C. Production process

(Scouring) —> (dyeing) —> (finishing)

D. Water/wastewater condition

1) Water consumption

Industrial water	:	700 m^3/day
City water	:	7 m^3/day
Steam	:	30 t/day

2) Water consumption ratio in each process

Scouring	:	130 m^3/day
Dyeing	:	130 m^3/day
Water washing	:	410 m^3/day

E. Sample and analysis

1) Sample

a. Waste washing water from scouring process (Acetate textile)
b. Dye-stuff solution (Acetate textile)
c. Waste washing water from dyeing process (Acetate textile)
d. Total effluent

2) Analysis
See Table 1.3.13

F. Other hearing information

1) Industrial water is not treated.
2) Steam condensed water is utilized as hot water.
3) pH of general drainage is always checked with pH test paper. But no special countermeasure is possible, even though pH value exceeds the standard.

(13) Factory No. 13

A. Business

Dyeing of P/C mixed knit	2,400 t/year
Dyeing of cotton knit	1,200 t/year
Dyeing machine	
Jet dyeing machine	6 sets
Vertical dyeing machine	13 sets

B. Production process

* P/C mixed knit dyeing process
  (desizing) —> (scouring) —> (bleaching) —> (dyeing) —> (finishing)
* Cotton knit dyeing process
  (desizing) —> (scouring) —> (bleaching) —> (marcerizing) —> (dyeing) —> (finishing)
  Marcerizing is performed once in a while.

C. Water/wastewater condition

1) Water consumption
Industrial water : 2,400 m^3/day

Table 1.3.13 Analytical Value of Effluent Quality (Factory No.12)

(1) Sample

a. Waste washing water from scouring process (Acetate textile)

b. Dye-stuff solution (Acetate textile)

c. Waste washing water from dyeing process (Acetate textile)

d. Total effluent

(2) Analytical Value

Items		Samples			
		a	b	c	d
pH	[-]	7.0	6.2	7.2	6.5
SS	[mg/ℓ]	39.0	110.0	6.0	74.0
COD_{Mn}	[mg/ℓ]	190.4	5611.2	1853.7	721.4
BOD_5	[mg/ℓ]	74.0	5250.0	555.0	315.0
n-Hex	[mg/ℓ]	48.7		52.0	126.0
T-P	[mg/ℓ]				0.8
T-N	[mg/ℓ]				1.7
Color	[deg.]		45000	356	2010
Temparature	[°C]				31

City water : 6 m^3/day
Steam : 150 t/year

2) Water consumption ratio in each process
Desizing : 120 m^3/day
Bleaching : 240 m^3/day
Dyeing : 480 m^3/day
Water washing : 1,200 m^3/day

D. Sample and analysis

1) Sample
a. Waste washing water from dyeing process (Cotton knit)
b. Total effluent
2) Analysis
See Table 1.3.14

E. Other hearing information

1) Industrial water flows; sand filtration —> activated carbon adsorption —> ion exchange —> storage in an overhead tank ready for use
2) The present dyeing machines have a comparatively large liquor ratio of about 1:10. The introduction of a low liquor ratio machine is hardly possible, because its cost is too high.
3) pH of total effluent is always checked with pH test paper but no special countermeasure is available even if pH value exceeds the standard.
4) Future water consumption may increase up to 2,300m^3/day; however, it cannot be guaranteed in consideration of possible future depression of the textile industry.
5) Measures to save energy and water is taken by the recycling of cooling water.

(14) Factory No. 14

A. Business

Chiefly dyeing polyester textile for car interiors, partly dyeing yarns
Polyester textile dyeing ... 3.3 million yards/year

Table 1.3.14 Analytical Value of Effluent Quality (Factory No. 13)

(1) Sample

a. Waste washing water from dyeing process (Cotton knit)

b. Total effluent

(2) Analytical Value

Items		Samples	
		a	b
pH	[-]	10.2	10.5
SS	[mg/ℓ]	248.0	41.5
COD_{Mn}	[mg/ℓ]	634.6	92.2
BOD_5	[mg/ℓ]		54.0
n-Hex	[mg/ℓ]		8.7
T-P	[mg/ℓ]		6.8
T-N	[mg/ℓ]		2.5
Color	[deg.]	12900	1610
Temparature	[°C]		45

yarn dyeing ... 120 t/year

B. Dyeing machine

Jet dyeing machine 6 sets

C. Production process

(scouring) —> (dyeing) —> (finishing)

D. Water/wastewater condition

1) Water consumption

Industrial water	:	580 m^3/day
Subterranean water	:	130 m^3/day
City water	:	30 m^3/day
Steam	:	84 t/day

2) Water consumption ratio in each process

Scouring	:	70 m^3/day
Dyeing	:	570 m^3/day

E. Sample and analysis

1) Sample
   a. Scouring process drainage
   b. Drainage of dyeing process water cleaning
   c. Dyeing process drainage + living drainage tank
   d. General drainage
2) Analysis
   See Table 1.3.15

F. Other hearing information

1) Besides industrial water, underground water is also utilized after softening process, as its original hardness is 200 - 300 mg/l.
2) The well is 160 m deep.
3) Free drawing of underground water is approved but the water volume is reported to the cooperative. Some of other cooperative member companies are also utilizing underground water.

Table 1.3.15 Analytical Value of Effluent Quality (Factory No. 14)

(1) Sample

a. Effluent from scouring process (Polyester textile)

b. Waste washing water from dyeing process (Polyester textile)

c. Total effluent from dyeing process (Polyester textile)

d. Total effluent

(2) Analytical Value

Items		Samples			
		a	b	c	d
pH	[-]	7.0	7.6	6.9	6.9
SS	[mg/ℓ]	26.0	1.5	26.0	38.0
COD_{Mn}	[mg/ℓ]	55.3	14.8	151.5	134.9
BOD_5	[mg/ℓ]	75.0	4.5	54.4	60.0
n-Hex	[mg/ℓ]	156.0	2.0		32.7
T-P	[mg/ℓ]				0.7
T-N	[mg/ℓ]				2.3
Color	[deg.]		201	1510	1250
Temparature	[°C]				33

4) Industrial water supply in Ansan City sometimes runs short in summer.
5) As corn oil is used in the material textile, the pollution load seems to be rather light.
6) As a water-saving countermeasure, about 360 m^3/day of washing water used in dyeing process is circulated to be utilized.

(15) Factory No. 15

A. Business

Tanning, partly dyeing

Fox	10,000/month
Rabbit	25,000/month
Mink	18,000/month

and laundry

B. Production process

(soaking) —> (water washing) —> (pickling) —>
(tanning) —> (finishing)

C. Water/wastewater condition

1) Water consumption

Industrial water	:	140m^3/day
City water	:	10m^3/day
Steam	:	30m^3/day

2) Water consumption ratio in each process

Soaking	:	8 m^3/day
Water washing	:	8 m^3/day
Pickling	:	8 m^3/day
Tanning	:	8 m^3/day
Dyeing	:	8 m^3/day
Laundry	:	100 m^3/day

D. Sample and analysis

1) a. Effluent from tanning and dyeing process (before chelate treatment)

b. Effluent from tanning and dyeing process
(after chelate treatment)

c. Laundry effluent

d. Total effluent

2) Analysis
See Table 1.3.16

E. Other hearing information

1) Cr coming out from tanning process is treated within the factory.
Cr^{3+} is partly hydroxide to be precipitated and eliminated, and Cr^{6+} after chelate formation is discharged outside.

2) Laundry process shares the majority consumption of water.

Table 1.3.16 Analytical Value of Effluent Quality (Factory No. 15)

(1) Sample

a. Effluent from tanning and dying process (before chelate treatment)

b. Effluent from tanning and dying process (after chelate treatment)

c. Laundry effluent

d. Total effluent

(2) Analytical Value

Items		Samples			
		a	b	c	d
pH	[-]	4.4	4.1	11.0	6.5
SS	[mg/ℓ]	490.0	570.0	56.0	473.0
COD_{Mn}	[mg/ℓ]	143.6	390.8	110.2	188.4
BOD_5	[mg/ℓ]	113.3	380.0	145.0	150.0
n-Hex	[mg/ℓ]	55.3	118.0	73.3	57.3
T-P	[mg/ℓ]				0.1
T-N	[mg/ℓ]				0.2
Color	[deg.]				44
Cr^{6+}	[mg/ℓ]	ND	ND		ND
Cr	[mg/ℓ]	114.0	241.9		209.4
Al	[mg/ℓ]				0.1
Temparature	[°C]				33

* ND ; not detected

1.3.2 Pollutants

Pollutants in wastewater from dyeing processing factories vary, depending on each factory's production and process. Intensive discharge of main pollution factors such as problematic pH, BOD and COD from particular processes in wastewater treatment is one of specific features of wastewater from dyeing process and is important when determining treatment measures.

Pollutants and specific features of wastewater are mentioned below in classified production process.

(1) Desizing, scouring process

A. Object fibers

Cotton, synthetic fibers

B. Pollutants

Fiber rubbish, decomposer of sizing agent, sizing agent, desizing agent, oil, surface active agent, weak acid, alkali

C. Others

Solely 2 factories out of 14 surveyed (excluding Factory No. 15) do not perform desizing or scouring work because such factories use pretreated materials. Object fibers in dyeing process are chiefly cotton, and others are P/C, polyester and acetate.

Almost all textiles go through scouring process. Most of the factories do not grasp sizing agents or oils used in the raw materials. However, some of the factories are considered to be concerned about wastewater treatment, because they use corn oil applied raw materials which can easily be treated biologically. In general, the BOD contaminant rate is seen high when desizing and scouring process is through, and 2/3 of the entire BOD volume produced from all the processes is produced there form.

(2) Bleaching process

A. Object fibers

Cotton, synthetic fibers

B. Pollutants

Chlorine, chlorine decomposition, textiles mixture, surface active agent, salt

C. Others

It is found though factory survey that bleaching is processed only in light colour dyeing.

(3) Marcerizing process

A. Object fibers

Cotton, P/C mixed

B. Pollutants

NaOH, fiber materials

C. Others

3 out of 14 factories surveyed (excluding Factory No.5) are carrying out marcerizing process. Drainage from marcerizing process has a high pH level, therefore requiring much acid for neutralization in waste water treatment processing. Some factories surveyed are collecting NaOH from concentrated wastewater produced from marcerizing process by themselves within the factories, or through a company dedicated to the collection of pollutants.

(4) Dyeing process

A. Object fibers

Cotton, P/C

B. Pollutants

Un-reacted dyestuff remnant, processing aid, surface active agent, other chemicals

C. Others

This process produces the largest variety of ingredients in waste liquid. When printing is required, there is another addition sizing agent and dyestuff solvent to the above pollutants. The factory survey result shows that there are various dyestuffs such as reactive dye, dispersed dye, acidic dye, and cationic dye being used. It seems that a variety of processing aids are also used depending on the kind of dye.

1.3.3 Chemicals used

Different sorts of chemicals are used in individual processes. Any further information on kinds and quantities of chemicals used is unknown; however, each factory has its own way. An outline is mentioned below regarding chemicals used in each process:

* Desizing process
  Enzyme, desizing agent
* Scouring proves
  NaOH, surface active agent
* Bleaching process
  Soda hypochlorite, soda chlorite, hydrogen peroxidex
* Marcerizing process
  NaOH
* Dyeing process
  Dyestuff, processing aid, sizing agent, surface active agent
* Finishing process
  Softening agent, sizing agent, finishing agent
  Wastewater produced is in finishing process very little.

1.4 Water and Wastewater Systems

The current water supply system for each factory and reclamation and wastewater discharge systems are described below:

(1) Water supply system

City water, industrial water and steam are the three essential elements composing the water supply system. Besides, underground water is also utilized by some factories. City water and industrial water are supplied under an agreement with Ansan City, and steam is supplied under an agreement with the dyeing estate power station.

City water is chiefly used as domestic water. There are different ways of city water usage in different factories. Some factories use city water for drinking only, while other factories have a wider range of usage, for example, from drinking and washing of toilet. Total quantity of city water agreed to be supplied to the entire industrial estate is about 5,000m^3/day.

Industrial water is chiefly used as processing water (partly for living water). 60,000 m^3/day is the total quantity of industrial water agreed to be supplied to the entire dyeing estate. Each factory has an industrial water storage tank within the factory in anticipation of shorter supply of industrial water (most possible in summer). Whenever necessary, industrial water is used as processing water after softening treatment by sand filtration —> activated carbon adsorption —> ion exchange, and pretreatment with chemicals. According to factory hearing results, raw water with hardness 50 - 70 mg/l is softened to hardness 8 - 10 mg/l. Generally the industrial water quality is good; however, it deteriorates during water shortage in summer.

Steam is utilized to heat up dyeing bath liquid and washing water. Steam condensed water is mixed with industrial water to be utilized, and, in certain factories, even condensed water is partly used for living water. The majority of factories surveyed this time have boilers; however, all the boilers only for emergency occasions.

Underground water is utilized by several factories of the cooperative mainly for the dry season in summer. They are allowed to draw some form their well; however, the quantity of water drawn up is to be reported to the cooperative. As this dyeing estate is located on the land reclaimed from a beach the well is 160 m deep to avoid sea water invasion. The hardness of underground water is as high as 200 - 300 mg/l, and thus, it is softened before being used.

(2) Re-use within factory

The factory survey results show the following 3 patterns of water re-use:

A. Re-use of steam condensed water

The quality of steam condensed water is equal to the City water level.

B. Re-use of cooling water for washing water

Practiced by most of the factories to gather with heat recovery for washing water or dyeing bath liquid.

C. Re-use of washing water in the front of dyeing bath

Washing water once used for light colour dyeing process is reused for dark colour dyeing. Only one factory follows this process. The amount of washing water reused is 5 to 10% of the total water consumption.

(3) Drainage

Living water is stored at a factory septic tank for a while and is drained later to the central treatment plant. Any treatments including aeration and coagulation/sedimentation are not particularly performed for the septic tank.

Drainage from each process is separated into hot and cool water is mixed with cool water after neat recovery is made and is drained into the central treatment plant. However, some factories discharge drainage from process without heat recovered into the central treatment plant. There is only one plumbing from each factory down to the central treatment plant. Living drainage and drainage from processes are mixed together at the outlet of the factory to be discharged. Rain-water is directly drained into the sea through the other plumbing, and does not flow into the central treatment plant. Factories conduct the following 2 pre-treatments.

A. pH adjustment

Solely one factory among those surveyed is continuously measuring pH in the general drainage in order to maintain the pH value under 11.0. All the other factories do not try to adjust pH. (However, some of the factories are periodically measuring pH.)

B. Chrome treatment

At one factory draining chrome contained wastewater, Cr^{3+} is converted into hydroxide partial and eliminate purposes and Cr^{6+} undergoes chelate formation before being drained into the central treatment plant.

Some factories have wastewater storing tanks and grit chambers set at the outlet of the general drainage to standardize the wastewater quality.

(4) Water cost and wastewater treatment costs

Water cost and wastewater treatment costs are shown in Table

1.4.1. The quantity for the sake of convenience shall be the sum of City water and industrial water examined.

Table 1.4.1 Cost/fee of Water and Waste Water

Items	Cost/Fee
Drinking Water	180Won/m^3
Industrial Water	110Won/m^3
Steam	5,250Won/t
Waste Water (received)	450Won/m^3
Sewage (discharge)	85Won/m^3

1.5 Condition of Wastewater Treatment and Reclamation Plants

This section covers the facilities' detailed specification, layout, operation, maintenance/management condition, inflow water quality and treated water quality.

(1) Specification of treatment facilities

Fig. 1.5.1 shows how the treatment facilities operate, and Fig. 1.5.2 indicates the treatment facilities' layout. Treatment process consists of the combination of physicochemical treatment and biological treatment. Wastewater is drained into stabilization tank after chelate formation of heavy metals in a pump pit is done and is afterward treated in either of 2 systems.

The following explanation is the summary of treatment procedures according to process in each system.

A. The old system

1) Coagulation/sedimentation treatment

NaOH is added to wastewater to have pH10 adjust PH value to 10, and further addition of $FeCl^2$, cationic coagulant and polymer is made for coagulation/sedimentation treatment to eliminate COD as seen in colouring materials.

2) Biological treatment

Sulfuric acid for pH adjustment and nutrients (phosphorus, nitrogen) are added for biological treatment to eliminate BOD ingredients.
When aeration capacity get worse due to high water temperature in summer, hydrogen peroxide is added to supplement the insufficient aeration capacity.

3) Sedimentation treatment

Wastewater after sedimentation and elimination of SS ingredients is mixed with water treated by the new system.

B. The new system

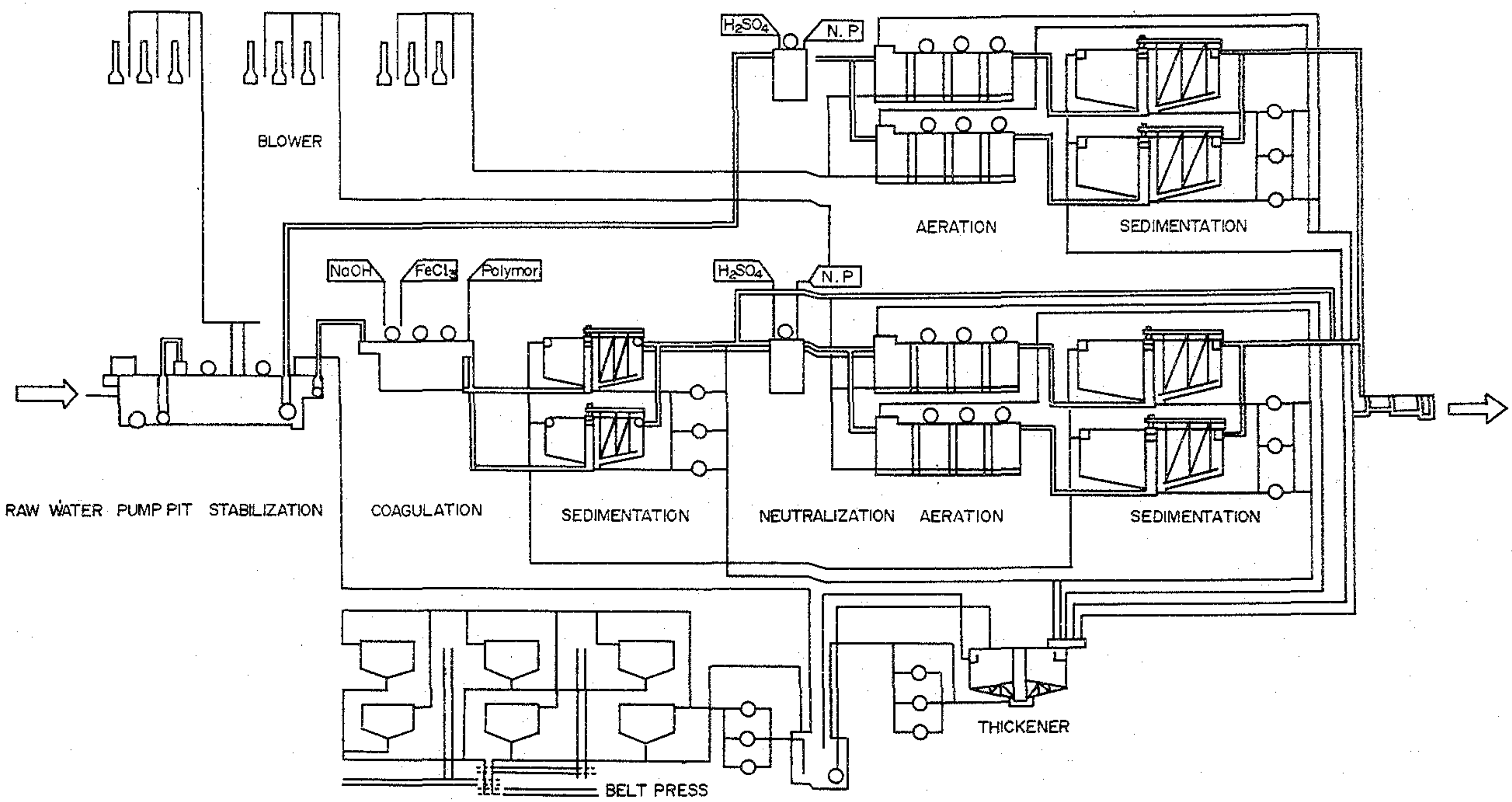


Fig. 1. 5. 1 Flowchart of Treatment in Central Waste Water Treatment Plant

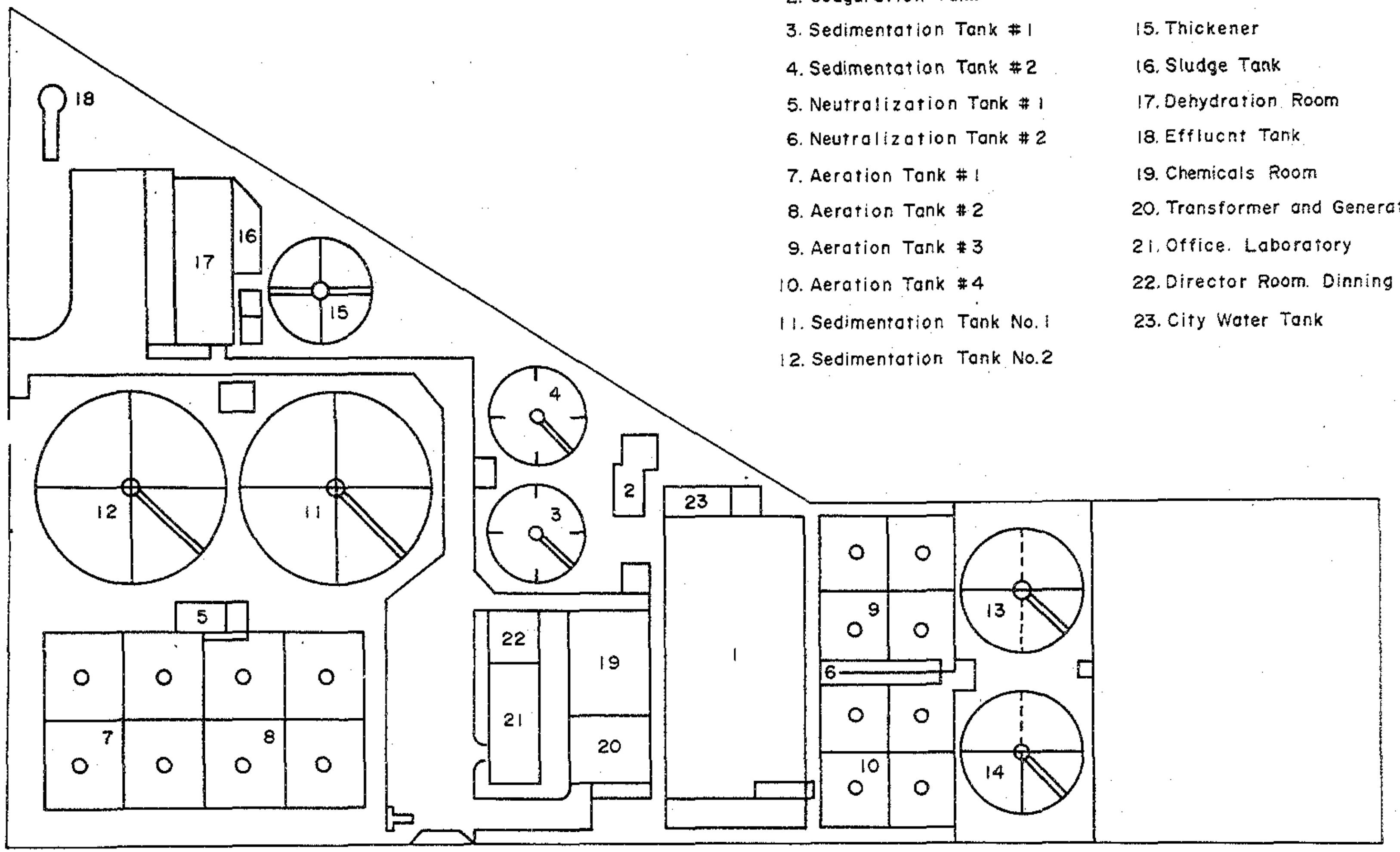


Fig. 1.5.2 Layout of Central Waste Water Treatment Plant

1) Biological treatment

2) Sedimentation treatment

After the above treatment is conducted, again soda hyposulfite is added for reduction process to eliminate COD ingredients (colouring materials) and is discharged into quality the Ansan City sewage terminal treatment plant.

For reference, Table 1.5.1 shows analysis data on the quality of wastewater sampled on a process-by-process basis when the visiting survey was made to the central treatment plant.

Cationic condensing agent is added to excess sludge for condensation, which is then dehydrated by a belt press filter. The dehydrated sludge is transported to the treatment plant to be reclaimed. Sludge treatment charge is Won 46,800/t.

The facilities treat wastewater alone and do not recycle it.

Table 1.5.2 shows specifications of the wastewater treatment facilities.

(2) Operation condition

Yearly change is shown in Chart 1.5.3 - 5 on both quality of inflow original water and treated water. The quality and condition of wastewater is almost stable throughout the year, and that of treated water is good, generally. However, sludge in August 1991 when bulking occurred. Supposedly, it was because of aeration capacity shortage due to a rise in wastewater temperature.

Table 1.5.3 shows the consumption of chemicals at this treatment plant and also gives a price list of the chemicals.

(3) Maintenance/management condition

The quantity and pH of the inflow raw water are continuously measured, while COD and pH of the treated water are likewise measured. Besides, such fundamental water quality is daily checked and $CODM^n$, BOD^5, SS, hexane extract, temperature and colouring both in inflow raw water and treated water are also checked.

Table 1.5.1 Quality of Raw Water and Treated Water in Central Waste Water Treatment Plant

1. Sample

a. Flow in waste water(Stabilization Tank)

b. After treatment of coagulation and sedimentation

c. Aeration tank (No.8)

d. After treatment of coagulation, sedimentation, activated sludge and sedimentation

e. Aeration tank (No.14)

f. After treatment of activated sludge and sedimentation

g. Total effluent

2. Analytical Value

Items		Samples			
		a	b	c	d
pH	[-]	10.2	9.9	7.4	7.3
Conductivity	[μ s/cm]				
SS	[mg/ℓ]	1110.0	260.0	2855.6	16.0
COD_{Mn}	[mg/ℓ]	741.5	307.3		89.1
BOD_5	[mg/ℓ]	290.0	192.0		18.8
n-Hex	[mg/ℓ]	60	41.3		4.5
T-P	[mg/ℓ]	9.1			
T-N	[mg/ℓ]	4.0			
Color	[deg.]	2940	2630		660
MLVSS	[mg/ℓ]			2322.2	
Temparature	[°C]	37.2	36.0		
Turbility	[deg.]	500	260		
DO	[mg/ℓ]			0.2 - 3.5	

Table 1.5.1 Quality of Raw Water and Treated Water in Central Waste Water Treatment Plant

(continue)

Items		Samples		
		e	f	g
pH	[-]	7.2	7.2	7.3
Conductivity	[μ s/cm]			193
SS	[mg/ℓ]	4500.0	71.1	15.0
COD_{Mn}	[mg/ℓ]		172.3	80.2
BOD_5	[mg/ℓ]		52.5	23.0
n-Hex	[mg/ℓ]		11.3	5.0
T-P	[mg/ℓ]			1.1
T-N	[mg/ℓ]			3.1
Color	[deg.]		1240	353
MLVSS	[mg/ℓ]	3442.9		
Temparature	[°C]	34.4	30.3	
Turbility	[deg.]		28	
DO	[mg/ℓ]	0.1 - 3.2		

Table 1.5.2 Specification of Equipmet in Central Waste Water Treatment Plant

No.	NAME	Q'TY	MATERIAL	SPECIFICATION	REMARK
	GRIT CHAMBER	1	RC	$29m^L x2m^W x6m^H$	pHIR
	SAND PUMP	1		$80Ax0.3m^3/mx10m^H x3.7kW$	
	SLUDGE COLLECTER	1		0.6m/m	
	AUTO SCREEN	1		$3,000m^3/hr$, Pith 10mm	
	PUMP PIT	1	RC	$24m^L x4m^W x6.3m^H$	
	PUMP	8		300Ax10.5m3/mx14mHx37kW	LICA
1	STABILIZATION	1	RC	$42m^H x28m^W x6.3m^H$	LIA, LS
	PUMP	7		$300Ax10.5m^3/mx14mHx37kW$	LICA
	BLOWER	3		$150Ax25.9m^3/mx6,000mmAqx45kW$	
	DISTRIBUTION TANK	1		$120,000m^3/D$	FIRQ
	pH ADJUSTMENT CHAMBER	1	RC	$5m^L x5m^W x4.6m^H$	pHICR
	AGITATOR	1			
2	COAGULATION	2	RC		
	AGITATOR	2			
3, 4	SEDIMENTATION #1, 2	2	RC	$\phi 18mx3m^H$	
5	NEUTRALIZATION CHAMBER	1	RC	$5.5m^L x4.5m^W x5.6m^H$	pHICR, FIRQ
·	AGITATOR	1		1/87x5.5kW	
6	NEUTRALIZATION CHAMBER	1	RC	$19.45m^L x2m^W x2.9m^H$	pHICR, FIRQ
	AGITATOR	1		60x3.75kW	
7, 8	AERATION TANK #1, 2	4x2	RC	$15.6m^L x15.6m^W x5.3m^H$	DOIR, TIR, FIRQ
	AERATOR	4x2		55kW, 45kW, 45kW, 37kW	
	BLOWER	3		$150Ax25.9m^3/mx6,000mAqx45kW$	
9, 10	AERATION TANK #3, 4	1x2	RC	$53m^L x14.5m^W x7m^H$	DOIR, TIR, FIRQ
	SUBMERSIBLE AERATOR	4x2		$65kg\text{-}O_2/hrx30kW$	
	BLOWER	3x2		$200Ax45.2m^3/mx6,000mAqx75kW$	

Table 1.5.2 Specification of Equipmet in Central Waste Water Treatment Plant (continue)

No.	NAME	Q'TY	MATERIAL	SPECIFICATION	REMARK
11, 12	SEDIMENTATION No. 1, 2	2	RC	37m ϕ x3m^{H}	
	SCRAPER	2		1.5kW	
	PUMP	3		250Ax7m^{3}/mx8mHx30kW	
13, 14	SEDIMENTATION NO. 3, 4	2	RC	29m ϕ x3m^{H}	LICA
	SLUDGE COLLECTOR	2		0.6m/m	
	PUMP	2x2		300Ax10.5m^{3}/mx14mHx37kW	
	SLUDGE PIT	1		13m^{L}x2m^{W}x4.2m^{H}	LICA
	PUMP	2		300Ax10.5m^{3}/mx14mHx37kW	
	SCUM PIT	2		5.5m^{L}x2.6m^{W}x2.1m^{H}	LCA
	PUMP	2x2		80Ax0.3m^{3}/mx10mHx3.7kW	
15	THICKENER	1		20m ϕ x4m^{H}	
	SLUDGE COLLECTOR	1		1.5kW	
16	SLUDGE TANK	1		13.3m^{L}x6m^{W}x4m^{H}	LAC
	PUMP	4		0.4m^{3}/mx15m^{H}x5.5kW	
	BLOWER	2		4m^{3}/mx4,000mmAqx7.5kW	
18	EFFLUENT TANK	1		12.9m^{L}x2m^{W}x3.5m^{H}	CODR, pHIR
	CITY WATER TANK	1		13.5m^{L}x5.5m^{W}x3.5m^{H}	LAC
	PUMP	2		1.5m^{3}/mx50mHx22kW	
	ALUM TANK	1		6m^{L}x6m^{W}x3.5m^{H}	LA
	PUMP	2		0.4m^{3}/mx10m^{H}x3.7kW	
	AGITATOR	2		15kW	
	$Ca(OH)_2$ TANK	1		3m^{L}x3m^{W}x3.5m^{H}	LA
	PUMP	2		0.2m^{3}/mx30m^{H}x2.2kW	
	AGITATOR	2		7.5kW	

Table 1.5.2 Specification of Equipmet in Central Waste Water Treatment Plant (continue)

No.	NAME	Q' TY	MATERIAL	SPECIFICATION	REMARK
	H_2SO_4 TANK	1		4mφx3.5m"	
	PUMP	3		20ℓ/mx15m"x1.5kW	
	NUTRITIOUS TANK	2		2,194mmφx2445mm"	LA
	PUMP	3		10ℓ/mx20m"x0.75kW	
	AGITATOR	2		3.75kW	
SLUDGE TREATMENT SYSTEM					
17	BELT PRESS	6		$16m^3$/hr	
	VELT CONVEYOR	1		3.75kW	
	SCREW CONVEYOR	5		5kW, 7.5kW	
	POLYMER TANK	2		2,194mmφx2445mm"	
	PUMP	2		$1.5m^3$/mx20m"x3.75kW	
	AGITATOR	2		60rpmx5.5kW	
	POLYMER STORAGE TANK	1		2,194mmφx2,445mm"	
	PUMP	6		$1.5m^3$/mx20m"x3.75kW	
	MIXING TANK	6		800mmφx1,100mm"	
	AGITATOR	6		20-80rpmx0.75kW	
	COMPRESSOR	1		11kW	
	FAN	3		22kW	

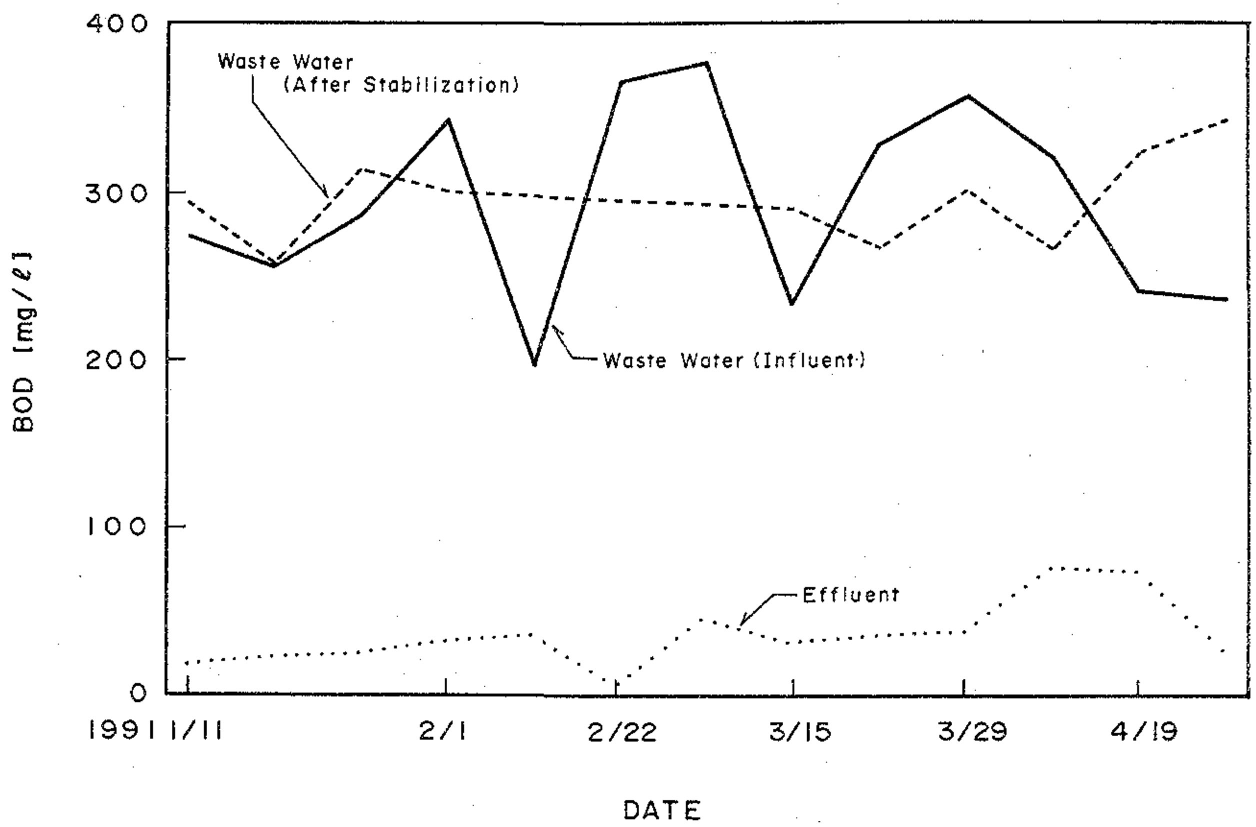


Fig. 1. 5. 3 Monthly BOD Change of Waste Water and Treated Water

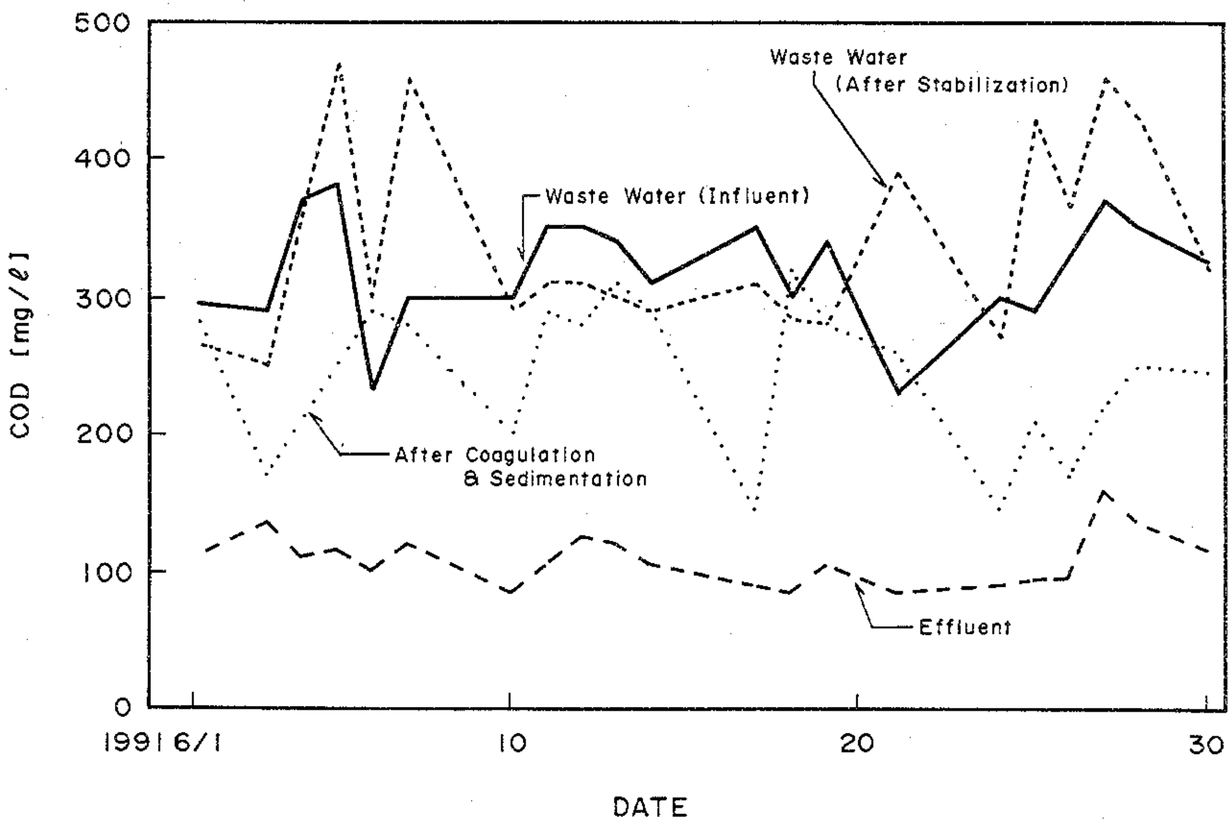


Fig. 1. 5. 4 Monthly COD Change of Waste Water and Treated Water

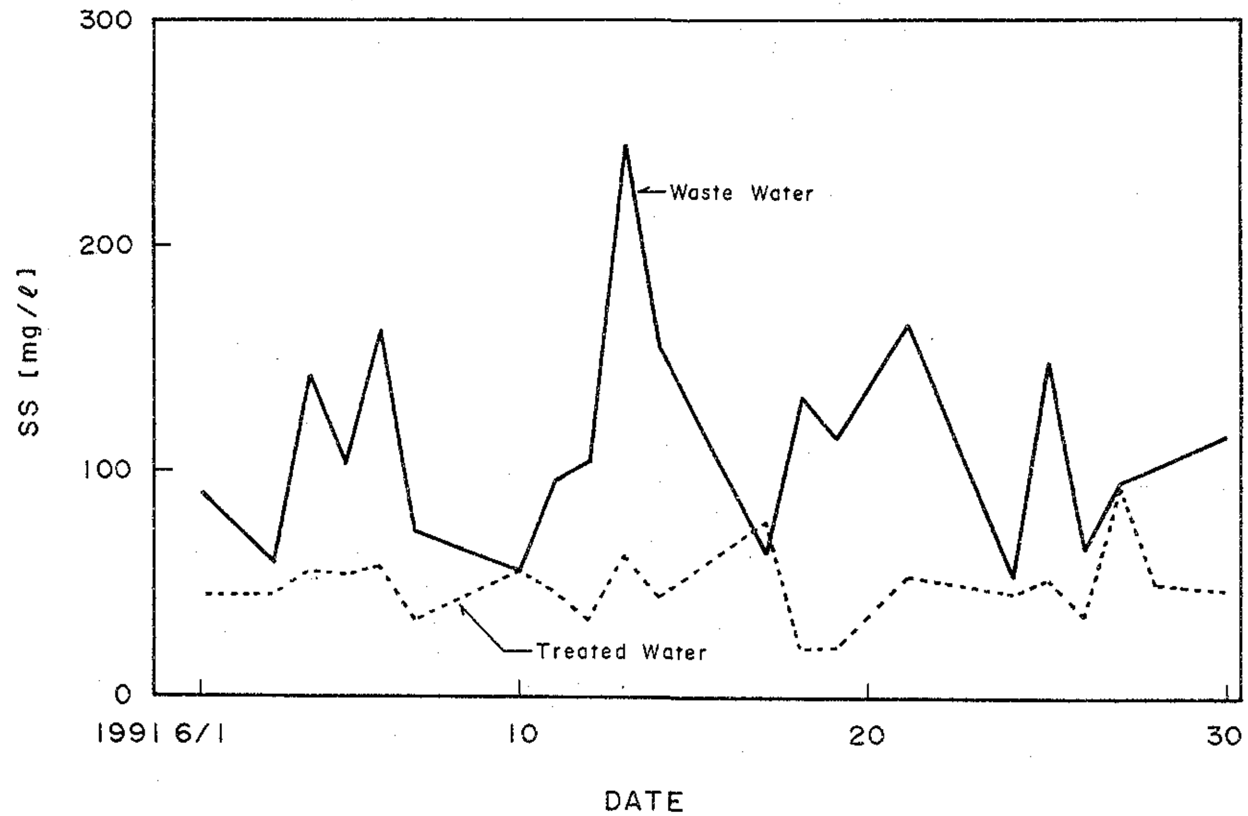


Fig. 1.5.5 Monthly SS Change of Waste Water and Treated Water

Table 1.5.3 Monthly Quantity and Cost of Chemicals in Central Waste Water Treatment Plant

Items	Cost [Won/kg]	Quantity [kg/M]
$FeCl_2$	70	262,700
NaOH	148.7	64,660
H_2SO_4	63	406,810
H_2O_2	400	104,580
Deforming agent	1,350	28,890
Polymer	1,700	92,550
Cation	3,150	2,610
N and P	700	13,200
Chelate	2,150	6,250
Seed of Sludge	4,300	7,900
$Na_2S_2O_4$	1,120	3,450

For reference, a sample daily report sheet is attached herewith.

The qualities of water treated by the old treatment system and the new one shall be equal in principle. However, in case that COD value in the treated water the set value, measures are taken by increasing the quantity of treated water by the old system. In order to maintain the quality of treated water, the central treatment facility give the factory (Factory No.15) discharging chrome contained wastewater instruction not to let chrome concentration in wastewater discharged exceed the set value.

Table 1.5.4 shows the standard cost of wastewater treatment. The amount of money paid by each factory for wastewater treatment is the product of water consumption (City water quantity + industrial water quantity) multiplied by the standard cost, having nothing to do with the wastewater quality. Nevertheless, the central treatment plant, without notice, measures pH of general drainage from each factory, and adds neutralization chemical charges to the cost whenever it exceeds pH11.0.

Table 1.5.4 Cost of Waste Water Treatment

Items	Cost
Waste Water (received)	450Won/m^3
Sewage (discharge)	85Won/m^3
Total	535Won/m^3
Sludge (disposal)	46,800Won/t

1.6 Other Related Conditions

Industrial Estate has a power station in the site, supplying electricity to 1,165 companies and steam to about 200 companies in the estate. The operation of the power station is taken charge of by the industrial estate corporation.

It seems that the dyeing estate is operating well without any problem. However, local people's movement is arising against the terminal waste treatment in the estate, and, the central treatment plant seems to be having trouble disposing of sludge.

The current facilities of the central treatment plant are now being remodeled in order to cope with increased water volume in future. The summary of remodeling is as per the following:

Treatment capacity	:	100,000 m^3/day
Process	:	Opflow Pure O^2 Process + Fenton's Oxidation
Quality of treated water	:	Of dischageable level as of Jan. 1, 1996
Specific features	:	Treatment to reduce sludge quantity to a minimum

This treatment plant is positively studying and considering in an active manner introducing new technologies for wastewater treatment.

2. Review of the Current Wastewater Treatment and Reclamation System

2.1 Evaluation and Problems Concerning the Current Systems

Generally, the present treatment facilities are well-operated and seems to have no big problem. However the following problems are seen:

(1) Aeration capacity shortage in summer season

The temperature of inflow wastewater into the central treatment plant sometimes exceeds 40°C in summer season. The current aeration system is based on the combination of surface aeration and diffuser tube. The aeration efficiency is not necessarily high. Therefore, aeration capacity tends to be insufficient in summer when the wastewater temperature rises high. In fact, bulking took place in 1991, probably due to aeration capacity shortage. At present, hydrogen peroxide is added to cope with insufficient aeration capacity. If not properly used, however, hydrogen peroxide may become materials to check breaking-out of microorganism in the aeration tank. Therefore, it can be said that the current operation method is unreliable.

(2) Chrome content in wastewater

The wastewater drained into the central treatment plant contains a very small amount of chrome. Under the present circumstances, Cr^{3+} is converted into hydroxide for sedimentation and elimination within the Cr^{3+} producing factory. However, owing to the defective sedimentation tank, most chrome is discharged into the central treatment plant. Discharged chrome is also contained in underflow, and accordingly there comes another problem in a sludge treatment. Cr^{6+} is harmless after chelate formation, but this is merely a temporary treatment.

(3) Addition of reductant

The central treatment plant is adding reductant to the water treated by the second-stage treatment method to remove colouring materials. If an improper amount is added by mistake, reductant becomes the case of an increase in COD concentration. And thus, the additional amount of reductant is delicate. This central treatment plant pays full attention to reductant amount to be used, and, the controling of the amount must be performed depending mostly on experience and intuition.

(4) Position of the central treatment plant

This central treatment plant is regarded as an intermidiate wastewater treatment plant, and, water treated thereby is again treated at the terminal sewage treatment plant in Ansan City. However, as stated before, the quality of water treated at this central treatment plant is better than that of water treated at the sewage treatment plant. At present, remodeling work for the facilities including the 2nd-stage treatment facilities is under contemplation and is in progress at the sewage treatment plant. Though, the central treatment plant solely can work well enough to maintain the current water quality.

2.2 Proposal for the Improvement of the Current Systems

Plants for the improvement and better management for the current treatment facilities are mentioned below regarding to the problems mentioned in 2.1:

(1) Aeration capacity shortage in summer

Since the solubility of oxygen varies inversely with the temperature of the wastewater, greater efficiency will be achieved by installing a cooling tank to drop the temperature of the wastewater before biological treatment. It is also possible to use one of the highly efficient diffusers now being developed, such as an ejector type, diffuser plate, etc. instead of a diffuser tube.

(2) Chrome contained in waste water

Only one factory out of 61 in total is discharging chrome contained wastewater. It is very inefficient to treat such wastewater at the central treatment plant. It is advisable that chrome treatment should be done within the factory discharging chrome. It is required that Cr6+ in wastewater should be reduced to Cr^{3+}, which is then changed into hydroxide for sedimentation & elimination to be delivered to the central treatment plant.

(3) Addition of reductant

The problem with excessively added reductant may be resolved by conducting treatment with reductant followed by aeration treatment. Decoloration can be performed by activated carbon adsorption, oxidation represented by ozone process & Fenton process and coagulation sedimentation in addition to reductant addition though it seems difficult due to the site area.

(4) Position of the central treatment plant

The present central treatment plant, as mentioned before, is left in a neutral position and is rather inefficient. More effective treatment could be possible, if the central treatment plant is equipped with more advanced treatment facilities to be upgarded to a terminal treatment plant.

Table 2.2.1. shows the problems concerning the current systems and the gist of the proposal for better facilities.

Table 2.2.1. Problems and Proposal for the Improvement of the Current Systems

Problems	Proposal for the Improvement
Aeration capacity shortage	To replace high efficiency aeration equipments Installing a cooling tower
Chrome treatment	Chrome treatment within the discharging factory
Addition of reductant	To reduce the excess reductant for following aeration treatment Employing the other decoloring process
Position of the central treatment plant	Ranking up as aterminal treatment plant

3. Determination of the Optimum Systems

Industrial estate of B Cooperative is adopted as a typical example of Korean dyeing industrial estates. Then, the actual state of its central wastewater treatment plant is surveyed and problems concerning the current system are pointed out.
Though this survey is a case study of dyeing industrial estate, it is looked upon as a model of the estate, and optimum systems of the central wastewater treatment plant are determined for the model estate.

3.1 Basic Policies

The basic policy is exactly the same as that in Chapter II. Plating Industrial Estate. Table 3.1.1 indicates criteria for the selection of the most ideal systems. Regarding wastewater treatment, conceptional designs and economic calculations of the most ideal systems are made on CASE-1 and CASE-2. The most suitable system for CASE-4 is studied on and selected for reference. In reclamation, concept design and economic calculation are made on CASE-3 that adds reclamation to CASE-1 as a basic system. The most ideal system is studied on and selected also for CASE-5 for reference. The most ideal system is prescribed as the most economical system to meet the selection criteria given in Table 3.1.1 A system for making concept design is chosen, referring to some cases applied in Japan.

The following is a file of the model industrial estate (central treatment plant location and inflow wastewater) for the deliberation on and selection of the most ideal systems.

Location	:	Ansan City B Industrial Estat
Object wastewater	:	General drainage from 61 factories in Ansan City B Industrial Estate
Wastewater volume	:	0.1 million m^3/day No inflow on Sunday, 24-hour inflow on other days Average ... 4,170 m^3/h

Table 3.1.1 Criteria for the Selection of the Most Effective System

Case \ Treatment Levels	Existing Standards	High Reduction of COD	Removal of irresolvable materials
Waste water treatment only	◎	◎	○
Waste water treatment and recycling	◎	○	×

◎ Will be selected ○ Studied for reference × Will not be selected

(max. 6,500 m^3/h,
min. 2,100 m^3/h)

Wastewater quality : As per Table 3.1.2

In cost estimation for construction and operation, adopted are standard cost in considering of the site in Korea. The data obtained from the visiting survey at the central treatment plant are for reference for making a trial calculation of operation costs, etc.

Table 3.1.2 Quality of Waste Water

Item		Designed Value	Analytical Value
pH	[-]	11.5	10.2
BOD	[mg/ℓ]	300	290.0
COD	[mg/ℓ]	400	741.5
SS	[mg/ℓ]	120	1110.0
n-Hexane	[mg/ℓ]	20	60
T-P	[mg/ℓ]		3.96
T-N	[mg/ℓ]		9.11
Color	[deg.]	1500	2940
Conductivity	[deg.]		500
Temparaure	[°C]	40～32	37.2

3.2 Measures for the Reduction of Wastewater Quantity

3.2.1 Conditions of Water Usage

(1) Water consumption by water sources and applications

In the dyeing industrial estate covered by this survey, there are about 60 factories, and questionnaires were collected from about 50 of them. Table 3.2.1 summarizes the industrial water consumption by water sources and applications based on these questionnaires.

From this table, the following are seen.

A. As classified by water sources, industrial water supply (water supply intended exclusively for industrial water) occupies a great part (96.5 % of the whole). Tap water supply is used only for domestic water and miscellaneous water, and occupies 2.9 % of the whole. Well water is used only in 2 factories and its consumption is very small (0.6 % of the whole).

The probable reason why the well water consumption is very small is that the site of this industrial estate has been built up by reclamation of the sea and there, it is difficult to lift up ground water.

B. As classified by applications, washing water has a very large ratio and its consumption occupies 91.3 % of the whole. Cooling water consumption is small and occupies 5.3 % of the whole. Domestic water and miscellaneous water, which are from tap water supply as mentioned above, occupy 2.9 % of the whole.

C. Boiler water consumption is very small (0.4 % of the whole). This is not because steam is not used in these factories, but because separately steam is supplied to each factory, and its quantity is estimated to be less than 11 % of the whole make-up water.

D. Recovered water consumption is very small, and the recovery

Table 3.2.1 Water consumption of the dyeing industrial estate

Unit:m^3/d

Use \ Source	Make-up water				Recovered water	Total	Recovery rate %	Ratio of water use %	
	Tap water	Industrial water	Well water	Sub-total				Make-up	Total
Boiler	—	188	—	188	—	188	0	0.4	0.4
Washing	—	40,826	233	41,059	1,417	42,476	3.3	91.3	90.8
Cooling	—	2,377	—	2,377	440	2,817	15.6	5.3	6.0
Air-conditioning	—	—	—	—	—	—	—	—	—
Domestic	1,284	—	40	1,324	—	1,324	0	2.9	2.8
Total	1,284	43,391	273	44,948	1,857	46,805	4.0		
Usage ratio %	2.9	96.5	0.6	100					

rate is only 4 %. Its great part is the drainage of indirect cooling water used during dyeing, which is cascade-used as washing water. From an impression during the visiting survey, there is a possibility that some part of cooling water consumption was omitted from the questionnaires and it is estimated that the recovery rate should be a little higher.

In the following, for each application, the conditions of water usage will be described in detail.

(2) Conditions of washing water usage

Washing water is used mainly in the dyeing processes in the narrow sense and also before and behind them. Fig.3.2.1 shows the standard dyeing processes which are almost common to cotton textiles, mixed textiles, cotton yarns, mixed yarns, etc. "Desizing", "Scouring", "Bleaching" and "Marcerizing" shown in this figure are classified each as pre-treatment, and "Finishing" and "Oiling" are classified each as post-treatment.

Among the 50 questionnaired factories, 37 factories were clarified of the washing water consumption as classified by applications. Table 3.2.2 shows washing water consumption for each of these factories as classified by pre-treatment, dyeing and post-treatment. As will be seen from this Table, water used in the dyeing processes in the narrow sense occupies 61 % of the whole, and next, pre-treatment occupies 27 %, and post-treatment only 12 %. This is because, while pre-treatment is used in almost all factories, post-treatment exists only in those factories which manufacture specific products or use specific dyes.

Water used in the dyeing processes can be classified roughly into the water for preparing the dyeing bath (the water used for dissolving dye in water to prepare the liquid with which the fiber is to be dyed) and washing water to be used after dyeing.

The former is about 10-20 times by weight of the fibers to be dyed (this ratio is called liquor ratio) and the water quantity is relatively small.

The latter is used to sufficiently remove dyes, etc. attached to the dyed fibers. This is used in the largest quantity in all the dyeing processes, and for reducing the quantity of

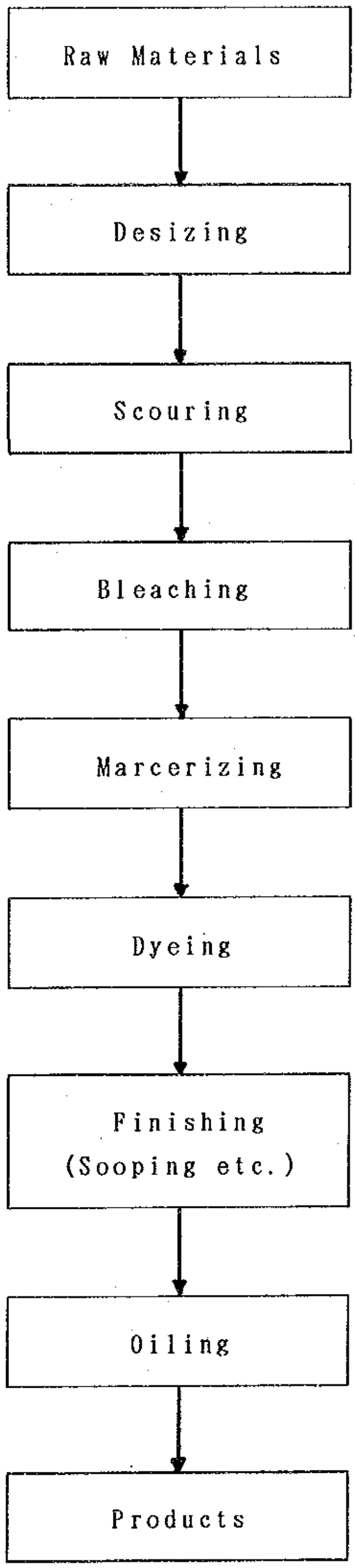


Fig. 3.2.1. Standard Dyeing Process

Table 3.2.2 Usage of washing water

Unit: m^3/d

Classification / Industry	No. of factories	Pre-treatment	Dyeing	After-treatment	Others	Total
Cotton fabric	13	3,225 (26.4)	8,693 (71.1)	310 (2.5)	—	12,228 (100)
Silk & synthetic fiber fabric	8	1,184 (29.2)	2,692 (66.4)	79 (1.9)	100 (2.5)	4,055 (100)
Knit & lace	8	3,911 (38.7)	4,154 (41.1)	2,037 (20.2)	—	10,102 (100)
Yarn	8	1,045 (12.3)	5,763 (67.9)	1,675 (19.8)	—	8,483 (100)
Total	37	9,365 (26.8)	21,302 (61.1)	4,101 (11.8)	100 (0.3)	34,868 (100)

Note :( ) shows a ratio of water use for classifications wastewaters from the dyeing factories, it is the most effective to reduce the consumption of the washing water following the dyeing processes. This will be described in 3.2.2.

(3) Conditions of cooling water usage

As shown in Table 3.2.1, the cooling water consumption is small. The reasons are as shown below.

A. Dyeing is done at high temperatures, and, therefore, cooling after dyeing is absolutely necessary. However, in any dyeing machine excepting the jet machines where indirect cooling can be done, washing serves also as cooling and there is no recognition as cooling water. For the jet dyeing machines, refer to Fig.3.2.2 and Fig.3.2.3.

B. Even in the case of the jet dyeing machines, the drainage of heated indirect cooling water is cascade-used as washing water, and therefore, there is no recognition as cooling water in many cases.

C. In any processes other than the dyeing processes, only a small quality of cooling water is used with air compressors, etc.

In spite of the cooling water being used almost for indirect cooling, the recovery rate is low as shown in Table 3.2.1. This is because the drainage from cooling, as it is, is cascade-used as washing water. Therefore, it is judged that regarding cooling water, there is little possibility of water saving.

(4) Comparison with the conditions of water usage in Japan

1) General conditions of water usage

Table 3.2.3 and Table 3.2.4 show the conditions of industrial water usage in Japanese factories which are almost similar in the business content to the surveyed industrial estate. In contrast to Table 3.2.1 showing water consumptions by water sources and applications, the Japanese industrial statistics show the water consumption respectively by water sources and by water

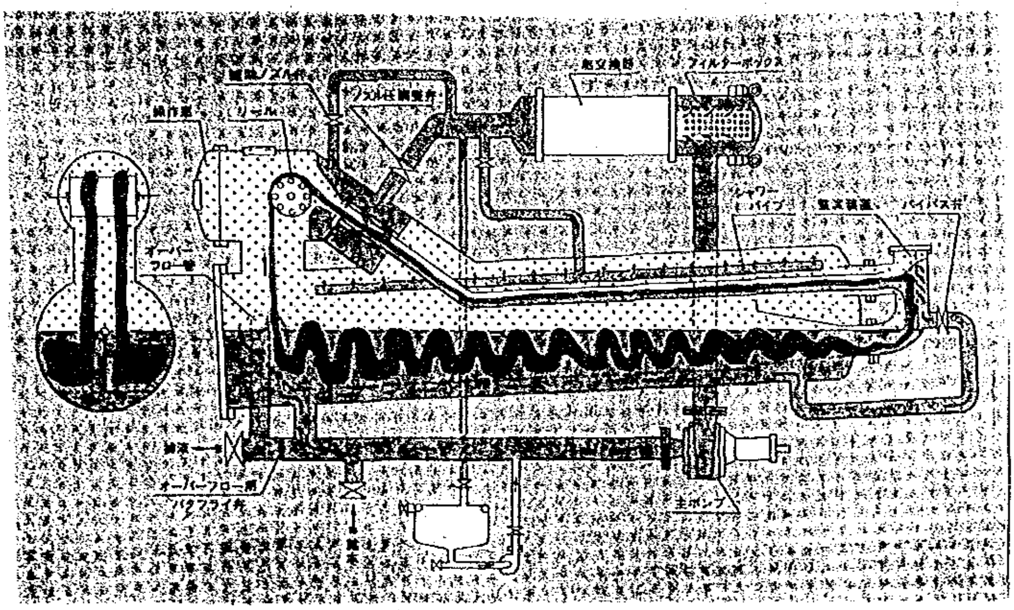
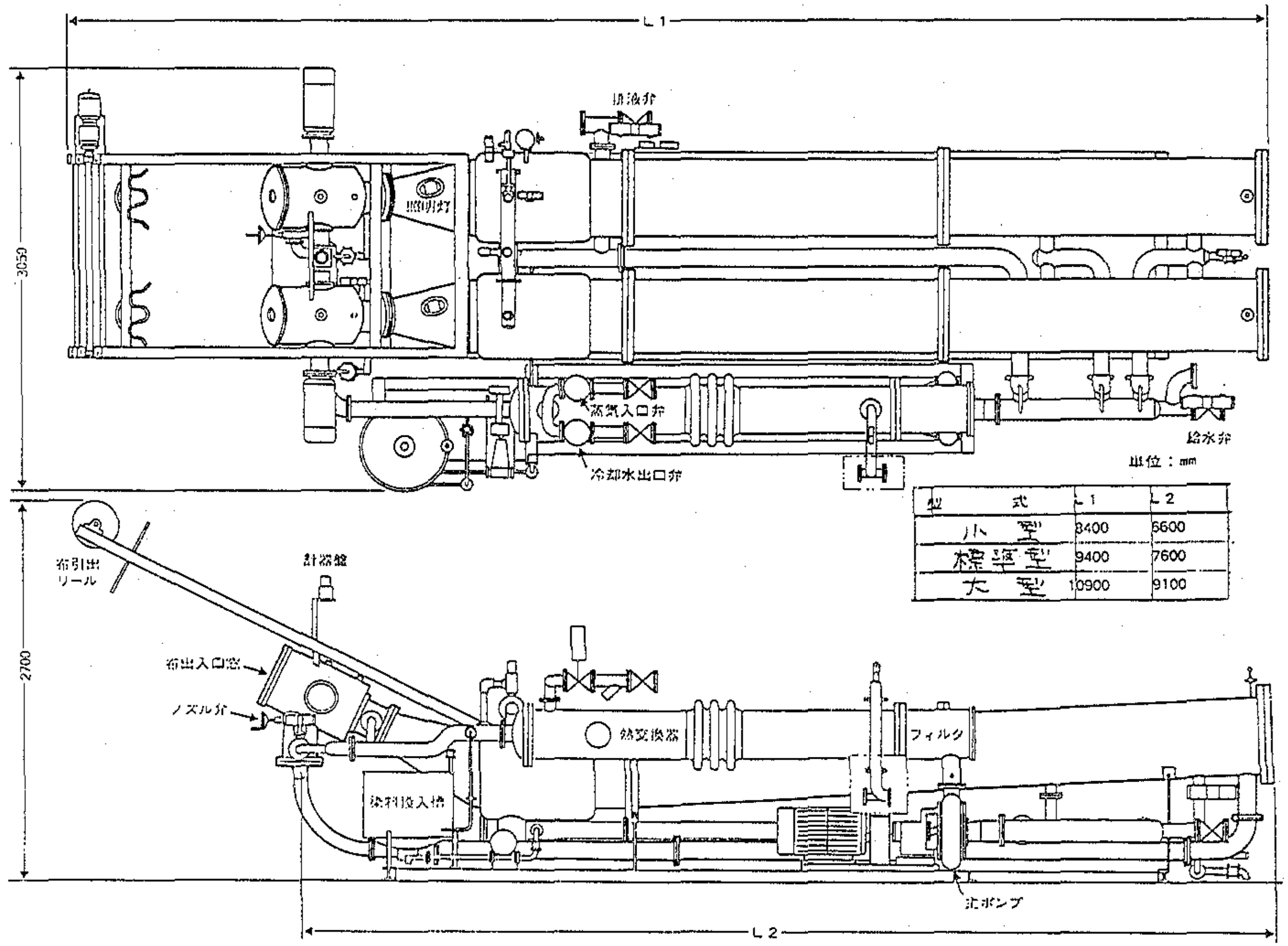


Fig. 3.2.2 System of jet dyeing machine



型式	L 1	L 2
小型	8400	6600
標準型	9400	7600
大型	10900	9100

Fig. 3.2.3 Outside view of jet dyeing machine

Table 3.2.3 Water consumption of fiber dyeing industry according to sources

Industry	No. of factories	Make-up water 1000m^3/d						Recoverd water 1000m^3/d	Tatal 1000m^3/d	Recovery rate %
		Tap water	Industrial water	Surface water	Well water	Others	Sub-total			
Cotton fabric	115	6.5	75.7	64.8	192.2	1.2	340.4	29.3	369.7	7.9
Silk & synthetic fiber	84	11.1	25.3	30.9	137.9	—	205.3	24.3	229.6	10.6
Knit & lace	92	4.3	26.0	6.1	111.1	1.8	149.2	11.2	160.4	7.0
Yarn	134	7.1	83.5	30.5	69.2	—	190.4	9.6	200.0	4.8
Total	425	29.0	210.5	132.3	510.4	3.0	885.3	74.4	959.7	7.8
Water usage ratio %		3.3	23.8	14.9	57.7	0.3	100			

From the industrial statistics of 1990

Table 3.2.4 Water consumption of fiber dyeing industry according to usage

Unit: $1000m^3/d$

Industry	Boiler	Material	Washing	Cooling	Air-conditioning	Others	Total	Recovery rate %
Cotton fabric	23.4	—	241.9	17.7	67.9	18.8	369.7	7.9
Silk & synthetic fiber fabric	13.0	—	169.8	35.1	5.6	6.1	229.6	10.6
knit & lace	8.5	—	134.9	13.4	1.2	2.4	160.4	7.0
Yarn	11.6	—	170.0	14.3	1.9	2.2	200.0	4.8
Total	56.5	—	716.6	80.5	76.5	29.5	959.7	7.8
Water usage ratio %	5.9	—	74.7	8.4	8.0	3.1	100	

From the industrial statistics of 1990

applications. It is possible to break down the water consumptions shown in Table 3.2.1 into the sub-classified industries shown in Table 3.2.1, but since the number of factories belonging to each industry becomes smaller and cannot be handled as reasonable statistics. From these Tables, the following are seen.

A. The recovery rate in Japan is slightly higher than that of the surveyed industrial estate. The reasons are as follows. Usage ratios of cooling water and air conditioning water which can be easily recovered and used are higher in Japan (the former 6 % and the latter 16.4 %), and further, as described before, entries of recovered water were probably omitted sometimes in the survey.

B. The reason why the usage ratio of boiler water in the surveyed industrial estate is lower than in Japan is probably that as shown before, steam is supplied separately, and if it is included, the usage ratio in the surveyed industrial estate may become approximately equal to that in Japan.

C. In the surveyed industrial estate, no air conditioning water is used at all. In Japan, air conditioning is done not only in offices but also in some factories. In the surveyed industrial estate, air conditioning is done only in some offices.

D. The reason why the usage ratio of washing water in the surveyed industrial estate is high as compared with Japan is that the usage ratio of water for boiler, for cooling and for air conditioning, is low for the reasons as described before, and it is not considered that the conditions of washing water usage are significantly different.

E. The usage ratios of domestic water and miscellaneous water are approximately similar between both countries.

2) Specific water consumption

A comparison of the specific water consumption of make-up water will be shown below. The specific water consumption may be shipped quantity specific, site area specific, employee number specific, etc. However, regarding the shipped quantity, it is difficult to compare price between both countries, and here, other two factors will be taken. Table 3.2.5 shows the results.

From this table, the following are seen.

A. Factory scale: In the industrial estate of Korea, medium-scale factories (but belonging to the large scale in Korea) are located. The site area ranges 5000-15000 m^2 and the number of employees ranges 120-250.

On the other hand, the Japanese industrial statistics include all factories of 30 or over employees, and the factory scale ranges widely. However, in terms of the average value per factory, the site area in Japan is 1.7 times as large and the number of employees is nearly the same.
It is not reasonable to compare the factory scale between both countries in terms of these numerical values alone, but according to the observations during the visiting survey, it seems that the number of employees in the Korean factories is larger than that in the Japanese factories of the same scale, and therefore, it is considered that the factory scale on the average is larger in Japan to such a degree as shown by the difference in the area site.

B. Site area specific water consumption: The make-up water quantity (m^3/day) per 100 m^2 site area is slightly smaller in Korea (about 74 % of Japan), but according to the observations during the visiting survey, it was felt that the factories in Korea have some allowance in the site area as compared with the Japanese factories of the same scale, and therefore, it is considered that there is almost no difference in the site area specific water consumption between both countries.

C. Employee number specific water consumption: The make-up water quantity (m^3/day) per employee is obviously smaller in Korea (about 1/3 of Japan), as shown in the Table. This is because, as already described, the number of employees in Korean factories is large as compared with that in Japanese factories of the same scale.

Table 3.2.5 Specific water consumption of Korea and Japan

Nation / Items / Industry	Dyeing industrial estate in Korea						Japan					
	No. of factories	Site area $100m^2$	No. of workers	Make-up water m^3/d	Specific water consumption		No. of factories	Site area $100m^2$	No. of workers	Make-up water m^3/d	Specific water consumption	
					Area	Worker					Area	Worker
Cotton fabric	13	1,269 (97.6)	1,498 (115)	12,960 (997)	10.2	8.7	115	29,947 (260)	14,735 (128)	340,360 (2,960)	11.4	23.1
Silk & synthetic fiber fabric	14	1,316 (94.0)	2,228 (159)	7,221 (516)	5.5	3.2	84	22,796 (271)	10,491 (125)	205,265 (2,444)	9.0	19.6
Knit & lace	8	696 (87.0)	822 (103)	10,217 (1,277)	14.7	12.4	92	11,755 (128)	7,634 (83)	149,230 (1,662)	12.7	19.5
Yarn	10	1,486 (149)	1,226 (123)	10,703 (1,070)	7.2	8.7	134	10,966 (82)	8,586 (64)	190,348 (1,421)	17.4	22.2
Total	45	4,767 (106)	5,774 (128)	41,101 (913)	8.6	7.1	425	75,464 (178)	41,446 (98)	885,203 (2,083)	11.7	21.4

Note :1) Japanese data is based on the industrial statistics of 1990
2) ( ) shows an average value per a factory
3) Specific water consumption per area is indicated as m^3/day/$100m^2$
4) Specific water consumption per capita is indicated as m^3/day/capita

From the foregoing, it can be said that the conditions of water usage in the surveyed industrial estate are similar to those in Japanese factories of the same scale.

3.2.2 Basic Conceptions

(1) General

The basic conceptions are similar to those in the case of the plating industrial estate in II. Particular items to the dyeing industrial estate are as follows.

For the reduction of washing water consumption, the methods described in II, a. Complete implementation of water usage control, b. Adoption of counter-current multi-stage washing system, c. Adoption of cascade use, d. Adoption of automatic water supply system for washing tank, and e. Use of hand control valve, and as a method unique to the dyeing factories, f. Adoption of low liquor ratio type dyeing machines, are applicable.

These methods will be described below.

(2) Adoption of counter-current multi-stage washing system

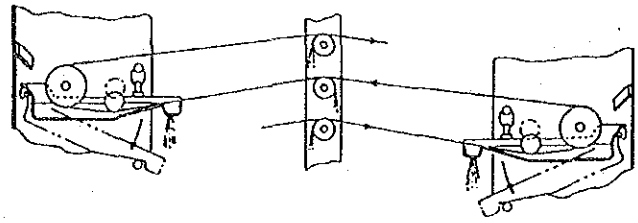
An example applying the counter-current multi-stage washing system in the dyeing factories is the counter-current multi-stage washing machine which is used in the washing process after dyeing. It has several types, one of which is shown in Fig.3.2.4.

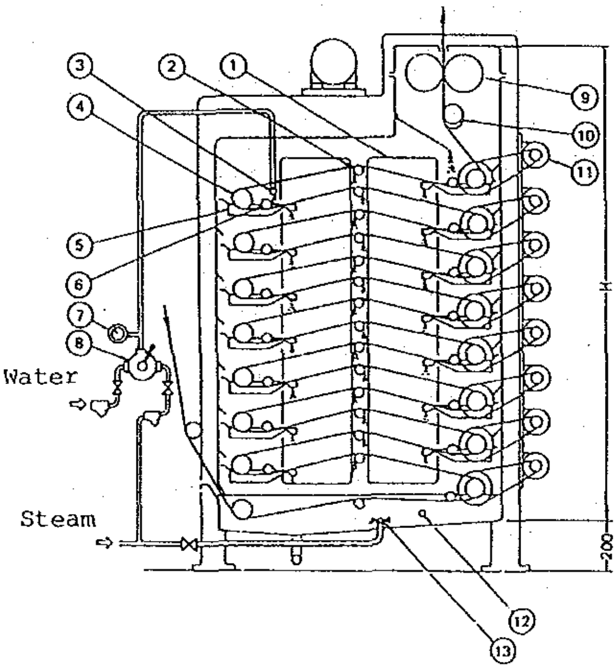
In this figure, the textile moves from below to above while the washing water flows from above to below in the counter-current multistage washing system.

However, since this washing system is of continuous type, it is difficult to apply it to the production in small lots. In the case of the surveyed industrial estate, the lot size is generally small. Therefore, the dyeing process is batchwise in all companies other than one, and the possibility of adopting the counter-current multi-stage washing machine is small.

(3) Adoption of cascade use

Washing
Mechanism





Legend

(1) Door
(2) 50ø (75ø) Guide Roller
(3) Water Supply Pipe
(4) 100ø (125ø) Guide Roller
(5) Small Tank
(6) 48.6ø Bar
(7) Thermometer
(8) Water Heater
(9) Pneumatic Squeezing Apparatus
(10) Rubber Curve Expander
(11) Tolque Motor
(12) Thermometer (Option)
(13) Steam Heater

Fig. 3.2.4 Counter-current multistage washer

As shown in Fig.3.2.2, in the case of the jet dyeing machine, the dyeing bath is cooled indirectly using a heat exchanger. Therefore, the drainage of the cooling water is raised in temperature alone and is not contaminated at all. Therefore, the cascade use of this drainage as the cooling water after dyeing not only serves for water saving but is an effective energy saving means.

In the surveyed industrial estate, it seems that where the jet dyeing machine is used, the cascade use described in this paragraph is carried out considerably.

(4) Adoption of low liquor ratio type dyeing machine

The liquor ratio is the ratio by weight of the liquor used for dyeing (dyeing bath) to the fiber to be dyed (dyeing bath/fiber). The lower this value, the smaller the dyeing bath quantity not to speak of, and the washing water consumption after dyeing. This is a significant water saving.

Among the low liquor ratio type dyeing machines, a typical one is the jet dyeing machine shown in Fig.3.2.2. Based on this figure, the functions of the jet dyeing machine will be briefly described.

The textile to be dyed is charged inside the dyeing machine in the ring shape of ropes. The dyeing bath is heated by steam in a heat exchanger, and is jetted out of a nozzle through a circulating pump, causing the textile ropes to be circulated under the liquid pressure. For cooling, cooling water is run in a heat exchanger to cool the inside in a similar way.

A comparison of the liquor ratio and the water saving ratio between this system and the winch dyeing machine frequently used conventionally in batchwise dyeing is as follows.

	Liquor Ratio	Water Usage %	Water Saving Ratio %
Jet Dyeing Machine	5-10	25-50	50-75
Winch Dyeing Machine	Ca.20	100	0

Some winch dyeing machines have lower liquor ratios, while in the newest type of jet dyeing machines, the liquor ratio is further decreased. It is sure, therefore, that by adopting new dyeing machines significant water saving will be possible.

3.2.3 Concrete Measures

(1) Method of investigation

From among the 16 surveyed factories, a factory whose conditions of water usage have been clarified was selected as a representative, and on this factory, measures for reducing the wastewater quantity will be investigated concretely.

The outlines of the factory selected are as follows.

Factory No.: 13
Number of employees: 130
Site area: 17029 m^2
Make-up water quantity: 2040 m^3/day
Major products: Dyeing of cotton and mixed knits
Number of dyeing machines installed:
Jet type: 6
Winch type (or jigger type): 13
Total: 19

Fig.3.2.5 shows the manufacturing processes and the conditions of water usage of this factory.

(2) Measures for reducing the wastewater quantity

1) Adoption of the low liquor ratio dyeing machine

In this factory, a total of 19 dyeing machines are used as described before. About 70 % of them are the machines of the winch type which has a high liquor ratio, and the remaining machines of the jet type also cannot be said to have a specifically low liquor ratio. The average liquor ratio is about 10 (according to the factories' explanation).

It is impossible to change all these dyeing machines to the low liquor ratio type. However, even if only a part of the winch

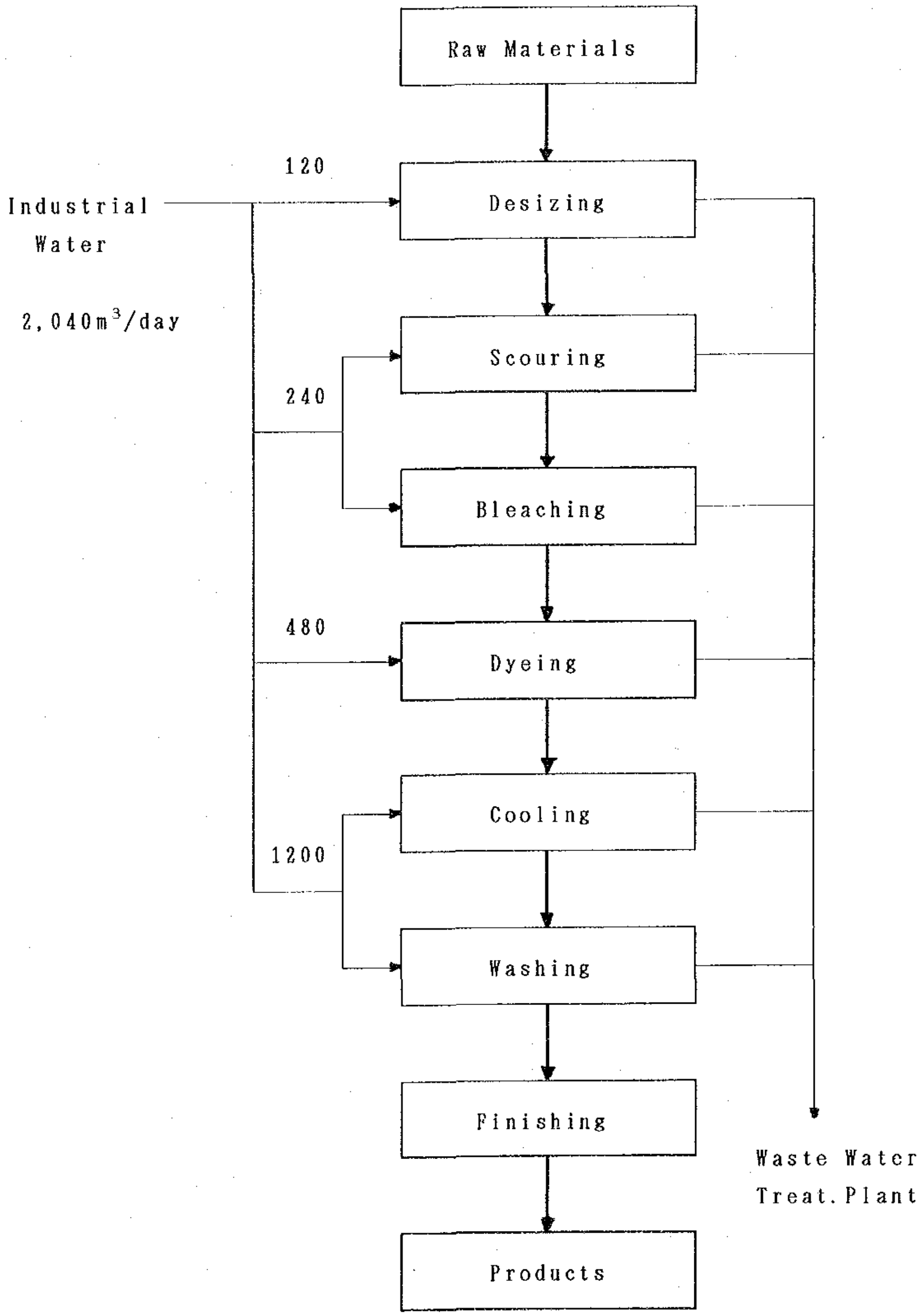


Fig. 3.2.5. Water usage of No.13 Factory

dyeing machines are changed, it will be not difficult to reduce the average liquor ratio by about 20 %.

All processes shown in Fig.3.2.4 are based on the batchwise operation. Usually, a separate equipment is not used for each process, but the dyeing machine is used in common to all processes. Consequently, if the liquor ratio is reduced by 20 %, it is considered that the water consumption in each process is reduced at approximately the same rate. Therefore, the realizable amount of water saving (wastewater quantity reduction) by this method will be about 20 % (400 m^3/day) of the make-up water consumption 2040 m^3/day.

2) Cascade use

In Fig.3.2.5 the cooling water consumption in the dyeing process is not clear, but it is sure that a considerable amount of cooling water is included in the water consumption 1200 m^3/day of the water washing process.

In the case of the winch type, the cooling water is included at last in the washing water, but if it is replaced by the jet type which uses the indirect cooling system, it is possible to cascade use the drainage as the washing water.

Of the water consumption 1200 m^3/day in the washing process, about 40 % (about 500 m^3/day) is assumed to be the cooling water, then by implementing cascade use completely, it is possible to save about 200-300 m^3/day.

3) Summary

The investigated methods for wastewater quantity reduction may be summarized as follows.

Reduction Method	Adoption of the Low Liquor Ratio Type Dyeing Machine	Implementation of Cascade Use
Realized Amount of Reduction	400 m3/day	200-300 m3/day
Description	Replacement of the Winch Type Dyeing Machine with the Jet Type	Use of the drainage from indirect cooling as the Washing Water

Total Amount of Reduction 600-700 m3/day

That is, the realizable amount of wastewater quantity reduction is about 30 % of the make-up water quantity.

(3) Realizable amount of wastewater quantity reduction

It is not acceptable that the results of investigation of a representative factory should be applied directly to the whole of the industrial estate. However, if the following items are taken into consideration, it is possible to estimate the realizable amount of reduction approximately.

A. In the industrial estate as a whole, the jet dyeing machines are in a relatively wide use, but the winch type and other dyeing machines having high liquor ratios are also used in a considerable number. Moreover, the jet type dyeing machines having liquor ratios of about 10 are also used considerably beside the low liquor ratio type.

B. In the case of yarn dyeing, the type of dyeing machines is rather different, but similarly the low liquor ratio type dyeing machines can be used. The degree of the spread of use of the low liquor ratio type is nearly the same as in the case of the cloth dyeing.

C. In the case of knit and lace dyeing, the type of dyeing macine is almost the same as cloth dyeing.

D. The realizability of water saving was studied on some factories engaged in dyeing mainly of cotton and synthetic fiber cloths in a certain area of Japan.
The results are as follows.

Present State		Realizability of Water Saving	
Number of Factories	42	Realizable Amount of Water Saving	13961 m3/day
Make-up Water	109959 m3/day	Water Saving Rate	12.7%
Recovered Water	35031 m3/day		
Total	144990 m3/day		
Recovery Rate	24.2%	Attainable Recovery Rate	33.8%

The realizability of water saving in Japan is about 13 % as shown above, and is not so large. This is because the factories in the surveyed area of Japan have already reached a considerably high level (24 %) of recovery rate at present.

If it is assumed that the recovery rate in the surveyed industrial estate can be raised up to about 30 % similarly to Japan, then the realizable amount of water saving and the water saving rate become as follows.

Unit:m3/day	Make-up Water	Recoverd Water	Total	Recovery Rate %
Present State	44,948	1,857	46,805	4.0
After Water Saving	32,763	14,042	46,805	30.0
Amount of Water Saving	12,185	Water Saving Rate		27.1%

The results of study on the realizability of water saving in a typical factory show that the realizable amount of water saving (the realizable amount of wastewater quantity reduction) is about 30 % of the make-up water quantity as described above. Moreover, the realizable amount of water saving, as obtained by comparison with Japan, is about 27 % of the make-up water quantity.

From these study results, it is estimated that the realizable amount of wastewater quantity reduction is about 30 %.

However, in the implementation of these reduction methods, the following problems will be involved.

A. The principal reduction method is to replace the high liquor ratio type dyeing machines with low liquor ratio type ones, but the latter machines are expensive and the replacement with them requires much cost.

B. In each factory of this dyeing industrial estate, the produc tion lots are generally small, and therefore, the high liquor ratio type dyeing machines such as the winch type which is easy to use with these lots are required.

C. With some kinds and shapes of fiber, the low liquor ratio type dyeing machines cannot be used.

However, the replacement with the low liquor ratio type dyeing machines has many effects such as not only water saving but also saving of dyes, chemicals, etc., saving of energy such as power and steam, and reduction of working personnel. Moreover, using the drainage at high temperatures from indirect cooling by cascade use as the washing water must be implemented by any means for energy reduction. In the long run, these measures must be implemented as a matter of course in every factory.

3.2.4 Wastewater Reclamation

Apart from the methods described in 3.2.2 (a - f), wastewater reclamation is also a method of saving washing water. This method enables discharged washing water to be treated in each individual factory and reused as washing water.

Water discharged from some factories shown in Table 1.3.2 - 16, for example Factories 2(a), 3(a), 7(a-c), 8(c), 9(a), 10(a), 12(a), 14(b), 15(c), etc. is of better quality than that of the overall discharged water which flows into the central treatment plant.

If these wastes were treated in the factory instead of being discharged into the central treatment plant, the reclamation of wastewater would be more economical. However, there are the following problems with this approach.

1) Since almost all dyeing operations are batch processes, the quality of the wastewater changes constantly and it can not be said that wastewater of a measured quality is constantly discharged.

2) Since the quantity of wastewater is not measured, the quantity of comparatively high quality wastewater is unknown.

3) The quantities of both wastewater and washing water fluctuate so widely with time that they can not be accommodated unless

substantial water tank is provided for the reclamation of the wastewater.

4) The kinds of fibers or dyestuffs used in the dyeing process change so frequently and produce fluctuations in the quality and quantity of the wastewater, making it very difficult to form a plan for the reclamation treatment facility.

Despite the existence of problems such as these, it is still possible to determine conditions under which the economical reclamation of wastewater becomes feasible if a thorough study is made. Fig. 3.2.6 shows one possible flow.

This flow involves the following approach.

1) Reclaim only the comparatively good quality wastes from pre-treatment and washing processes. Poor quality wastes from the dyeing process are not reclaimed.

2) Limit the use of reclaimed water to the pre-treatment and washing processes where it has less effect on product quality.

3) As each process is a batch operation, wastes are discharged intermittently. The initial discharge is concentrated but in time it quickly becomes diluted and its quality improves. Discharge the concentrated portion and reclaim only the diluted, good quality portion. Valves A and B are provided for this switching.

4) Provide a wastewater receiving tank and a processing water tank with capacities large enough to accommodate the fluctuations in the quantities of wastewater and processing water.

5) The main aim of the processes at the treatment facility will be to eliminate SS, COD and color, though this may vary depending on the quality of the wastewater. For this purpose, apart from the normal wastewater treatment processes of coagulation and sedimentation, biological treatment, sand filtration, etc., it is highly probable that advanced treatment processes, such as activated carbon, membrane treatment, etc. will be required.

3.3 Determination of the Optimum Wastewater Treatment System

The most effective systems are studied on and selected concerning 2 systems for wastewater treatment (treatment meeting the existing standards, high reduction of COD) and 1 system (removal of irresolvable materials).

3.3.1 System meeting the existing effluent (CASE-1)

(1) Treatment water quality

Table 3.3.1 shows the effluent standards and planned values of treated water quality. The effluent standards shall be effective from January 1, 1996, and, planned values of treated water quality are set based on the standards.

(2) Treatment system

There is no particular treatment for dyeing wastewater. The *status quo tells that factories are coping with the situation by* combining of conventional treatment technologies, depending on a wastewater condition and the effluent standards. There are various kinds of pollutants in dyeing wastewater. When they are *classified into organic substances, the former is more problemat*ic in preserving the environment. Therefore, any measure effective to remove organic substances can be basically applied to treat wastewater. But dyeing wastewater, differing from wastewater of other industries, contains irresolvable organic matters.

The existing treatments mainly conducted at present for dyeing wastewater are biological aerobic treatment, presented by activated sludge treatment separation by sedimentation & floatation using coagulant, activated carbon adsorption, and chemical oxidization with ozone. Generally, biological treatment is conducted for removing BOD, and other treatments are for removing COD and colouring materials. Table 3.3.2 shows COD removal methods and their characteristics with a single treatment out of the above, it is difficult both technically and economically to remarkably remove COD and colouring materials as well as BOD,

Table 3.3.1 Quality of Treated Water in CASE-1

(Design Criteria)

Items		Effluent Standards	Design Criteria
pH	[-]	5.8～8.6	5.8～8.6
BOD	[mg/ℓ]	<80	30
COD	[mg/ℓ]	<90	80
SS	[mg/ℓ]	<80	50
n-Hexane	[mg/ℓ]		<10
Color	[deg.]	<400	400
Temparaure	[°C]	<40	<40

Table 3.3.2 Method of COD Removal and its Characteristic

Treatment Method	Color Removal [%]	COD Removal [%]	Sludge Disposal
Coagulation	60 - 70	30	Necessary
Ozonization	80 - 90	30 - 50	Unnecessary
Fentin's Oxidation	> 90	> 80	Necessary
Reduction	> 90	Worse	Unnecessary
Electolytic Oxidation	60 - 70	20 - 30	Unnecessary
Electolytic Oxidation Cqagulation	> 90	30 - 50	Necessary
Activated Carbon Adsorption	80 - 90	> 90	Unnecessary

and, thus, a combination of some treatment methods is generally adopted.

This treatment plant processes much water - 100,000 m^3/day, so biological treatment is most economical for BOD removal. However , by biological treatment only, it is difficult to remove colouring and COD up to the target levels, and, thus, another treatment is required to remove COD. With regard to COD, coagulation sedimentation is adopted from an economical view point. The main treatment of this system is the combination of biological treatment and coagulation sedimentation.

Fig. 3.3.1 shows a flowchart of a selected treatment system. The functions of main equipments is as follows.

* Screen	To remove large substances such as textile rubbish, cloth pieces. out of SS
* Grit chamber	To remove medium-sized substances such as textile rabbish, sand, out of SS
* Stabilization tank	To standardize wastewater inflow and quality
* Neutralization tank	For pH adjustment
* Activated sludge tank	For biological removal of soluble BOD, COD and colloidal BOD, COD
* 1st sedimentation tank	For removal of coagulated excess sludge
* Contact aeration	For biological removal of soluble BOD, COD and colloidal BOD, COD materials
* Coagulation tank	For coagulation of soluble and colloidal COD
* 2nd sedimentation tank	For removal of coagulated COD by sedimentation
* Belt press	For dehydration of sludge

For treatment cost reduction, pollutants are removed to the utmost by biological treatment. Accordingly, the biological treatment is composed of two steps — activated sludge and contact aeration Coagulation sedimentation set after biological treatment is aimed at better separation of solid and liquid, and

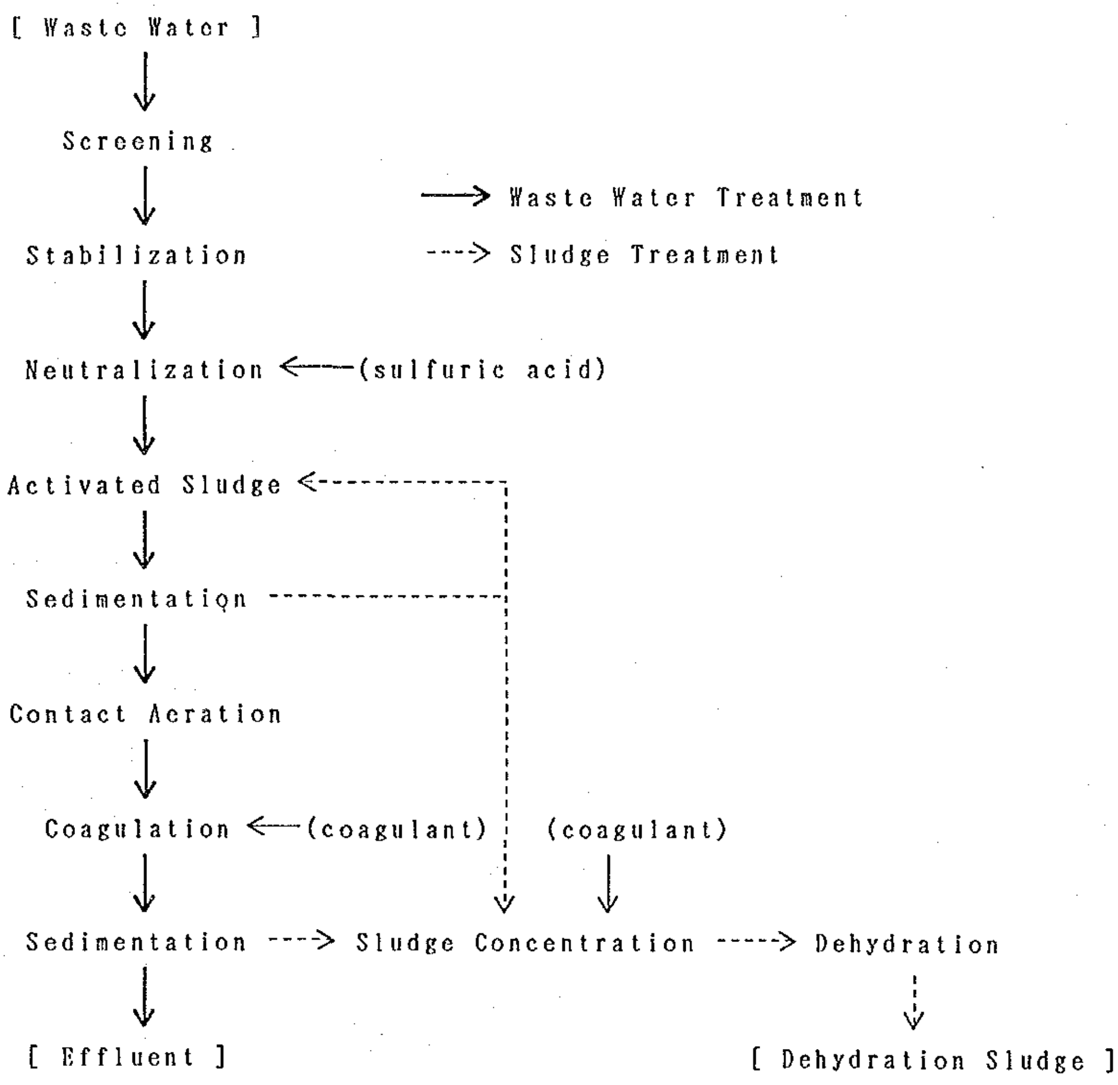


Fig. 3. 3. 1 Flow Diagram of Treatment in CASE-1

less coagulant consumption.

Table 3.3.3 shows planned values of treated water quality in each process.

3.3.2 High reduction of COD (CASE-2)

(1) Treatment water quality

Table 3.3.4 illustrates the effluent standards (effective from January 1, 1996) in regard to the industrial estate's terminal wastewater treatment plant in Korea and the planned values of treated water quality. The planned values in this system are set on the assumption that the central treatment plant should be upgarded to a terminal wastewater treatment facilities.

(2) Treatment system

This treatment method consists of a combination of CASE-1 treatment facilities and advanced treatment water facilities for COD removal in order to partly remove treat water from CASE-1 treatment facilities.Treated water quantity from the advanced treatment facilities is 80,000 m^3/day and is mixed with un-treated water of 20,000 m^3/day to be discharged. Activated carbon adsorption is chosen for advanced removal of COD from an economical point of view.

Fig. 3.3.2 illustrates a flowchart of the treatment system, and Table 3.3.5 shows planned values of treated water quality in each process.

3.3.3 System to remove irresolvable substances (CASE-5)

(1) Treated water quality

Dyeing wastewater contains such irresolvable organic substances as dyestuffs and surfactants, which become sources of colouring and foaming in water. The objects on which conventional regulations against water contamination are laid chiefly organic substances (BOD, COD) from an environment protection point of view and heavy metals & poisons from a health protection point.

Table 3.3.3 Quality of Effluent after each Treatment in CASE-1 (Design Criteria)

[Waste Water] → Stabilization →① Neutralization →② Activated Sludge → Sedimentation

→③ Contact Aeration →④ Coagulation → Sedimentation →⑤ [Effluent]

Process	①	②	③	④	⑤
Quantity [m^3/day]	100,000	100,000	100,000	100,000	100,000
pH [-]	11.5	6～8	6～8	6～8	6～8
BOD [mg/ℓ]	300	300	55	30	25
COD [mg/ℓ]	400	400	170	110	80
SS [mg/ℓ]	120	120	50	50	20
n-Hex [mg/ℓ]	20	20	10	10	<10

Table 3.3.4 Quality of Treated Water in CASE-2

(Design Criteria)

Items		Effluent Standards	Design Criteria
pH	[-]	5.8～8.6	5.8～8.6
BOD	[mg/ℓ]	<30	20
COD	[mg/ℓ]	<40	40
SS	[mg/ℓ]	<30	20

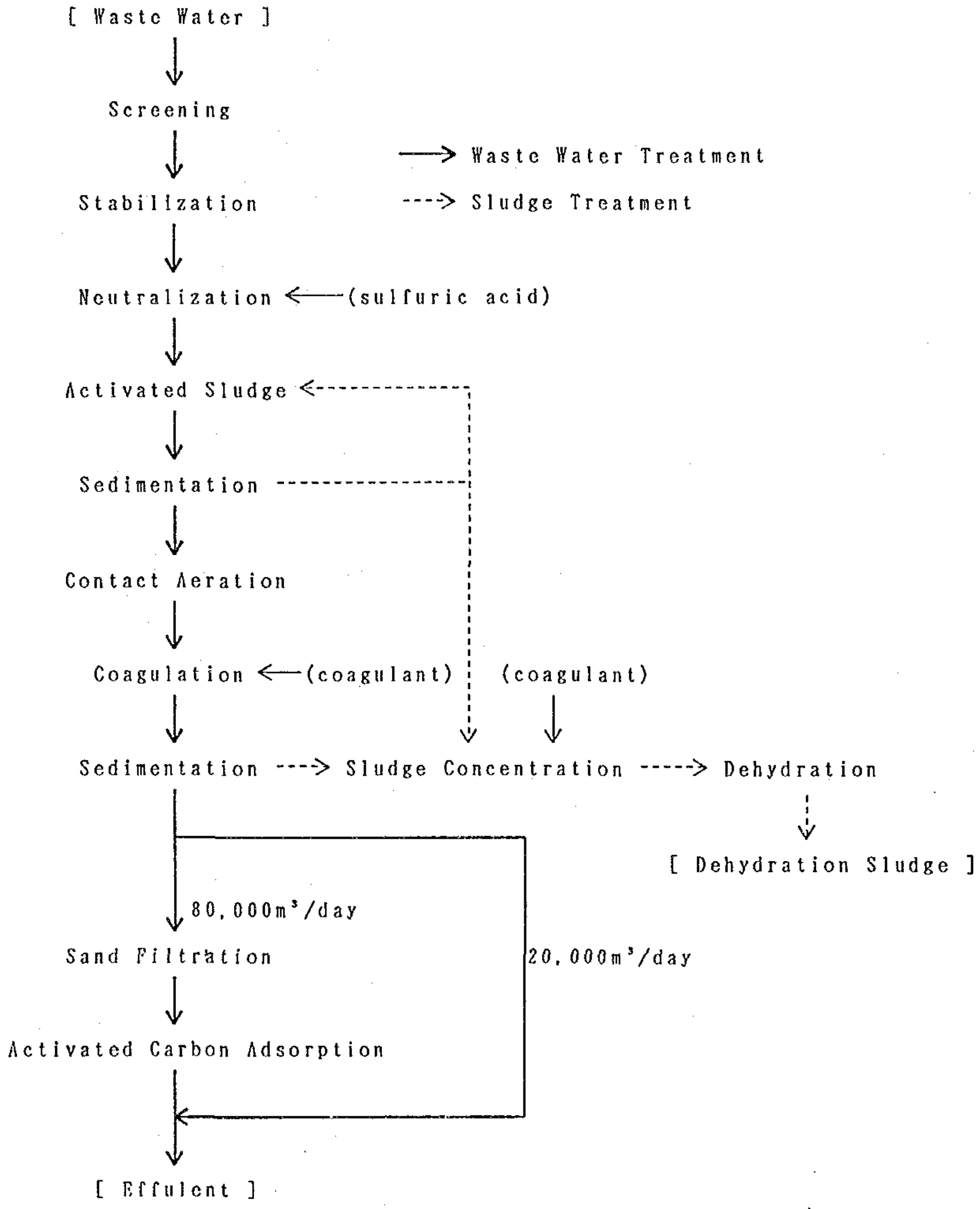
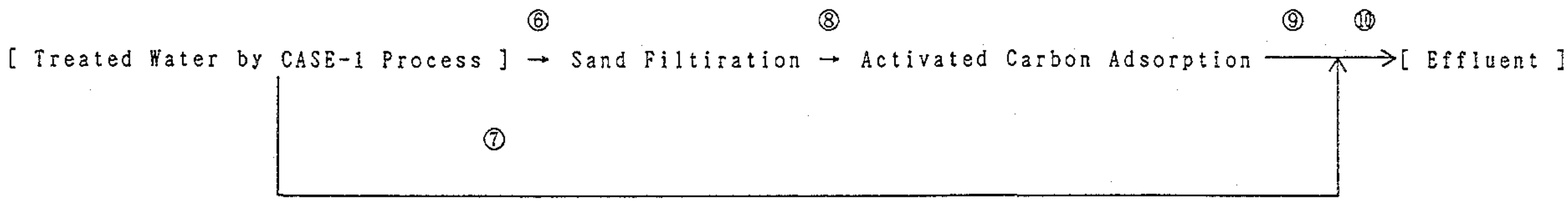


Fig. 3.3.2 Flow Diagram of Treatment in CASE-2

Table 3.3.5 Quality of Effluent after each Treatment in CASE-2 (Design Criteria)



Process		⑥	⑦	⑧	⑨	⑩
Quantity	[m³/day]	80,000	20,000	80,000	80,000	100,000
pH	[-]	6～8	6～8	6～8	6～8	6～8
BOD	[mg/ℓ]	25	25	25	15	17
COD	[mg/ℓ]	80	80	80	30	40
SS	[mg/ℓ]	20	20	2	2	5.6
n-Hex	[mg/ℓ]	<10	<10	<10	<10	<10

And, any complete countermeasure are not necessarily taken against colouring and foaming substances that are not harmful directly to the health.

There is the colouring index for colouring and the ABS concentration index for surfactants. However, the colouring index is determind based on the theory of relativity, and, as the ABS concentration is the concentration of major surfactants, the index cannot be absolute. Herein, COD is used as the index of the concentration irresolvable substances, and the target value of treated water is set under 10 mg/l of COD concentration.

(2) Treatment system

Methods to remove colouring materials are coagulation, adsorption and oxidation treatments. And surfactant removal is performed by biological treatment, oxidation or adsorption. Herein, biological activated carbon process (BAC process), the combination of activated carbon adsorption & biological treatment is chosen to form a treatment system. BAC process is lately applied for advanced treatment to remove irresolvable substances in water purification plants. Pollutants (including irresolvable substances) are adsorbed into activated carbon, and are decomposed later by microorganism breeding over the activated carbon surface. The life of activated carbon is prolonged with this biological reclamation effect. Besides, microorganism with a long sludge life can breed because activated carbon functions as supporter.

The majority of BAC process applications up to now is for advanced water purification, and the minor is only for wastewater treatment. And, there are only several cases applied in dyeing wastewater treatment. In any case, however, BAC process is very effective to remove colouring materials and surfactants. Fig. 3.3.3 Illustrates a flowchart of the treatment system.

Activated carbon (powder form) in this system is thrown into the outlet of the aeration tank, and circulates together with activated sludge during the process.

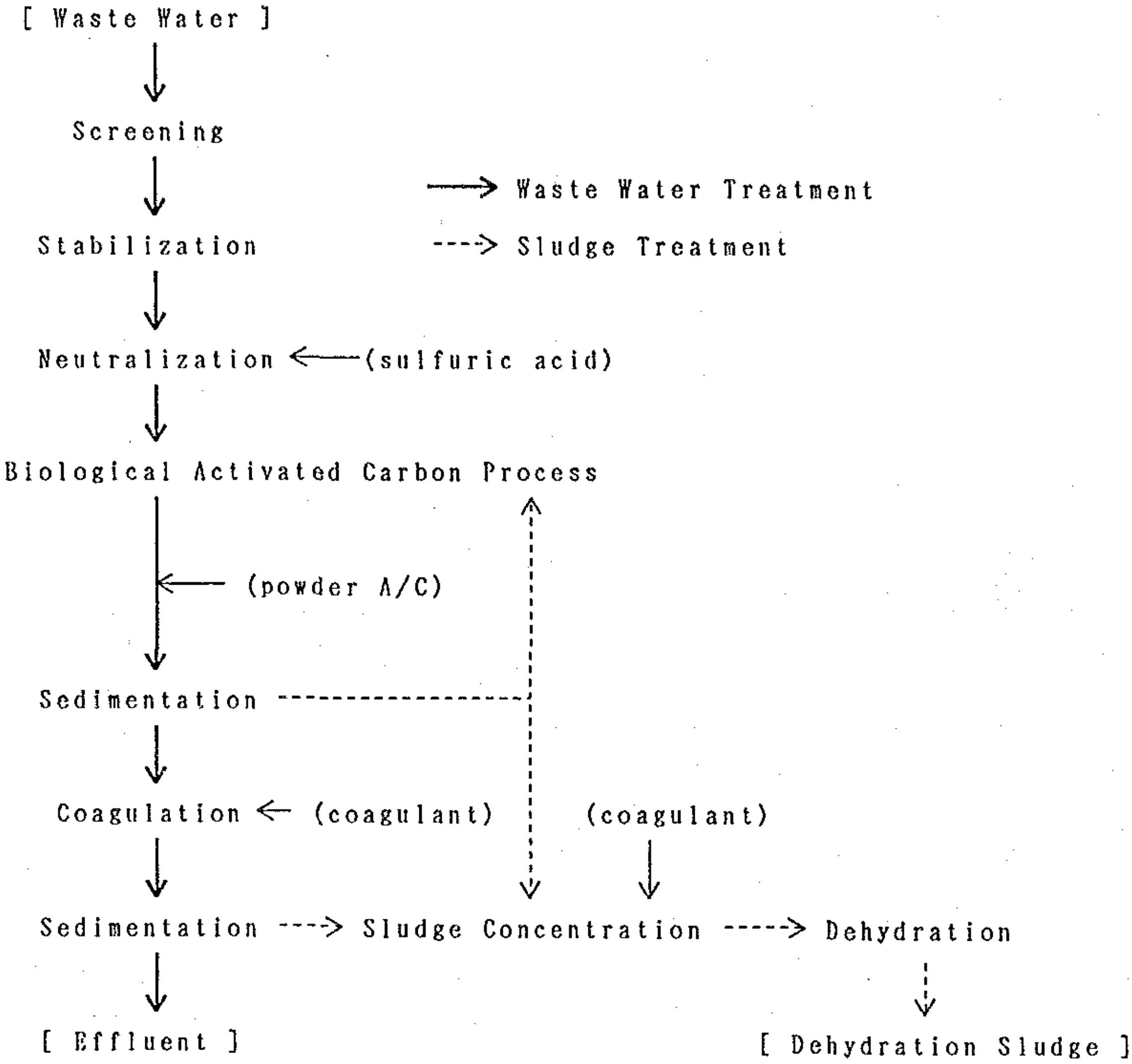


Fig. 3. 3. 3 Flow Diagram of Treatment in CASE-5

3.4 Determination of the optimum reclamation system

The most suitable system is examined and selected regarding standard system in reclamation (wastewater treatment — conforming to current drainage standard) and 1 system for reference (wastewater — advanced treatment of COD materials).

3.4.1 System conforming to current drainage standard (CASE-3)

(1) Reclaimed water quantity

Reclaimed water is used in pretreatment process of dyeing (desizing, scouring, bleaching and marcerizing process), which supposedly has comparatively less influence on products. Based on the data from 13 factories having water consumption data in each process out of 15 factories in Ansan City Dyeing Industrial Estate, water consumption ratio in pretreatment process to the whole water consumption is calculated, and reclaimed water quantity is estimated. The total water consumption in pretreatment process by 13 factories is 4,800 m^3/day, that shares about 26% of the whole consumption of 18,500 m^3/day. Reclaimed water quantity set is 20% (20,000 m^3/day) of the whole water consumption.

(2) Reclaimed water quality

There is no case in Japan where reclaimed water from dyeing wastewater is again used for factory processing water. But studies are being conducted on what process and on influences that reclaimed water may give to products, when used in production process.

Reclaimed water quality herein is set as per Table 3.4.1, referring to the results of tests conducted by NAGASAWA (Brochure 1). And, the quality of water treated is set equivalent to CASE-1 (Table 3.3.2).

(3) Treatment system

Flowchart 3.4.1 shows a flowchart of the treatment system.

Table 3.4.1 Quality of Reclaimed Water in CASE-3

(Design Criteria)

Items		Design Criteria
pH	[-]	6.7～7.4
Turbidity	[deg.]	< 5
COD	[mg/ℓ]	<10
SS	[mg/ℓ]	< 2

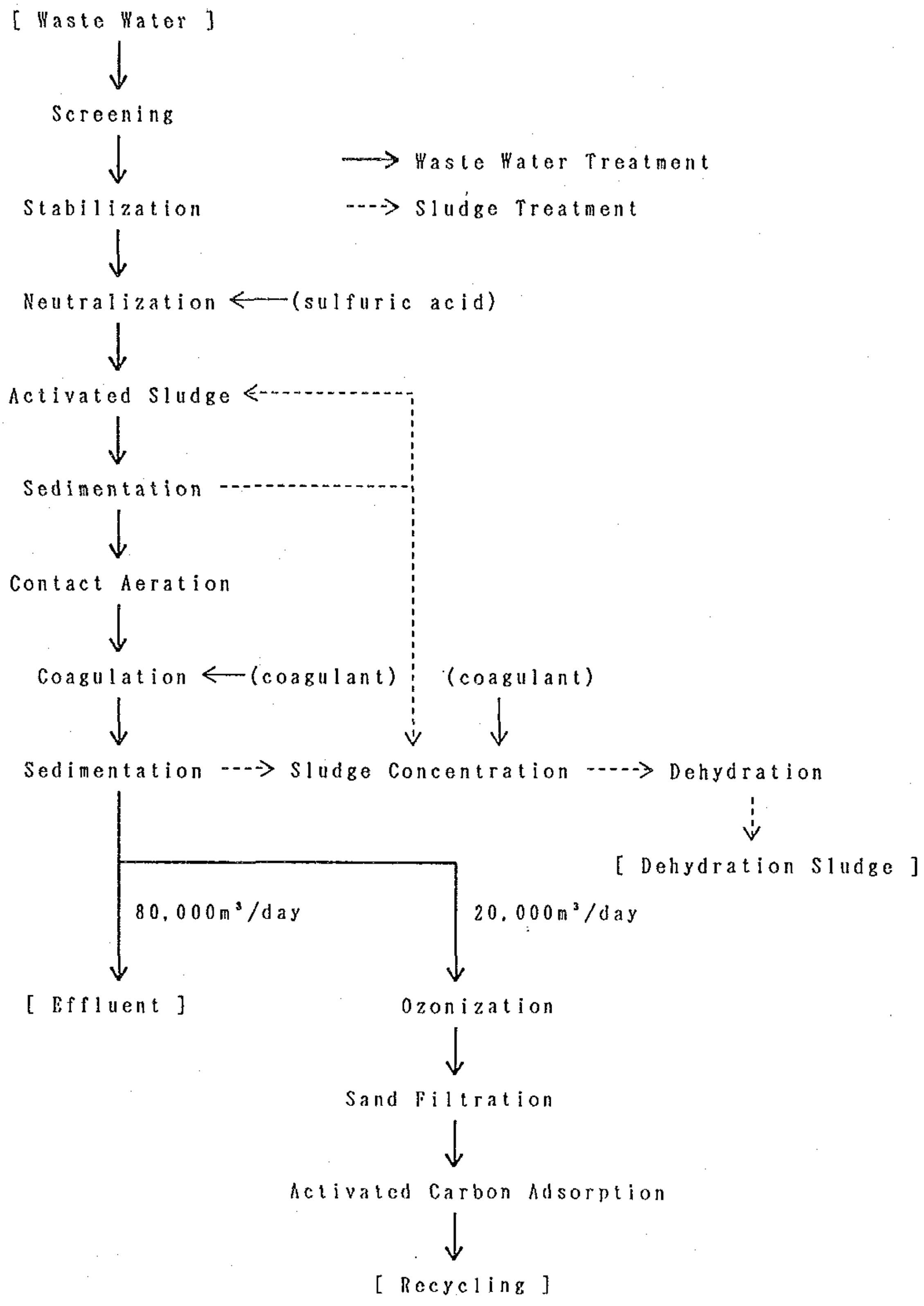


Fig. 3.4.1 Flow Diagram of Treatment in CASE-3

Water reclaimed after CASE-1 treatment is 20,000 m^3/day only. Reclamation process is the combination of ozone oxidation and activated carbon adsorption.

Ozone oxidation tends to oxidate the following by choice;

1) Compound of unsaturated bond olefine and acetylene
2) Aromatic monocyclic and condensed ring compound
3) Carbon-nitrogen double bond compound
4) Amine, sulfide
5) Compound including oxygen of alcohol, ether and aldehyde

Ozone oxidation is herein applied to decompose these highly activated compounds so that reclaimed water may least affect products. However, by ozone oxidation alone, it is difficult to completely resolve organic substances into carbonic gas and water, and the treatment costs much. For this reason, activated carbon adsorption is used for the final process of water reclamation.

Table 3.4.2 shows target values of treated water in each process.

3.4.2 Advanced treatment system of COD materials (CASE-4)

(1) Reclaimed water quantity

Reclaimed water quantity is set at 20,000 m^3/day.

(2) Reclaimed water quality

Table 3.4.1 illustrates reclaimed water quality. And dischargeable water is equivalent to CASE-2 (Table 3.3.4).

(3) Treatment system

Fig. 3.4.2 shows a flowchart of the treatment system. 20,000 m^3/day is reclaimed in the same manner as in CASE-3, and 80,000 m^3/day in the same manner as in CASE-2.

(Reference brochure)

1 NAGASAWA : ZOHSUI GIJUTSU, 12, 33 (1986)
"The Water Re-use Technology"

Table 3.4.2 Quality of Effluent after each Treatment in CASE-3 (Design Criteria)

[Treated Water by CASE-1 Process] → ⑪ Ozonination → ⑫ Sand Filtiration

→ ⑬ Activated Carbon Adsorption → ⑭ [Recycling Water]

Process	⑪	⑫	⑬	⑭
Quantity [m^3/day]	20,000	20,000	20,000	20,000
pH [-]	6～8	6～8	6～8	6～8
BOD [mg/ℓ]	25	-	-	-
COD [mg/ℓ]	80	60	60	10
SS [mg/ℓ]	20	20	2	2
n-Hex [mg/ℓ]	<10	-	-	-

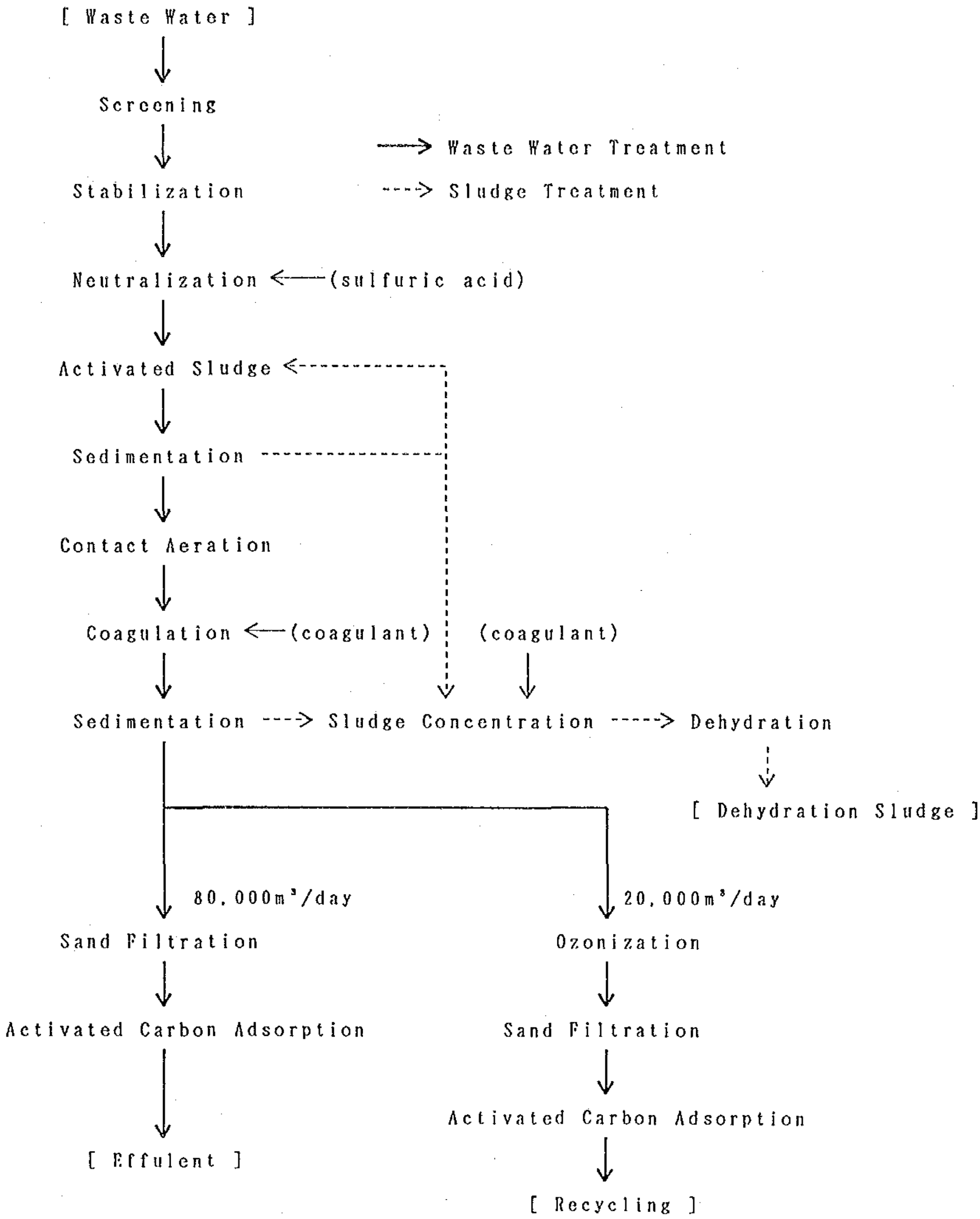


Fig. 3.4.2 Flow Diagram of Treatment in CASE-4