No. 38

FINAL REPORT
FOR
THE STUDY ON INDUSTRIAL WASTE WATER TREATMENT AND RECYCLING PROJECT IN THE REPUBLIC OF KOREA
(SUMMARY)

AUGUST 1993

JAPAN INTERNATIONAL COOPERATION AGENCY

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Preface

In response to a request from the Government of the Republic of Korea, the Government of Japan decided to coduct a study on The Industrial Waste Water Treatment and Recycling Project and entrusted the study to the Japan International Cooperation Agency (JICA).

JICA sent to Korea a study team headed by Mr.Totaro Goto, Water Re-Use Promotion Center, four times between March 1990 and May 1993.

The team held discussions with the officials concerned of the Government of Korea, and conducted field surveys at the study area. After the team returned to Japan, further studies were made and the present report was prepared.

I hope that this report will contribute to the promotion of the project and to the enhancement of friendly relations between our two countries.

I wish to express my sincere appreciation to the officials concerned of the Government of Korea for their close cooperation extended to the team.

August, 1993

Kensuke Yanagiya

Kensuke Yanagiya
President
Japan International Cooperation Agency

T A B L E   O F   C O N T E N T S

I. Introduction

I. Introduction

1.1 Background

At the outset of its first five-year plan in 1962, the Republic of Korea shifted its economic policy from import to export and has since registered remarkable economic growth.

However, this rapid economic development was accompanied by undesirable consequences such as environmental pollution and the destruction of nature, to the extent that environmental destruction due to industrial wastewater has now emerged as a serious social problem in some parts of the country.

In addition, it is predicted that shortages of water resources and land subsidence are likely to occur as a direct result of this rapid economic development.

Under these circumstances, the Korean Government made a request to Japan to carry out an investigation concerning industrial wastewater treatment and reclamation, and this forms the background to this Study.

In response, JICA dispatched its first study team to Korea in December 1990 to discuss the matter with the Korean counterparts. Consequently agreement was reached on the content of the Study, and the scope of the work was prepared.

On this basis, JICA formed another study team in March 1991 and conducted first step field stage, which identified some circumstantial difficulties for the investigation of the dyeing industrial estate in Taegu, previously agreed to be as a designated site.

In August 1991, the Korean counterparts communicated their desire to change the study site to Banwol Dyeing Industrial Estate so as to readjust to this new development. JICA agreed, after dispatching its second study team to Ansam City in December 1991 to gain first-hand information on the proposed industrial estate.

1.2 Study Site and Objectives

1.2.1 Study Site

The Study is conducted covering the following industrial estates and industries:

(1) Industrial Estates

1) A small-scale plating industrial estate in Inchon
2) A dyeing industrial estate within the Banwol industrial estate

(2) Industries

1) Electro-plating
2) Dyeing

1.2.2 Objectives of the Investigation

Based on the matters agreed on between the two countries, the objectives of the Study were set as follows:

1) To investigate the present state of the wastewater treatment facilities at the two industrial estates to be covered by the study, point out any identified problems, and put forward solution options to improve the situation.
2) To determine optimum wastewater treatment and reclamation systems for model electro-plating and dyeing industrial estates in Korea, by regarding the above industrial estates as such, so that the results of the Study, conducted as a mere case study, can be generalized to all industrial estates in these respective industries.
3) To prepare guidelines for wastewater treatment and reclamation in the two industries based on the study results.

In the course of the Study, relevant technologies were to be transferred to the counterparts.

1.3. Content of the Study

1.3.1 Principles of the Study

(1) Reduction of wastewater loading
(2) Investigation of the present state of water balance at factories
(3) Selection of wastewater treatment processes
(4) Introduction to Japanese wastewater treatment and reclamation system
(5) Survey of individual factories at each industrial estate
(6) Preparation of guidelines for wastewater treatment and reclamation
(7) Technology transfer

1.3.2. Preparation for the Study

To carry out the Study, a team of experts was formed as shown in Table 1.3.1. KIST members also taking part are shown in Table 1.3.2.

1.4 Implementation of the Study

The work was executed in accordance with the flowchart shown in Figure 1.4.1., while the schedule of work done is shown in Figure 1.4.2.

Table 1.3.1 Study Team Members and Their Assignments (1/2)

Name	Function	Assignment
Totaro GOTO	Team Leader Overall Management	Overall management and Coordination Home office Work: Items described above Field work: Negotiation with counterparts Control of study team
Shigeru HASEBA	Sub-Leader Water Treatment Technology	Water treatment technology Home office work: Summarization of field study results Field work: Collection of information and data,and summarization of field study items
Naoto HASHIMOTO	Plant Designing	Study on waste water treatment and recycling facilities Home office work: Items described above Field work: Items described above
Yoshihiro TANAKA	Water Analysis	Inorganic water Analysis Study on waste water treatment facilities of electro plating process plant designing Home office work: Items described above Field work: Inorganic water analysis Study and analysis of waste water treatment of electro plating process
Tetsuya HIRAMATU	Study on related Technologies	Summarization of Japanese waste water treatment technologies (Home office work only)
Yosihiko KUBO	Study on related Technologies	Summarization of Japanese waste water treatment technologies (Home office work only)

Table 1.3.1 Continued (2/2)

Name	Function	Assignment
Sueo NAGASAWA	Water Analysis	Organic water analysis Study on waste water treatment facilities of dyeing process Home office work: Items described above Field work: Organic water analysis Study and analysis of waste water treatment of dyeing process
Manabu FUJIKAWA	Socio-Economic and Financial Analysis	Compilation of socio-economic and financial analysis of waste water treatment systems Home office work: Socio-economic and financial analysis based of field study results Field work: Study on items required for socio-economic and financial analysis
Tetsuo FUJIOKA	Study on related Technologies	Summarization of Japanese waste water treatment technologies (Home office work only)
Tatsuji OKADA	Water treatment Technologies	Study and plant designing of waste water treatment and recycling facilities of dyeing process Home office work: Items described above Field work: Study and analysis of waste water treatment of dyeing process

Table 1.3.2 List of KIST Staff

Name	Title	Division
Won-Hoon Park, Ph.D.	Director	Division of Environment & Welfare Technology
Kil-Choo Moon, Ph.D.	Director	Environment Research Center
Kyu-Hong Ahn, Ph.D.	Professor	Environment Research Center
Daewon Pak, Ph.D.		Environment Research Center
Kyung-Guen Song		Environment Research Center

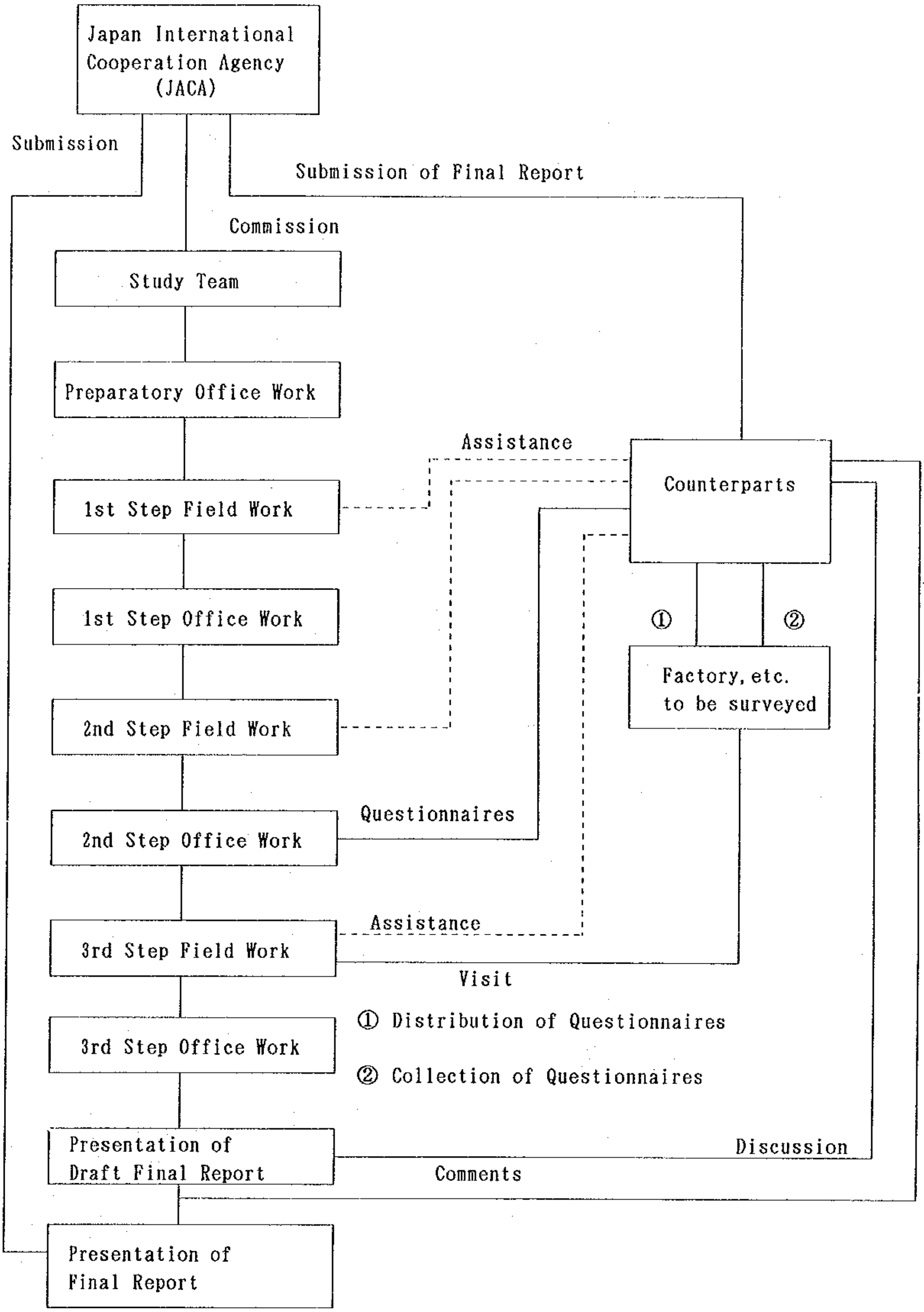

Fig. 1.4.1 Flowchart for the Study

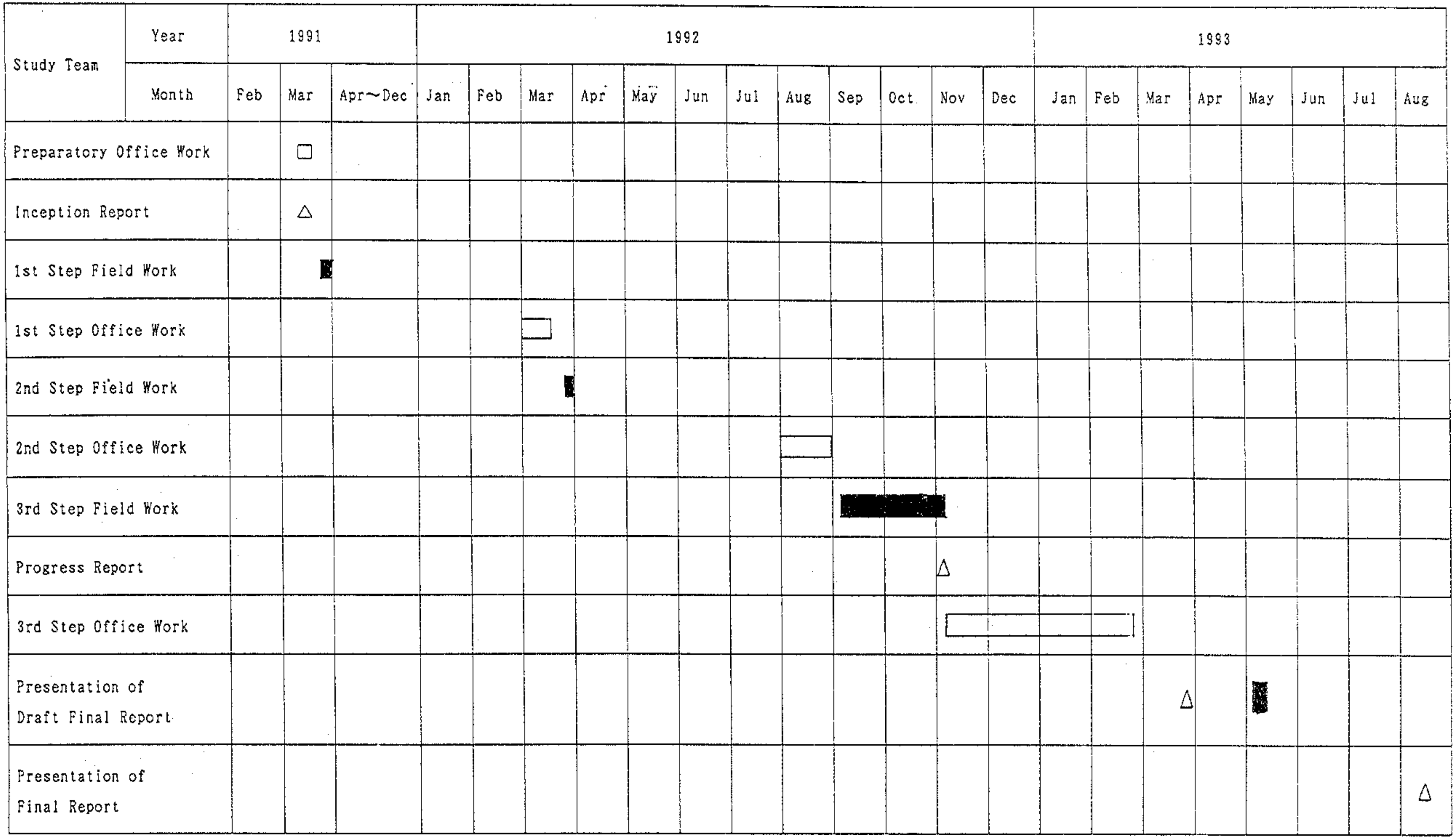

Fig. 1.4.2 Schedule of the study

II. Plating Industrial Estate

II Plating Industrial Estate

1. Condition of the Industrial Estate

1.1 Outline of the Industrial Estate

The plating industrial estate, being run by S Co., Ltd., is situated at the western verge of Inchon City. Business places which have joint wastewater treatment plants in this estate are Business Place No.1 and Business Place No.2.

(1) Location of the each of the business places mentioned above is shown in Fig.1.1.1. and is as follows:
Business Place No.1: 178-35 Ka Jaw Dong, Suh Ku Inchon
Tel: 032-575-7438,9
Business Place No.2: 223-42 Suk Nam Dong, Suh Ku Inchon
Tel: 032-573-7250, 7260

(2) Scale of the plating industrial estate

Business Place No.2 has a total site area of about $4600m^2$ and in this site area, a 3-storied building occupying a site of about $1200m^2$, a 1-storied plating factory occupying a site are of about $780m^2$, and a joint wastewater treatment plant occupying a site area of about $460m^2$. The 3-storied building is of apartment type. Plating factories of 23 companies in total are located in this building; 10 companies on the first floor and 13 companies on the second floor. The third floor is occupied by an office room and a testing and analysis room. The 1-storied building accommodates plating factories of 8 companies. The wastewater from each of these plating factories is discharged into the joint wastewater treatment plant and the effluent from the treatment plant is finally discharged into the public sewerage system.

Business Place No.1 has approximately the same scale as Business Place No.2, and in its site, there are a new 3-storied building, an old 1-storied (partly 2-storied) building for plating factory, a power substation, and a joint wastewater treatment plant. The 3-stoied new building is of apartment type. Plating factories of 14 companies in total are located in this building; 5 companies on the first floor, 5 companies on the second floor, and 4 companies on the third floor. The third floor is also occupied by an office and a testing and analysis room. Underground, there is a dining room for employees. The old building is occupied by plating factories of 14 companies on the first floor and plating factories of 3 companies on the second floor. The wastewater from each of these plating factories is discharged into the joint wastewater treatment plant and the effluent from the treatment plant is finally discharged into the public sewerage system.

In addition to the above, there is Business Place No.3 which was constructed in 1991. It has no joint wastewater treatment plant. The surface treatment factory of one company in this business place was surveyed. The wastewater from the factories located in this business place is discharged into a reservoir tank in the site of the business place, from which it is then transported by tank lorry to Business Place No.1 where it is treated.

In any of Business Place No.1, Business Place No.2 and Business Place No.3, the plating factories are small-scale enterprises having 100-200 m^2 site area and 3-16 employees.

(3) Organization

S Co., Ltd, has technology regarding wastewater treatment. It has been engaged in the manufacture of environmental equipment, while it is running a plating industrial estate as a part of its business.

In the plating industrial estate, small-scale plating companies can be located free of charge on the condition that they should observe the regulations. The wastewater and exhaust gas from the factories should be treated in the joint treatment plants installed in the plating industrial estate, and this is the basis for the running of plating industrial estate.

1.2 The State of Wastewater, Wastewater Treatment and Reclamation

Joint wastewater treatment plants were designed and constructed by S Co., Ltd. They are if approximately the same scale and are installed in /business Place No.1 and Business Place No.2.

The wastewater to be treated flows from each plating factory directly into the joint wastewater treatment plant, or is transported from the other business place and plating factories located outside the plating industrial estate by tank lorry (5t).

The wastewater treatment is done for a consideration, and therefore, these plants are recognized as the industrial waste treatment plants.

The joint wastewater treatment plant in Business Place No.2 is described below.

At present, the following quantity of wastewater is treated, and this is about 60 % the plant's treatment capacity:

Cyanide wastewater: 1,240m^3/M (217m^3/M from outside)
Chrome wastewater : 1,288m^3/M (362.4m^2/M from outside)
Acid and alkali wastewater:
1,842m^3/M (657.2m^3/M from outside)
(Total) 4,370m^3/M (1,236.6m^3/M from outside)

In design, on 12 hour/day operation basis. the quantity of wastewater treated is cyanide wastewater 100m^3, chrome wastewater 100m^3, and acid and alkali wastewater 120m^3, 320m^3/day in total, but at present, in 8 hour/day (9:00-17:00) and 25m^3/day operation, average 180m^3/day is treated.

1.3 Service Water and Wastewater Systems

(1) Water systems

Water which is used in the plating industry estate is supplied by the tap water supply system in any of the 1st Estate Section, the 2nd Estate Section and the 3rd Estate Section.

Roughly speaking, tap water is used as (1) water for production use and (2) water for domestic use.

Water for production use is classified as (1) production water in each plating factory and (2) water in the central wastewater treatment plant. Water for domestic use is classified as (1) water for cooking, (2) water for flush toilet and (3) water for laundry.

Water used in each plating factory is used for (1) preparation of bath, (2) washing, (3) washing of floors, (4) cooling, etc. In addition, it is used also as recycled water in the central gas scrubber tower, which purifies the flue gas discharged from the hood inside the room. This tower is installed as a measure for improving the working environment in the factory.

Water used in the central wastewater treatment plant is used for (1) dissolving of chemicals, (2) washing of the dehydrator, (3) backwashing of the filter tower, (4) regeneration of ion exchange resins, (5) washing of other equipment, (6) washing of floors, etc.

Water for cooking is used in the 1st Estate Section. Water for flush toilet and water for laundry are used in both the 1st Estate Section, the 2nd Estate Section and the 3rd Estate Section.

(2) Wastewater systems

Wastewaters from production processes are classified and discharged from each factory and are received in the cyanide wastewater tank, the chrome wastewater tank, and the acid-alkali wastewater tank of the central wastewater treatment plant installed in the estate section. The conditions of discharge are as follows. Floor spilled water is discharged at all times. Washing water is discharged at all times or once a day. Bath liquor is discharged at a frequency of once or more in a year. Further, recycled water in the central gas scrubber tower is discharged. The wastewater quantity is equal to the quantity of water used for production use less a high concentration wastewater to be treated by entrusting outside, an evaporated quantity of hot bath liquor and cooling water, and an evaporation in the gas scrubber. On the other hand, in the central wastewater treatment plant, wastewaters transported from plating factories located outside the plating industrial estate are also received and treated. For this reason, the quantity of effluent from the wastewater treatment plant surpasses that from production processes. The treated wastewater is finally discharged into the public sewerage system.

The domestic wastewater is classified as nightsoil and miscellaneous wastewater. The former is treated in the sceptic tank usually by anaerobic treatment and the wastewater is combined with the latter to be discharged into the public sewage system.

1.4 Condition of Wastewater Treatment and Reclamation Plants

Among the three estate sections of the plating industrial estate being run by S Co., Ltd., the 1st Estate Section and the 2nd Estate Section have the wastewater treatment plant.

Reclamation plants are not installed in any of the estate section.

The wastewater treatment plant installed in the 1st Estate Section and the 2nd Estate Section are approximately equal to each other in (1) wastewater treatment system, (2) plant construction and scale, (3) unit apparatus installed in the treatment plant, (4) method of operation, (5) number of personnel involved in the operation, etc., and therefore, the wastewater treatment plant of the 2nd Estate Section only will be selected and its conditions be described.

Fig.1.4.1. and Fig.1.4.2. show the flow sheet and the layout of the wastewater treatment plant, respectively.

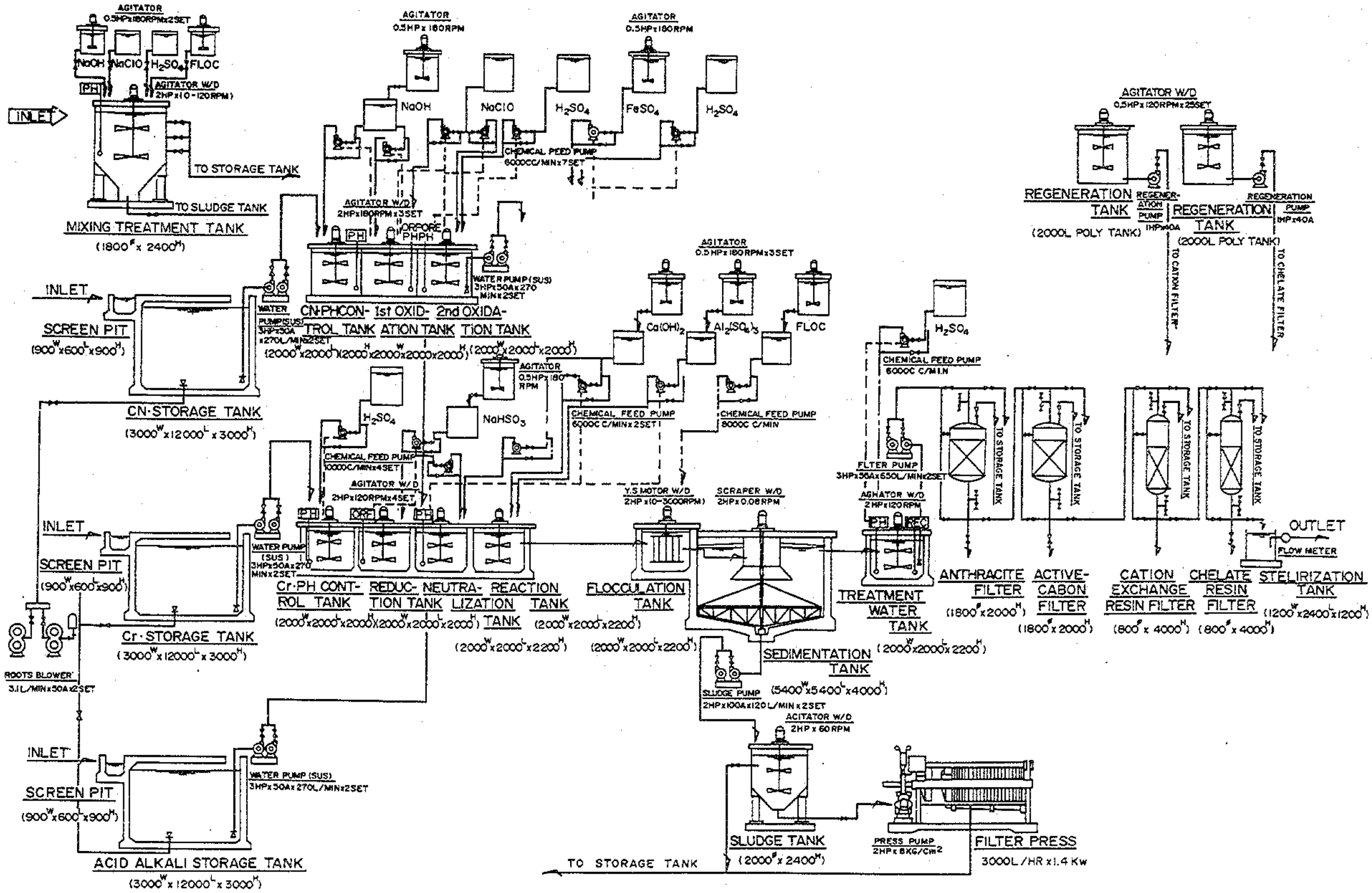

Fig. 1.4.1 Flow Sheet of Central Waste Treatment Plant

(Metal Plating, 2nd Estate)

NO.	N E M E	S I Z E
1	CN SCREEN PIT	600 x 800 x 1800
2	Cr SCREEN PIT	600 x 800 x 1800
3	ACID ALKALI SCREEN PIT	600 x 800 x 1800
4	SCREEN PIT(STANDBY)	600 x 800 x 1800
5	CN PH CONTROL TANK	2000 x 2000 x 2000
6	1st OXIDATION TANK	2000 x 2000 x 2000
7	2nd OXIDATION TANK	2000 x 2000 x 2000
8	Cr PH CONTROL TANK	2800 x 2800 x 2800
9	REDUCTION TANK	2800 x 2800 x 2800
10	NEUTRAUZATION TANK	2800 x 2800 x 2800
11	REACTION TANK	2800 x 2800 x 2800
12	FLOCCULATION TANK	2800 x 2800 x 2800

NO	N E M E	S I Z E
13	SEDMENTATION TANK	5600 x 5600 x 4000
14	TREATMENT WATER TANK	2800 x 2800 x 2800
15	ANTHRACITE FILTER	2000 x 2400
16	ACTIVE CARBON FILTER	2000 x 2400
17	CHELATE RESIN FILTER	800 x 4600 x 2SET
18	EFFLUENT TANK	900 x 900 x 900
19	MACHINE ROOM	5600 x 1600 x 1600
20	SLUDGE TANK	2000 x 2400
21	FILTER PRESS	3000L/HR x 2SET
22	MIXING TREATMENT TANK	1600 x 3200
23	REGENERATION TANK	2000L x 2SET

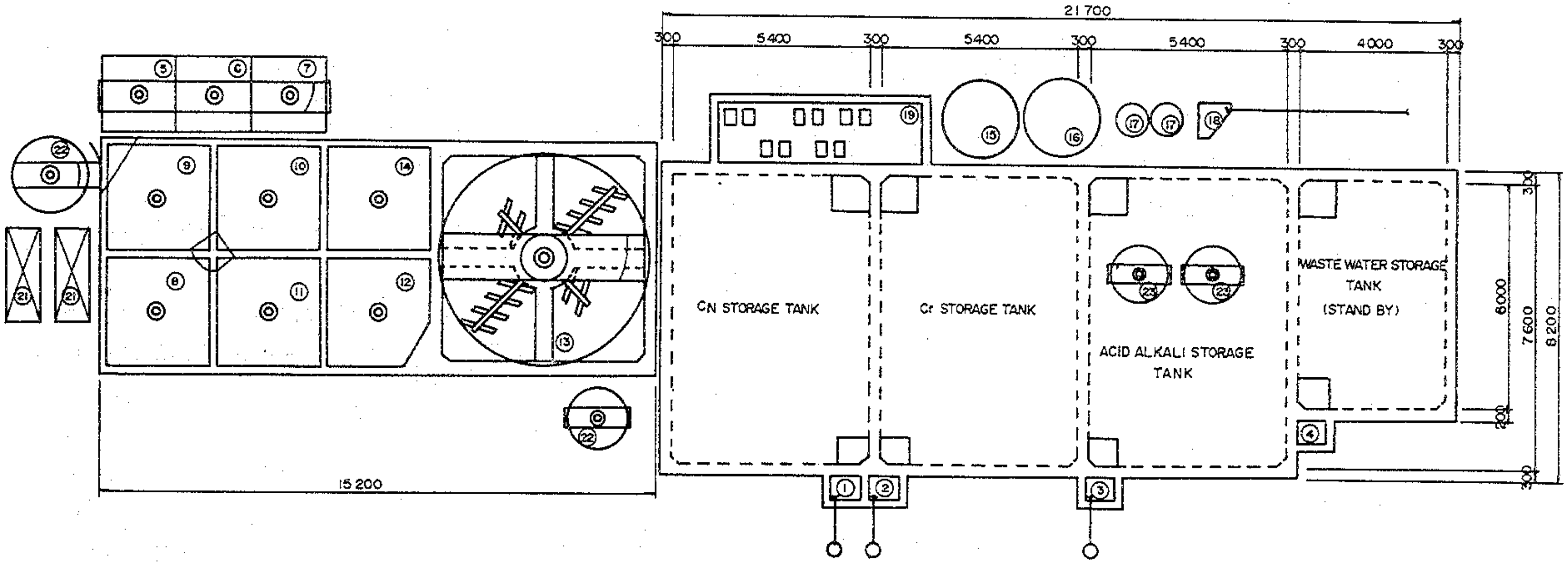

Fig.1.4.2 Layout of Central Waste Treatment Plant

(Metal Plating, 2nd Estate)

2. Review of the Current Wastewater Treatment and Reclamation Systems

2.1 Evaluation and Problems Concerning the Current Systems

The outlines of the present wastewater treatment plants are as described in "1.5 Conditions of Wastewater Treatment Plants".

It is also described above that there are no plating factories which perform wastewater reclamation, and in any of the central wastewater treatment plants in the 1st Estate Section and the 2nd Estate Section, wastewater reclamation is not done. Therefore, in this chapter, an evaluation of the central wastewater treatment plants will be made and some problems with them will be extracted.

The facilities in each central wastewater treatment plant of this plating industry estate comprise three systems: a system to receive wastewater discharged from each factory after being classified as three, (1) cyanide wastewaters, (2) chrome wastewaters and (3) acid-alkali wastewaters and treat them to be harmless; a system to remove organic substances such as COD, BOD, etc. remaining in the treated water; and a system to remove heavy metals in the form of chelate compounds which might remain in trace amounts after treatment.

For the sludge generated by wastewater treatment, a system which dehydrates the sludge and carries the dehydrated cake to the outside for entrusted disposition is adopted.

The wastewater treatment plant is a rational one which treats the overall wastewaters of the plating industrial estate safely and discharges the treated water finally to the public sewage system.

However, the wastewater treatment plant treats not only wastewaters discharged from plating factories located in the plating industrial estate, but also it is operated as an industrial waste treatment plant which receives wastewaters transported by tank lorry from plating factories located outside the plating industrial estate and treats and disposes of them for a consideration. Therefore, there are problems in the operation and maintenance of the wastewater treatment plant by the operators who have to address wastewater quantity and quality variations appropriately.

With the above-mentioned situations in mind, problems in the present wastewater treatment facilities will be extracted, and some fundamental ones of them will be described below.

2.2 Proposal for the Improvement of the Current Systems

The treatment system of the present central wastewater treatment plant is a rational one, and extracted problems are caused mainly by the discharge of incompletely classified wastewaters and the operating method of facilities.

Plating wastewaters are one of the industrial wastewaters which should be treated with most scrupulous care. Moreover, wastewaters of the plating industrial estate are overall wastewaters comprising various wastewaters discharged from many plating factories, and their properties are very complicated. In addition, since the same wastewater treatment plant is also used for the industrial waste treatment business, advanced technology is required.

From the foregoing, the central wastewater treatment plant as the receiving side requests the following prerequisites. Not only in the plating factories located in the plating industrial estate, but also in the plating factories located outside the plating industrial estate, wastewaters should be discharged after being classified and their sources of discharge should be clearly identified.

Plating factories are small enterprises and have no sufficient money to spare in Korea, as well as in Japan and Europe and America.

Considering the present state mentioned above, improvement plans to address the extracted points by making use of the existing facilities will be proposed.

(1) Consolidation of the laboratory

With the objectives of receiving of wastewaters, confirming of wastewater treatability, and research and development of wastewater treatment technology and plating technology, the laboratory should preferably be consolidated as follows.

1) Collection of data concerning the composition of wastewaters by kinds and treatment technology
2) Installation of automatic analyzers
   Common: pH meter, ORP meter, conductivity meter, absorptionmetry meter, etc.
   Heavy metals: Atomic absorptionmetry meter, inductively coupled plasma-atomic emission spectroscopy (ICP) analyzer
   Anion: Ion chromatography
   Cyanide: Cyanide automatic analyzer (capable of confirming of complexes)
3) Training of engineers

(2) Improvement of wastewater tanks

1) Separation of acid-alkali wastewater tanks into acid wastewater tanks and alkali wastewater tanks
2) Installation of high concentration wastewater tanks for each kind of wastewaters, or division of existing tanks
   High concentration wastewaters should be treated at a small rate together with low concentration wastewaters, or must be utilized effectively for neutralization of alkali wastewaters.

(3) Treatment of wastewaters containing cyanide complexes of iron

With the present wastewater treatment system, it cannot be expected to treat cyanide in the wastewaters containing cyanide complexes of iron.

It is desirable to add a treatment operation using the zinc white method after the present cyanide decomposition process.

For the principles, conditions, etc. of this treatment, refer to "V. Guidelines for Wastewater Treatment and Reclamation".

(4) Addition of some functions to batch reaction tanks

The batch reaction tank (mixing treatment tank) should be improved as follows: pH meter, ORP meter, etc. should be installed; in addition to the present flow diagram comprising sodium hydroxide, sodium hypochlorite, sulfuric acid and high polymer coagulant, it should be possible to feed reducing agents such as calcium hydroxide, inorganic coagulant, sodium sulfite, etc. and other oxidizing agents; and heating should be applicable, so as to cope with treatment of wastewaters which otherwise should be treated separately and recovery of resources.

Treatment to be covered is as follows. For the principles of treatment, conditions of treatment, etc., refer to the guidelines mentioned later.

1) Treatment of plating bath liquors containing cyanide complexes of nickel
2) Treatment by coagulation and sedimentation of cleaning liquors and stripping liquors containing heavy metal complexes
3) COD oxidation treatment by the Fenton method of non-electroplating liquors, and coagulation treatment of phosphorus
4) Treatment of fluoborate
5) Treatment of organic solvent containing wastewaters and chelate containing wastewaters and treatment of COD and BOD by the powdered activated carbon adsorption method
6) Ferrite formation of heavy metals
7) Recovery of EDTA from cleaning liquors and stripping liquors containing EDTA

(5) Automation

1) Installation of water level meters in the wastewater tanks
To indicate water level and be operated jointly with on-off pump operation.

2) To be operated jointly with high polymer coagulant feed pump and storage pump.
3) Installation of graphic panels which display the present state.

3. Determination of the Optimum Systems

Industrial estate of S Co. is adopted as a typical example of Korean plating industrial estates. Then, the actual states 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 plating industrial estate, it is looking 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

(1) The optimum system for wastewater treatment plants will be defined as most economical wastewater treatment system which satisfied pollution related regulations now in effect or expected to be in effect , in Korea. Conceptual design and economic feasibility studies will be carried out on Case-1 and Case-2.

(2) the optimum system for reclamation plants will be defined as most economical system which produces reclaimed water having a quality equal to or better than that of tap water in use. A conceptual design and economic feasibility study will be carried out on Case-3, Case-4 and Case-5 will be reviewed as references.

The section of the plating industrial estate which was selected for the optimum system study is the 2nd Estate Section. The reasons for this selection are as follows. The 1st Estate Section and the 2nd Estate Section are approximately the same in the number, contents and scale of plating factories located therein and in the central wastewater treatment plant; the 2nd Estate Section is arranged in more compact; about the 2nd Estate Section, more abundant information was furnished; and the 2nd Estate Section treats a smaller quantity of industrial wastes and the present state can be grasped more easily.

The basic policies for this study are as follows:

A. The study for the optimum system will on be limited to central wastewater treatment and reclamation of wastewaters from plating factories located in the estate section, excepting the industrial waste treatment business which is run by S Co., Ltd. at present.

B. Each plating factory has a small working area and it is impossible for each plating factory to have its own wastewater treatment equipment or reclamation equipment. Therefore, wastewaters to be treated will be overall wastewaters of the plating industrial estate.

C. The wastewater quantity and quality to be treated will be estimated from the data obtained by the visiting survey and the various data in Japan.

First, it will be assumed that wastewaters are discharged after being completely classified and the wastewater quantity and quality at that time will be determined and be taken as the present wastewaters. Then, it will be assumed that wastewater quantity reducing measures have been taken and wastewaters are discharged after being classified as high concentration wastewaters discharged when the plating liquor is renewed and as the present washing wastewaters, and the wastewater quantity and quality at that time will be determined and be taken as wastewaters after wastewater quantity reducing measures have been taken. The study for the wastewater treatment system will be made using these wastewaters. Further, washing wastewaters when the counter-current multi-stage washing system is adopted in the washing process will be classified as the semi-high concentration wastewaters and washing wastewaters. These wastewaters will be taken as wastewaters after the counter-current multi-stage washing system, and the reclamation system will be studied using this wastewaters.

D. In order to give generality to the optimum system to be proposed, the local peculiarity of the 2nd Estate Section will be ignored and the place of installation of the treatment facilities will be within Inchon City.

E. In economic calculation of construction cost, running cost, etc., standard prices in Korea taking the installation place into account will be adopted.

3.2 Measures for the Reduction of Wastewater Quantity

3.2.1 Concrete Measures

(1) Complete implementation of water usage control

In each of the surveyed factories, tap water supply is only the water source available. The pipe diameter is about 25 mm in general. There is only one water tap. Near the pipe end, a water meter (integrating flowmeter) is provided. With this meter, the integrated value of water consumption can be known, but it is difficult to know the instantaneous flow rate. However, since the factory is small in scale and its water consumption is small, it is almost impossible to provide a flowmeter at every point of water use.

A relatively practicable method of water usage control will be to install at the outlet of the water tap a flowmeter capable of measuring the instantaneous flow rate, such as an area flowmeter (rotameter).

By this means, the water consumption at least at a certain point of time is known and it becomes possible to monitor whether the water consumption is proper or not for the working conditions at that point of time.

However, for this means to be applicable, it is necessary, as described above, to have the working standard concerning the water consumption prepared for each washing process.

Even such a degree of water usage control will make it possible to realize a considerable wastewater quantity reduction possible as compared with the present rough control method.

This type of flowmeter is relatively inexpensive (200-300 thousand wons or so) and its installation is also easy. It may be used sufficiently in the surveyed factories.

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

In the surveyed factories, with a few exceptions, the multi-stage system on washing method is adopted. The "Stored water washing" system is used in most cases, and the "Running water washing" system is used only in very few cases.

Even the "Stored water system" washing can be considerably effective for water saving, but the water in the water tank is degraded of its quality with the lapse of time and requires early replacement. Therefore, it cannot be said the effect of water saving of this system is not necessarily sufficient.

If the "Stored water washing" tank being used at present is improved into a "Running water washing" system of at least two-stage counter-current type and the water flow is controlled well, then considerably effective water saving, that is, wastewater quantity reduction, may be accomplished.

However, adopting the counter-current system involves the following problems.

A. Because of the very confined space, it is considerably difficult to arrange the counter-current washing tanks in a way to insure good working efficiency.
B. As described before, the water supply tap is provided only at one place, and it is difficult to supply water therefrom to each water washing tank continuously because it may require many pipings to be installed on the limited floor surface.
C. The single tank which has been used conventionally can be moved easily and its application can also be changed easily. In contrast, the counter-current multi-stage washing tank, once installed, cannot be moved easily, nor its application can be changed. Thus, the flexibility in working is lost.

The counter-current multi-stage washing tank is made normally of synthetic resin (such as PVC) and is not too expensive. Therefore, if it is improved successively by solving the above problems one by one, it seems that this system will be applicable

(3) Cascade use

As the cascade use, it is the easiest and most effective way to use the drainage from indirect cooling for the use of washing as mentioned above. However, since cooling water is rarely used in the surveyed factories, this method cannot find any place of application. In the two factories where cooling water is used, the cooling tower has already been installed for recycling use, and so, there is no need for cascade use.

(4) Automatic water supply system for washing tank

This system is applicable to either single tanks or multi-stage tanks as described before. However, since it is rather too expensive to install many units (about 80 thousand yen each in Japan), its application is difficult where there are many water washing processes for the water consumption as in the surveyed factories.

This equipment is suitable for larger factories.

(5) Hand control valve

In the surveyed factories, water supply to water washing tanks, etc. is done not through fixed pipings, but frequently by means of long hoses of movable type. In such cases, it is effective for the purpose of water saving to install a hand control valve at the hose end.

Such valves are priced at about 5 thousand yen each in Japan and will be sufficiently usable.

(6) The realizable amount of wastewater quantity reduction

It is difficult to discuss for the individual factories concretely that to what degrees the wastewater quantity can be reduced by the methods (1)-(5).

However, based on the data obtained through hearings, observations, etc. by the visiting survey and the experience obtained through many factory surveys in the past, an overall study has been made and it is considered that if the methods (1), (2) and (5), and especially (2) and (3) are implemented, the present wastewater quantity can be reduced by 20-30 % sufficiently.

The realizable amount of wastewater quantity reduction is considerable (40-60 m^3 per day) for the industrial estate as a whole, but may be only small for the individual factories. Therefore, unless each of these factories recognizes the circumstances well and makes efforts for itself to save water even to a small degree, the wastewater quantity reduction of the whole would not be achievable.

3.2.2. Setting of The Effluent Characteristics of the Present Wastewater

Based on the date obtained by the visiting survey, the effluent characteristics of overall wastewater from the plating industrial estate will be defined as follows. It is assumed that wastewater quantity reducing measures such as classified discharge of wastewaters by concentrations, complete implementation of water usage control, mounting of hand control valve, etc. and pollution load reducing measures such as drag-out reduction, have been taken.

A. The overall wastewater quantity from the plating industrial estate will be 200 m^3/day.

B. Plating liquor renewal wastewater will be discharged separately from washing wastewaters. The quantity of plating liquor renew wastewaters will be assumed as 2% of the above-mentioned wastewater quantity and it will be added to the overall wastewater quantity.

C. Acid-alkali wastewaters are discharged without separation.D. As is carried out in the plating industrial estate at present, the 1st washing tank will be used as the recovery tank and its wastewater will not be discharged but be used for bath preparation.

E. Wastewater from the 2nd and subsequent washing tanks will be discharged.

F. When classified discharge is completely realized, effluent characteristics of wastewater are assumed as shown in Table 3.2.1.

G. When highly concentrated plating liquor wastes and washing wastewater are separately discharged, the effluent character istics of wastewater mentioned in F. above will be assumed as shown in Table 3.2.2.

3.2.3 Setting of the Effluent Characteristics of the Wastewaters

When the wastewater quantity reduction by the countercurrent multi-stage washing has been carried out by improving the water

Table 3.2.1. Condition of Water using in Plating Factory

ITEMS	CN Wastewater	Cr Wastewater	H·OH Wastewater
Quantity (m^3/d)	67	62	71
pH	10.2	2.6	2.5
COD (mg/ℓ)	370	240	300
SS (mg/ℓ)	320	210	270
n-Hex (mg/ℓ)	8	—	10
CN (mg/ℓ)	18	—	—
T-Cr (mg/ℓ)	—	100	—
Fe (mg/ℓ)	2	—	30
Zn (mg/ℓ)	30	25	25
Cu (mg/ℓ)	10	40	35
Ni (mg/ℓ)	—	—	25
Pb (mg/ℓ)	—	1	10
Al (mg/ℓ)	—	—	10
Cr^{6+} (mg/ℓ)	—	100	—
F (mg/ℓ)	—	—	10
T-N (mg/ℓ)	—	—	10
T-P (mg/ℓ)	—	20	20
TRICHLOROETHYLENE (mg/ℓ)	—	—	—
TETRACHLOROETHYLENE (mg/ℓ)	—	—	—

Table 3.2.2. Washing Water Ratio on Counter Current Maltistage Washing

ITEMS	CN Wastewater		Cr Wastewater		H·OH Wastewater		
	RINSE	CONC.	RINSE	CONC.	H·OH RINSE	H CONC.	OH CONC.
Quantity (m^3/d)	67	1.4	62	1.2	71	0.7	0.7
pH	10.2	12.2	2.6	0.3	2.5	0.3	13.0
COD (mg/ℓ)	37	3,700	24	2,400	40	4,000	4,000
SS (mg/ℓ)	10	100	10	100	10	1,000	1,000
n-Hex (mg/ℓ)	8	5	—	—	10	10	1,000
CN (mg/ℓ)	100	10,000	—	—	—	—	—
T-Cr (mg/ℓ)	—	—	100	10,000	—	—	—
Fe (mg/ℓ)	2	200	—	—	30	3,000	30
Zn (mg/ℓ)	30	3,000	10	1,000	25	2,500	25
Cu (mg/ℓ)	10	1,000	—	—	35	3,500	35
Ni (mg/ℓ)	—	—	—	—	10	1,000	10
Pb (mg/ℓ)	—	—	—	—	10	1,000	10
Al (mg/ℓ)	—	—	—	—	10	1,000	10
Cr^{6+} (mg/ℓ)	—	—	100	10,000	—	—	—
F (mg/ℓ)	—	—	—	—	10	1,000	10
T-N (mg/ℓ)	—	—	—	—	10	1,000	10
T-P (mg/ℓ)	—	—	20	2,000	20	2,000	20
TRICHLOROETHYLENE (mg/ℓ)	—	—	—	—	—	—	—
TETRACHLOROETHYLENE (mg/ℓ)	—	—	—	—	—	—	—

washing system as described below, the wastewater quantity will be reduced.

A. The 2nd washing tank will be batchwise operated. The wastewater from this tank is called "semi-high concentration wastewater" and will be discharged after being classified.The quantity of the semi-high concentration wastewater will be assumed as 40% of the present wastewater quantity, and the pollution load will occupy 90% of the present pollution load.

B. The 3rd and subsequent washing tanks will be the countercurrent multi-stage washing tanks. The wastewater from these tanks is called "washing wastewater" and will be reclaimed separately. The quantity of the washing wastewater will be assumed as 60% of the present wastewater quantity, and the pollution load will occupy 10% of the present pollution load.

3.3 Determination of the Optimum Wastewater Treatment System

3.3.1 Wastewater Quantity and Quality

On the assumption that wastewaters are completely classified and the high concentration wastewater discharged when the plating liquor is renewed is separately discharged from the present washing wastewaters.

3.3.2 Treated Water Quality

In accordance with the effluent standards in Korea, the treated water quality will be determined as shown in Table 3.3.1.

3.3.3 Determination of the Optimum System

(1) Wastewater treatment system satisfying the present effluent standards

Of the plating wastewater treatment systems, the one which is most positive and is most inexpensive regarding the construction and treatment costs is what follows. This is also most widely used.

A. Harmful substances are made harmless.
   Cyanide is oxidized with sodium hypochlorite. It is decom posed into nitrogen and carbon dioxide. hexavalent chromium is reduced with sodium sulfite or the like to trivalent chromium.
B. An iron-cyanide complex treatment process is added.
C. Heavy metals, aluminum, fluorine and phosphorus are removed by coagulation-sedimentation treatment.
D. Acid and alkali are neutralized.
E. COD and BOD, caused by organic substances, are removed by co-agulation-sedimentation treatment.
F. Heavy metals which are present in trace amounts in the efflu-

Table 3.3.1. The quality of trasted water

Items (unit)		Standard
BOD	(mg/l)	30
COD	(mg/l)	130 (40) *-1
SS	(mg/l)	30
pH	(mg/l)	5 ～ 9
n－Hex (mineral oil)	(mg/l)	5
n－Hex (plant oil	(mg/l)	30
Phenol	(mg/l)	3
CN	(mg/l)	1
T－Cr	(mg/l)	2
Fe	(mg/l)	10
Zn	(mg/l)	5
Cu	(mg/l)	3
Cd	(mg/l)	0.1
Hg	(mg/l)	0.05
Org－P	(mg/l)	1
As	(mg/l)	0.5
Pb	(mg/l)	1
Cr^{6+}	(mg/l)	0.5
Mn	(mg/l)	10
F	(mg/l)	15
PCB	(mg/l)	0.003
Trichloroethylene	(mg/l)	0.3
Tetrachloroethylene	(mg/l)	0.1
T－N	(mg/l)	60
T－P	(mg/l)	8

*－1 Standard on Advanced Treatment

ent from the coagulation-sedimentation treatment process are removed by adsorption on chelate resins.

G. High concentration wastewaters such as plating liquor are separately stored in the wastewater storage tank, from which they are added at a small rate to the washing wastewater of the same system to be treated.

The iron-cyanide treatment process is generally not incorporated. However, taking the results of the visiting survey into account and from the viewpoint of treating the overall wastewaters from the plating estate, this process will be added. For the principles of this treatment, refer to "V. Guidelines for Wastewater treatment and Reclamation".

Since aluminum is contained in the wastewater, pH adjustment to weak alkalinity is necessary for the coagulation-sedimentation treatment of heavy metals. Therefore, there is a possibility that heavy metals to be removed as hydroacid s remain ions. Moreover, it is anticipated that complexed heavy metals may exist, and in order to remove them, the system must have a chelate resin tower installed following the coagulation-sedimentation treatment process.

Fig.3.3.1. shows the flow diagram of the wastewater treatment system satisfying the present effluent standards.

(2) Advanced treatment system

In the case of the wastewater treatment systems satisfying the present effluent standards, almost all COD sources remaining in the effluent from the coagulation-sedimentation treatment process are organic substances. These organic substances as pollutants are generated by oils, etc. released in the cleaning process and additives contained in the bath liquor. For the removal of these organic substances, activated carbon adsorption is most widely used.

On the other hand, in those plating factories which perform manufacture of printed circuit boards and plating of plastics, chemical plating is done, and from these factories, wastewaters

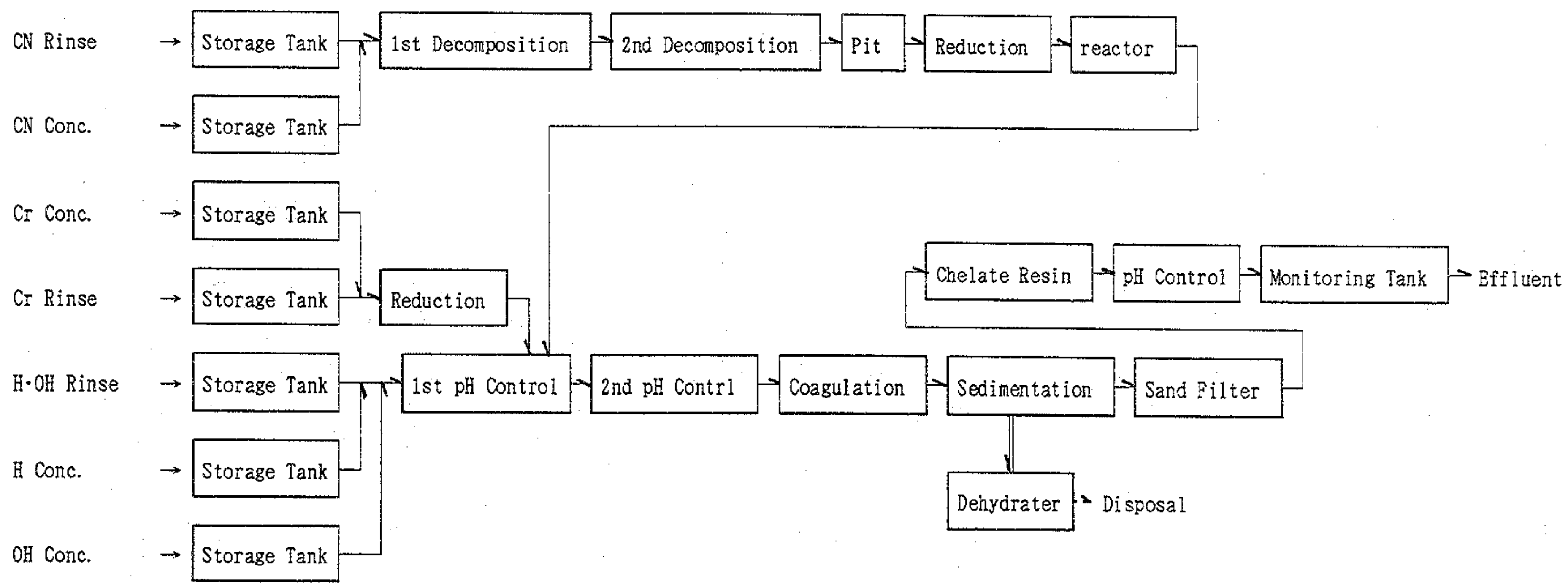

Fig. 3.3.1. Flow-Diagram of the Treatment System Satisfying the Present Effluent Standards

containing reducing agents of inorganic and organic substances are discharged. These reducing agents are measured as COD.

In general, concentrate wastewaters are added at a small rate to the washing wastewaters to be treated, or are separately treated and disposed of. Washing wastewaters to be discharged as such are reduced in concentration by reduction measures and have no problems in most cases.

From the foregoing, the following system will be adopted.

A. The wastewater treatment system satisfying the present effluent standards will be added with an activated carbon adsorption tower before the chelate resin tower.

Fig.3.3.2. shows the flow diagram of the advanced wastewater treatment system.

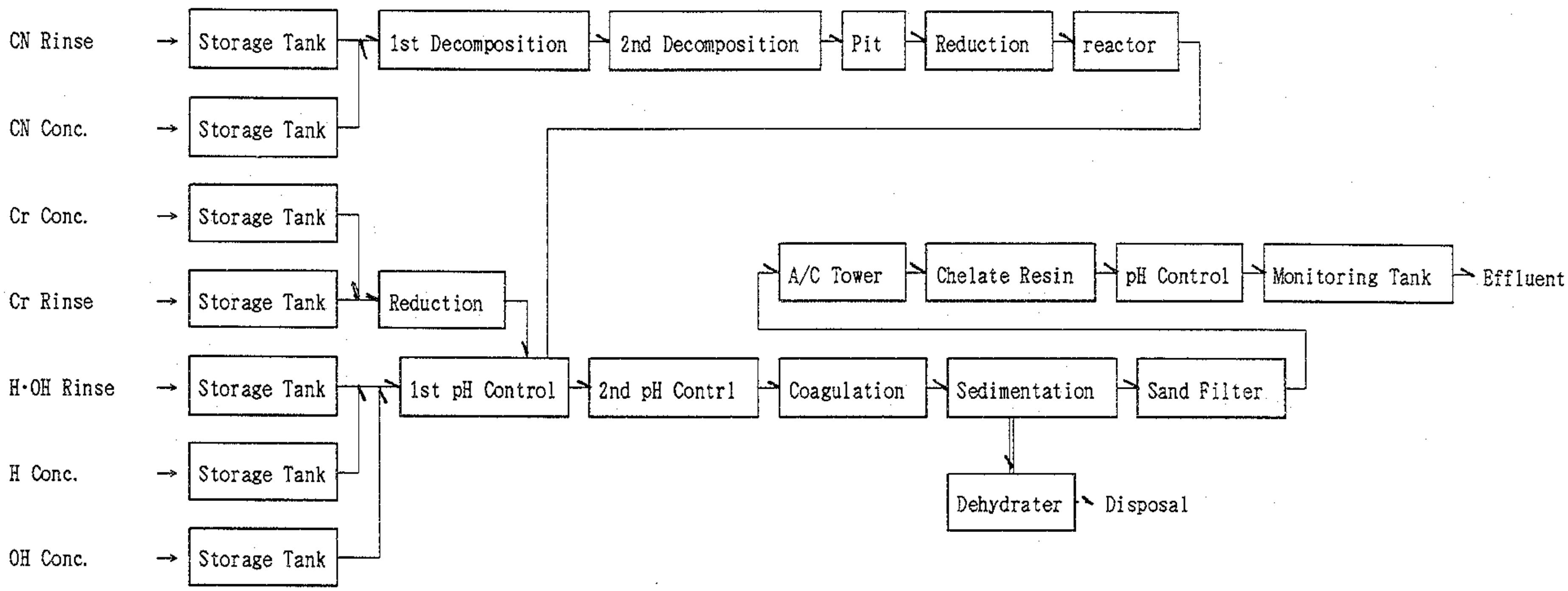

Fig. 3.3.2. The Flow-Diagram of the Advanced Treatment System

3.4 Determination of the Optimum Reclamation System

3.4.1 Wastewater Quantity and Quality

Classification of wastewaters was completely carried out and then, wastewaters were classified as high concentration wastewaters discharged when the bath liquor was renewed and present washing wastewaters.

Then, the wastewater quantity and quality on the assumption that the washing wastewaters are discharged after being classified as semi-high concentration wastewaters and washing wastewaters by adopting the counter-current multi-stage washing system in the washing process will be defined.

3.4.2 Treated Water Quality

The treated wastewater quality will be as shown in Table 3.3.1.

The reclaimed water quality will be better than 20 uS/cm in conductivity.

3.4.3 Determination of the Optimum System

(1) Combination of the Reclamation System and the Wastewater Treatment System Satisfying the Present Effluent Standards

A. Wastewaters to be reclaimed

Washing wastewaters from the 3rd washing tank and subsequent counter-current multi-stage washing tanks will be reclaimed. Washing wastewaters will be classified as acid-alkali washing wastewater, chrome washing wastewater and cyanide washing wastewater.

B. Wastewaters to be treated

a. Bath liquor renewal wastewaters

Bath liquor renewal wastewaters will be classified as acid high concentration wastewater, alkali high concentration wastewater, chrome high concentration wastewater, and cyanide high concentration wastewater.

b. Semi-high concentration wastewater from the 2nd washing tank Semi-high concentration wastewaters will be classified as acid-alkali semi-high concentration wastewater, chrome high concentration wastewater, and cyanide high concentration wastewater.

c. Regeneration wastewater of ion exchange resins

C. Reclaimed wastewater quantity

a. The wastewater quantity to be treated for the purpose of reclamation will be 60 % of the present wastewater quantity.

However, the wastewater quantity to be recovered as reclaimed water, less the regeneration water for ion exchange resins, will be 50 % of the present wastewater quantity.

If the dilute wastewater such as washing water after reduction measures being taken is to be reclaimed, a method using ion exchange resins for removing salts containing heavy metals in the wastewater is widely used.

Among ion exchange resin towers, the 1st tower is a single bed tower containing strong cation exchange resin only and the 2nd tower is a two-bed tower containing weak anion exchange resin and strong anion exchange resin. The water in treatment is applied in up-flow and the water for resin regeneration is applied in down-flow.

A comparison of this treatment system using ion exchange resins with the conventional systems is as follows. The treated water quality is 2-10 uS/cm in conductivity in the present system and 10-50 uS/cm in the conventional systems, and the chemical consumption for resin regeneration is reduced to 1/2 in the present system of that in the conventional system. Owing to such advantages, wastewater reclamation has come to wide use.

Fig.3.4.1 shows the flow diagram of the reclamation system and the wastewater treatment system satisfying the present effluent standards.

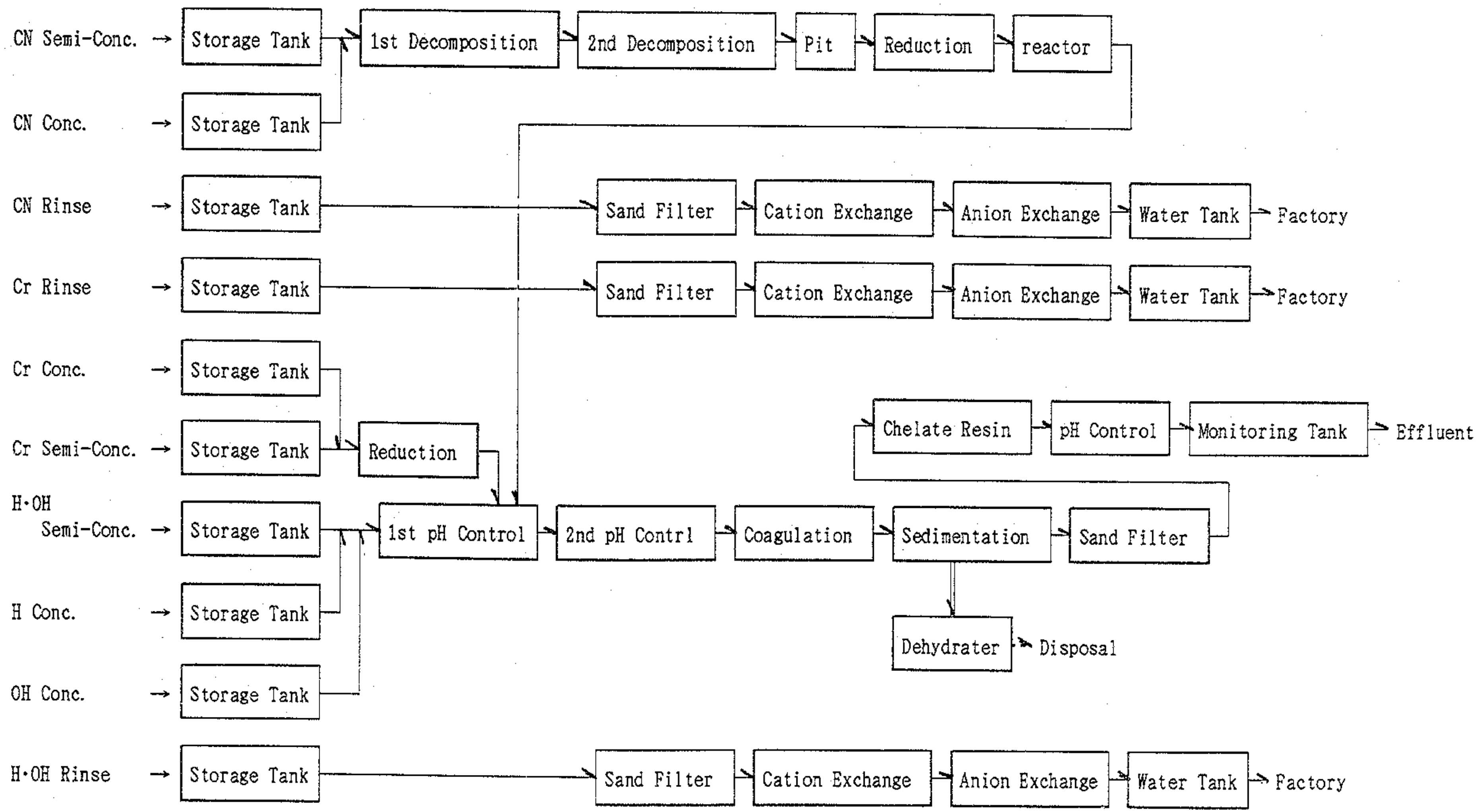

Fig. 3.4.1. The Flow-Diagram of the Reclamation System and the Treatment System Satisfying the Present Effluent Stadards

3.5 Economic Feasibility of the Optimum Systems

3.5.1 Construction Cost

The following cost calculation are based on 1992 prices.

Table 3.5.1. shows the construction cost of a treatment system satisfies the present effluent standards (Case-1), an advanced COD component treatment system (case-2) and a combination of the reclamation system and the wastewater treatment system satisfying the present effluent standards.

The construction cost of a combination of the reclamation system and the advanced COD component treatment system, called Case 4, is about 1466 million wons, and that of the closed wastewater treatment system called Case 5 is about 314 million wons.

3.5.2 Operation Cost

Table 3.5.2. shows details of unit prices of utilities such as chemicals used and labor costs for the calculation of operation costs.

Table 3.5.1. Cost of civil works

(Million Won)

	Case-1	Case-2	Case-3
(1) Civil and Architectural Work	—	—	—
(2) Machinery and Equipments	276	295	322
(3) Electrical Work	553	590	834
(4) Piping Work	60	64	70
(5) Test Working and Others	30	30	40
(Sub-total)	919	979	1.266
(6) The others	138	147	190
(Total)	1,057	1,126	1,456
Plottage (m^2) (Control Room)	820 (120)	820 (120)	913 (120)

Table 3.5.2. Cost of operation

(Million Won/Year)

	Case－1	Case－2	Case－3
(1) Chemicals	88.2	117.7	90.8
(2) City Water.	0.7	0.7	0.7
(3) Electric Power	7.2	7.2	8.6
(4) Sludge Disposal	12.9	12.9	12.9
(sub-total)	109.0	138.5	113.0
(5) Labor	30.5	30.5	30.5
(Total)	139.5	169.0	143.5
Unit Water (Won/m^3)	2,325	2,817	2,392

4 Financial and Economic Analysis

4.1 Total Capital Requirements and Operating Costs

4.1.1 Construction Cost and Total Capital Requirements

Construction Cost and Total capital requirements are summarized below. Optionally, the land acquisition cost is included in the table. This cost is assumed to be 451 million won for Case 1 and Case 2 at 820 m^2 and 502 million won for Case 3 at 913 m^2. These amounts are based on the actual purchase price of the plating industrial estate in Inchon. Unit price is set at 550,000 won per m^2.

Table 4.1.1 Construction Cost

Unit: million won

	Case 1	Case 2	Case 3
Civil and architectural work	-	-	-
Machinery and equipments	317	339	370
Electrical work	636	679	959
Piping work	69	74	81
Total	1,022	1,091	1,410

Table 4.1.2 Total Capital Requirements

Unit: million won

	Case 1	Case 2	Case 3
Construction cost	1,022	1,091	1,410
Preoperational expenses	35	35	46
Interest during construction	39	42	54
Total (1)	1,096	1,168	1,510
Land acquisition cost	451	451	502
Total (1)+Land acquisition cost	1,547	1,619	2,012

4.1.2 Operating Costs and Expenses

(1) Variable operating cost

This cost covers chemicals, water, utility (electricity) and disposal cost of sludge are included. The cost is summarized in Table 4.1.3. Details are discussed in Chapter 3.

(2) Fixed operating cost

Fixed operating cost consists of labor cost and maintenance cost. Labor cost is assumed to be 30.5 million won per year for each case. Details are shown in Chapter 3.

On the other hand, annual maintenance cost is estimated as 1.0 percent of the construction costs through out the project life period. The cost is summarized in Table 4.1.3.

Table 4.1.3 Operating Costs

Unit: million won

	Case 1	Case 2	Case 3
Variable operating cost			
Chemicals	88.2	117.7	90.8
Water	0.7	0.7	0.7
Utility (electricity)	7.2	7.2	8.6
Disposal cost of sludge	12.9	12.9	12.9
Sub-total	109.0	138.5	113.0
Fixed operating cost			
Labor cost	30.5	30.5	30.5
Maintenance costs	10.6	11.3	14.6
Sub-total	41.1	41.8	45.1
Total	150.1	180.3	158.1

4.2 Financial Analysis

4.2.1 Basic Assumptions and Premises

For the purpose of the financial calculations, the following basic premises are applied.

(1) Project life and plant operation

(a) Project life ; construction period : 1 year
; operating period : 15 years
(b) Implementation body : Non-profit industrial cooperative
(c) Waste water treatment capacity : 60,000 m^3 per year
(d) Volume of recycling water : 30,000 m^3 per year (Case 3)
(d) Annual operating days : 300 days
(e) Annual operating hours : 2,400 hours (8 hours per day)

(2) Escalation of costs and prices

All costs and prices used in the financial analysis are assumed to be fixed in the end of 1992, and no escalation factors are applied.

(3) Corporate income tax

Corporate income tax will be imposed at a rate of 10 % of taxable income. This preferential rate is provided to an operator of environment protection facilities under the regulation.

(4) Depreciation and amortization

Depreciable assets are assumed to be depreciate as follows.

(a) Mode : Declining balance method
(b) Period : 15 years
(c) Salvage value : 10 percent

Also, interest during construction are amortized for five years in the declining balance method.

4.2.2 Financial Plan

Total capital requirements and operating costs are assumed to be financed locally. An equity portion is assumed to be 30 percent for the total capital requirements. On the other hand, a portion by a long term loan is assumed to be 70 percent of them.

Unit: million won

	ratio	Case 1	Case 2	Case 3
Equity	30%	329	350	453
Debt (long term loan)	70%	767	817	1,057
Total	100%	1,096	1,168	1,510

4.2.3 Method of Financial Analysis

(1) Fixed profitability

In this financial analysis, emphasis is laid on whether or not the price of the discharged fee of waste water calculated based on the fixed level of Financial Internal Rate of Return on Investment (FIRROI) is viable. This means the price level of the fee is calculated in order to attain the target FIRROI. The applied rate is 10 percent.

(2) Internal Rate of Return (IRR) as applied indicators

In this analysis, two types of IRR are applied. One is Financial Internal Rate of Return on Investment (FIRROI) and the other is Financial Internal Rate of Return on Equity (FIRROE).

FIRROI is an indicator of the profitability in the total investment of the project. The total capital requirements except interest during construction, revenue, and operating costs in cash flow statements are components for calculating this indicator. The interest and repayment of debt is not included.

FIRROE, on the other hand, indicates the profitability of invested own funds (equity) in the project. Thus, this rate depends on financing conditions (interest, repayment amount and so on) as well as the total capital requirements, revenue, and operating costs.

4.2.4 Results of Financial Analysis

The levels of the discharged fee in order to attain the target FIRROI (10.0 %) for three cases are shown below. The levels of the fee for the case with land acquisition cost are also presented.

	Case 1	Case 2	Case 3
FIRROI	10.00	10.00	10.00
FIRROE	12.02	12.04	12.02
Price of Fee (won per m^3)	**4,763**	**5,415**	**5,750**
FIRROI (cases with Land Acquisition Cost)	10.00	10.00	10.00
Price of Fee (won per m^3)	**5,751**	**6,165**	**6,588**

4.3 Economic Analysis

Whereas financial analysis focuses primarily on market prices and cash flows, economic analysis should include the benefits and the costs of the effects that the project have on the environment.

However, the direct loss or damage to the environment in the Study Areas and the vicinity is not seen in this project because this is a conceptional design. As a result, the benefits based on market values can not been identified quantitatively except recycling water produced in Case 3. In this economic analysis, therefore, the introduction of generally applicable methods, the benefits of recycling water in Case 3 and the qualitative socio-economic impacts are discussed. The Economic Internal Rate of Return (EIRR) is not calculated.

4.3.1 Generally Applicable Techniques for the Analysis[1]

Three sets of valuation techniques using market prices, which are those of straightforward benefit-cost analysis, are used in

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1.The contents of this sub-section is mainly relied on "Economic Analysis of the Environmental Impacts of Development Projects" by the Asian Development Bank in 1986.

common in the economic analysis on the environmental project. The first one deals with changes in production and the value of output. The second one is the loss of earnings approach. And, the third one is the opportunity cost approach.

4.3.2 Benefits of recycling water

In Case 3, 30,000 m^3 of recycling water is annually produced. This recycling water is the benefit under the change-in-production approach, which is discussed before. The benefits from the recycling water are calculated based on the alternative resource saved by avoiding the needs to provide clean water (presumably least costly). This means that the production costs on the equal amount of water supply is the benefit for recycling water. Since the unit cost of water supply is 268 won per m^3 according to the data for water production in Inchon area, the total savings (benefits) amount to 8.05 million won per year although this is very small compared with the total cost for the treatment plant. Since recycling water is not produced from Case 1 and Case 2, the savings for these two cases can not be calculated. .

4.3.3 Socio-economic Impact Consideration

Industrial development (such as plating industrial estate) in general tends to cause the damage to the environment through the linkages. The development causes physical changes in water, air, soil and so on in terms of temperature, dissolved oxygen, nutrients, salinity, siltation, solid wastes and so on. These changes result in ecological changes such as biological displacement, change in species composition, lowered species diversity, reproduction failure, and so on. Then, these have the socio-economic consequences such as reduced incomes for fishermen and farmers through the reduction of the productivity, increased underemployment and unemployment, and increased incidence of human disease.

Therefore, the proposed project on the waste water treatment plant for plating industries is highly valuable in terms of protection of the environment, although a "with-and-without-project framework" is not simply applied to this project since the Korean Government has stringent standards for effluents.

III. Dyeing Industrial Estate

III. Dyeing Industrial Estate

1. Condition of the Industrial Estate

1.1 Outline of the Industrial Estate

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.

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

1.2 The State of Wastewater, 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.

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

(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

Table 1.2.1. 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

Contractor : Kolon Construction Co., Ltd.
Kolon Engineering Co., Ltd.
Reserve area : 3,318 m^3 (secured)

1.3 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.

1.4 Condition of Wastewater Treatment and Reclamation Plants

Fig. 1.4.1 shows how the treatment facilities operate, and Fig. 1.4.2 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.

2. Review of the Current Wastewater Treatment and Reclamation System

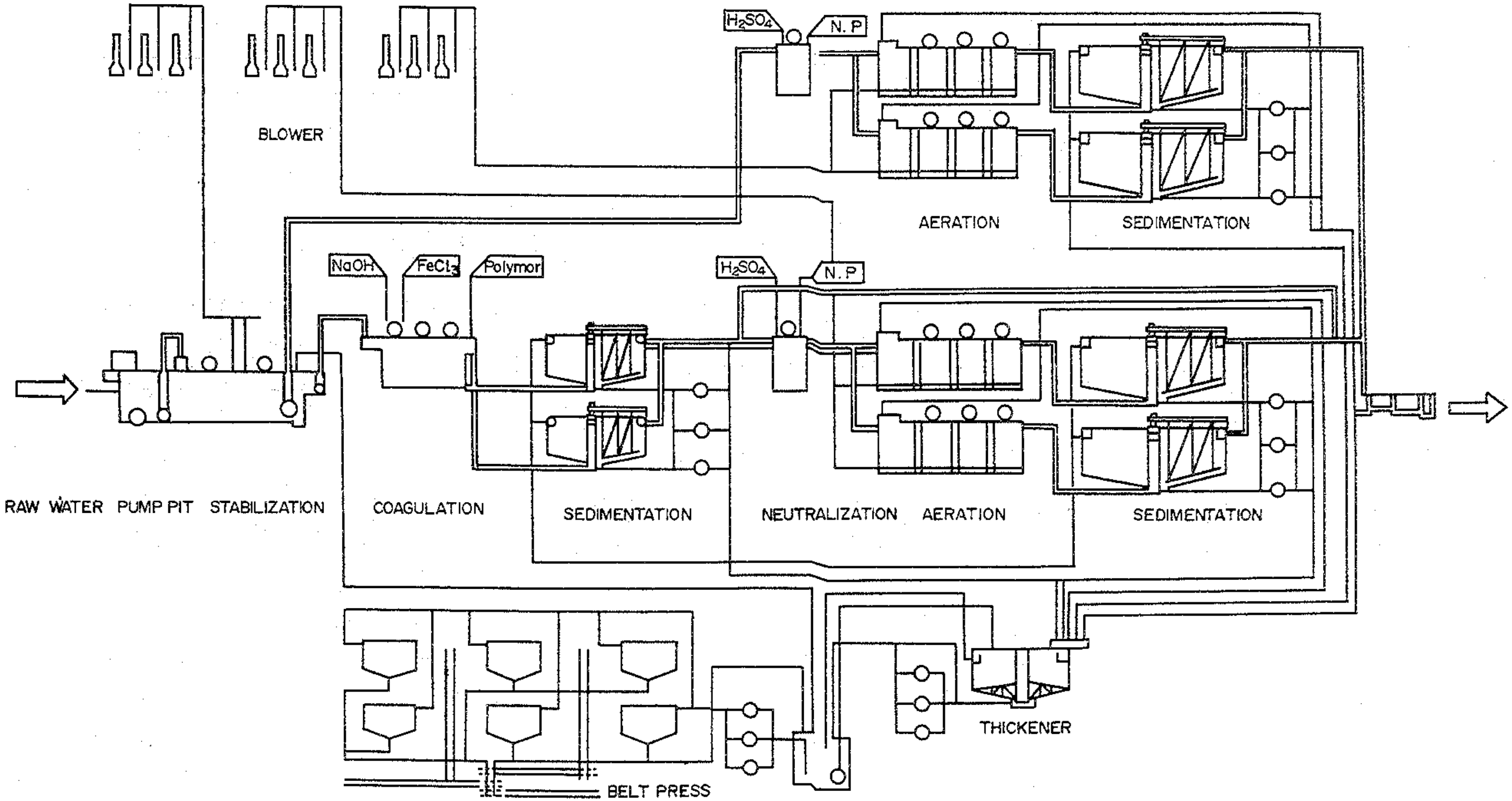

Fig.1.4.1 Flow Sheet of Central Waste Treatment Plant

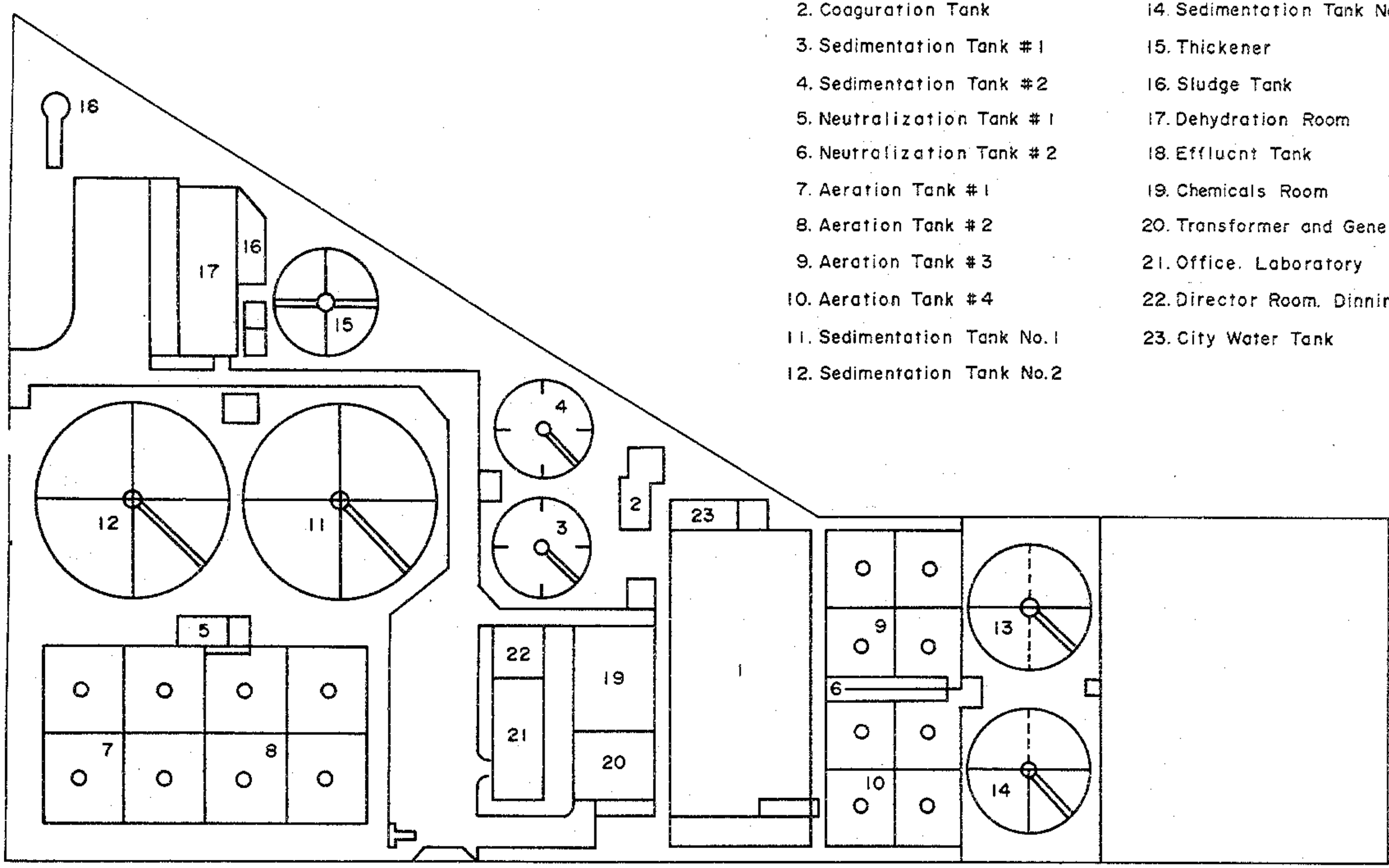

Fig.1.4.2 Layout of Central Waste Treatment Plant

1. Stabilization Tank
2. Coaguration Tank
3. Sedimentation Tank #1
4. Sedimentation Tank #2
5. Neutralization Tank #1
6. Neutralization Tank #2
7. Aeration Tank #1
8. Aeration Tank #2
9. Aeration Tank #3
10. Aeration Tank #4
11. Sedimentation Tank No.1
12. Sedimentation Tank No.2
13. Sedimentation Tank No.3
14. Sedimentation Tank No.4
15. Thickener
16. Sludge Tank
17. Dehydration Room
18. Effluent Tank
19. Chemicals Room
20. Transformer and Generator Room
21. Office. Laboratory
22. Director Room. Dinning Room
23. City Water Tank

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.

3. Determination of the Optimum Systems

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

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.

3.2 Measures for the Reduction of Wastewater Quantity

(1) Method of investigation

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 referennce × Will not be selected

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

(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 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

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.

3.3 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).

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 problematic 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.

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

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	[℃]	<40	<40

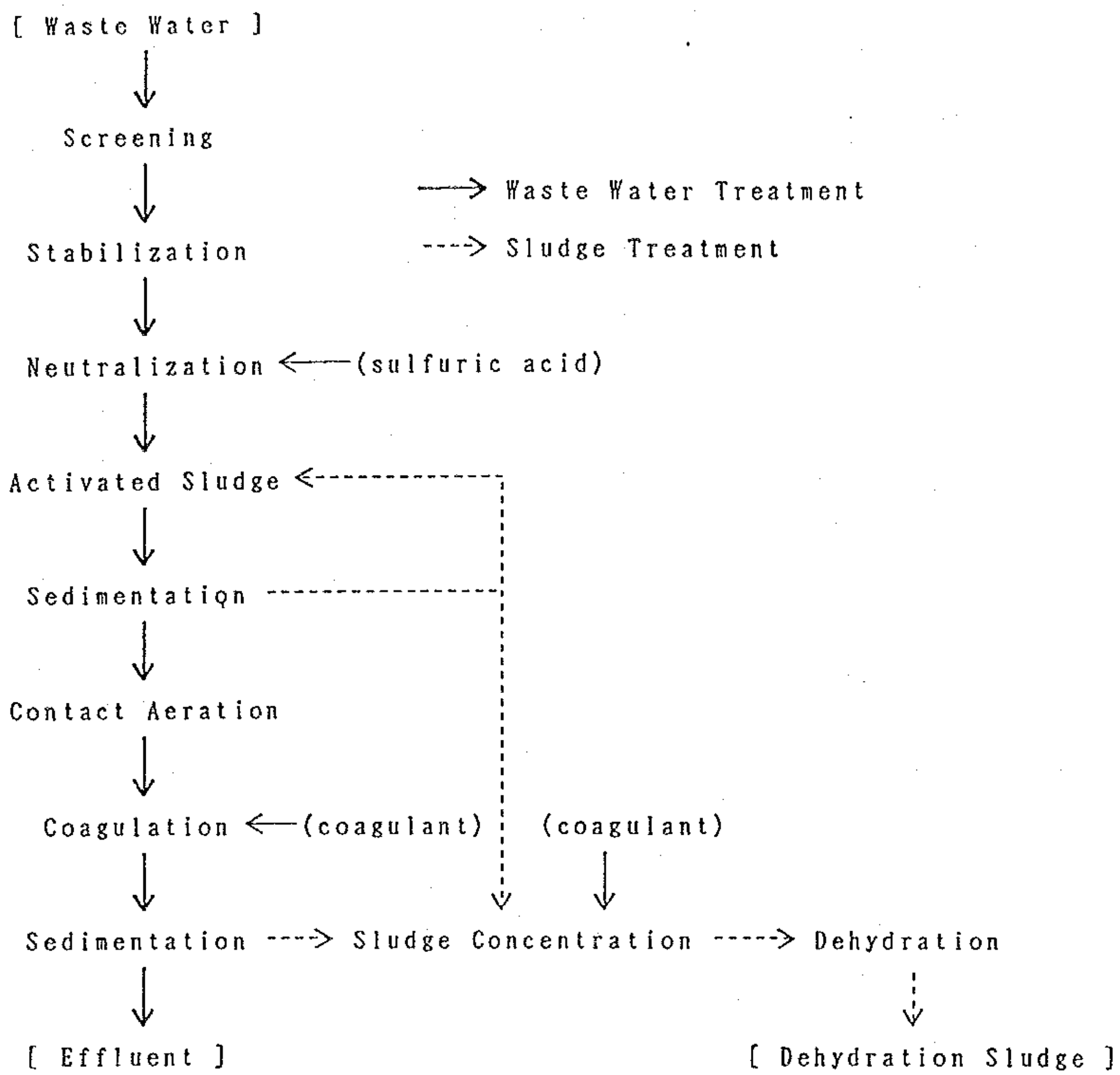

Fig. 3. 3. 1. Flow Diagram of Treatment in CASE-1

	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 less coagulant consumption.

3.3.2 High reduction of COD (CASE-2)

(1) Treatment water quality

Table 3.3.2 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-

Table 3.3.2. 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

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.

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).

(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 3.3.1).

(3) Treatment system

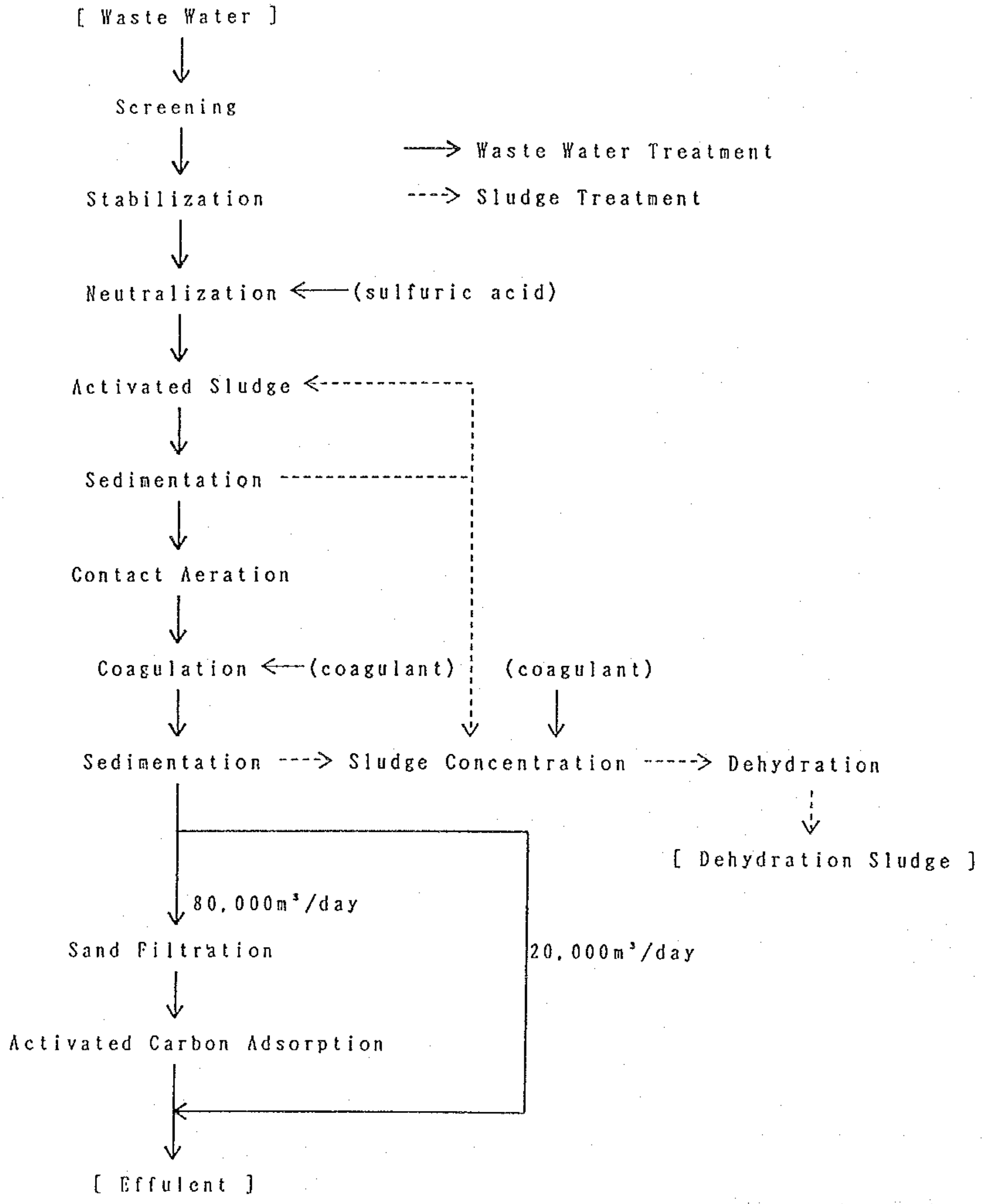

Fig. 3.3.2. Flow Diagram of Treatment in CASE-2

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 shows a flowchart of the treatment system. 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.

3.5 Economic Feasibility of the Optimum System

Construction costs, operation costs and other related costs are calculated for the above-mentioned 3 systems (CASE-1, -2, -3) on a trial basis.

3.5.1 Construction costs

Calculated construction costs are as follows.

CASE-1	65.4 bil Won
CASE-2	77.7 bil Won
CASE-3	85.4 bil Won

Based on the Korean prices as of February, 1992. Each breakdown is shown in Table 3.5.1.

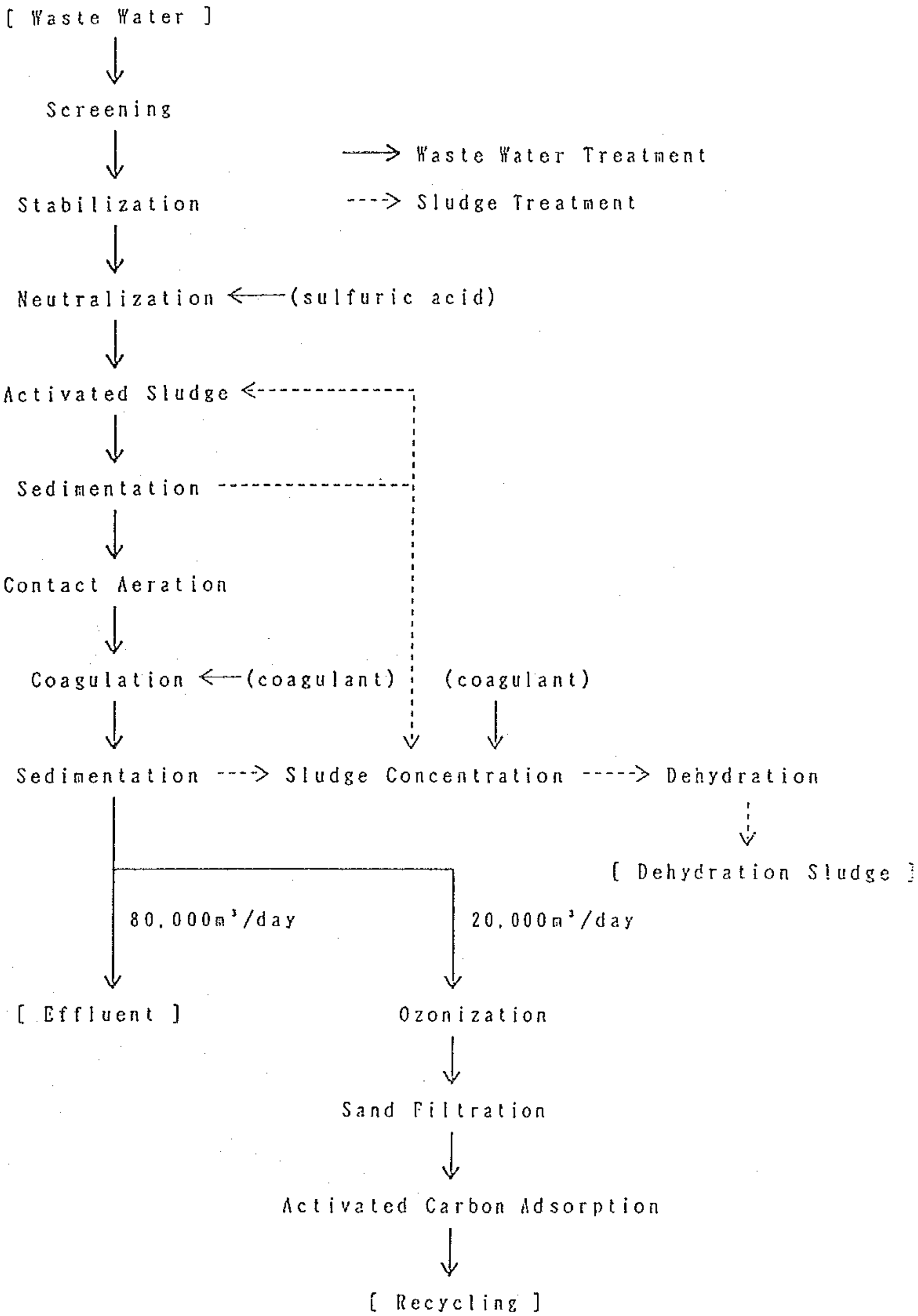

Fig. 3.4.1. Flow Diagram of Treatment in CASE-3

3.5.2 Operating Cost

Calculated operating costs are as follows.

CASE-1 9.37 bil Won/year
CASE-2 18.84 bil Won/year
CASE-3 13.54 bil Won/year

Treatment plant working days are assumed to be 300 days/year.

Breakdowns of chemicals, industrial water, electricity and sludge treatment in each case are shown in Tables 3.5.2 - 4.

Table 3.5.1. Items of Construction Cost

(1,000,000Won)

Items	CASE-1	CASE-2	CASE-3
Civil and Architectual Work	45,800	54,500	50,000
Machinerary and Equipments	8,200	9,900	20,700
Electrical Work	1,100	1,300	1,500
Piping Work	1,500	1,600	1,700
Test Run etc.	300	300	400
Sub-Total	56,900	67,600	74,300
Overhead(15%)	8,500	10,100	11,100
Total	65,400	77,700	85,400

Table 3.5.2. Items of Running Cost (CASE-1)

Items	Consumption	Unit Price	Cost [Won/m³]	Cost [10⁸Won/Y]
Chemicals				
H_2SO_4	30,090kg/day	63Won/kg	18.96	5.69
NaOH	10,980kg/day	149Won/kg	16.35	4.91
PAC	49,900kg/day	185Won/kg	92.32	27.70
A-Polymer	283kg/day	1,700Won/kg	48.11	14.43
K-Polymer	83kg/day	3,150Won/kg	26.15	7.85
Sub-Total			201.89	60.57
Industrial Water	500m³/day	110Won/m³	0.55	0.17
Electricity	50,218kW/day	60Won/kW	30.13	9.04
Sludge Disposal	164 t/day	46,800Won/t	76.75	23.20
Total			309.32	92.98

Table 3.5.3. Items of Running Cost (CASE-2)

Items	Consumption	Unit Price	Cost [Won/m^3]	Cost [10^8Won/Y]
Chemicals				
H_2SO_4	30,090kg/day	63Won/kg	18.96	5.69
NaOH	10,980kg/day	149Won/kg	16.35	4.91
PAC	49,900kg/day	185Won/kg	92.32	27.70
A-Polymer	283kg/day	1,700Won/kg	48.11	14.43
K-Polymer	83kg/day	3,150Won/kg	26.15	7.85
A/C Reclamation	20,000kg/day	1,021Won/kg	204.20	61.26
Sub-Total			406.09	154.68
Industrial Water	500m^3/day	110Won/m^3	0.55	0.17
Electricity	53,674kW/day	60Won/kW	32.20	9.66
Sludge Disposal	164 t/day	46,800Won/t	76.75	23.03
Total			515.59	187.78

Table 3.5.4. Items of Running Cost (CASE-3)

Items	Consumption	Unit Price	Cost [Won/m^3]	Cost [10^8Won/Y]
Chemicals				
H_2SO_4	30,090kg/day	63Won/kg	18.96	5.69
NaOH	10,980kg/day	149Won/kg	16.35	4.91
PAC	49,900kg/day	185Won/kg	92.32	27.70
A-Polymer	283kg/day	1,700Won/kg	48.11	14.43
K-Polymer	83kg/day	3,150Won/kg	26.15	7.85
A/C Reclamation	5,000kg/day	1,021Won/kg	51.05	15.32
Sub-Total			252.94	75.88
Industrial Water	500m^3/day	110Won/m^3	0.55	0.17
Electricity	196,810kW/day	60Won/kW	118.09	35.43
Sludge Disposal	164 t/day	46,800Won/t	76.75	23.20
Total			448.33	134.68

4 Financial and Economic Analysis

4.1 Total Capital Requirements and Operating Costs

4.1.1 Construction Cost and Total Capital Requirements

Construction cost and total capital requirements are summarized below. Optionally, the land acquisition cost is included in the table. This cost is assumed to be 17,160 million won for Case 1 at 42,900 m^2 and 19,360 million won for Case 2 and Case 3 at 48,400 m^2. These amounts are based on the actual purchase price of the dyeing industrial estate in Ansan. Unit price is set at 400,000 won per m^2.

Table 4.1.1 Construction Cost

Unit: million won

	Case 1	Case 2	Case 3
Civil and architectural work	52,642	62,643	57,470
Machinery and equipments	9,425	11,379	23,792
Electrical work	1,264	1,494	1,724
Piping work	1,724	1,839	1,954
Total	65,055	77,355	84,940

Table 4.1.2 Total Capital Requirements

Unit: million won

	Case 1	Case 2	Case 3
Construction cost	65,055	77,355	84,940
Preoperational expenses	345	345	460
Interest during construction	3,727	4,431	4,867
Total (1)	69,127	82,131	90,267
Land acquisition cost	17,160	19,360	19,360
Total (1)+Land acquisition cost	86,287	101,491	109,627

4.1.2 Operating Costs and Expenses

(1) Variable operating cost

This cost covers chemicals, water, utility (electricity) and disposal cost of sludge are included. The cost is summarized in Table 4.1.3. Details are discussed in Chapter 3.

(2) Fixed operating cost

Fixed operating cost consists of labor cost and maintenance cost. Labor cost is assumed to be 70 million won per year for each case. Details are shown in Chapter 3.

On the other hand, annual maintenance cost is estimated as 1.0 percent of the construction costs through out the project life period. The cost is summarized in Table 4.1.3.

Table 4.1.3 Operating Costs

Unit: million won

	Case 1	Case 2	Case 3
Variable operating costs			
Chemicals	6,057	15,468	7,588
Water	17	17	17
Utility (electricity)	904	966	3,543
Disposal cost of sludge	2,320	2,320	2,320
Sub-total	9,298	18,771	13,468
Fixed operating costs			
Labor cost	70	70	70
Maintenance costs	654	777	854
Sub-total	724	847	924
Total	10,022	19,618	14,392

4.2 Financial Analysis

4.2.1 Basic Assumptions and Premises

For the purpose of the financial calculations, the following basic premises are applied.

(1) Project life and plant operation

(a) Project life ; construction period : 2 year
; operating period : 15 years
(b) Implementation body : Non-profit industrial cooperative
(c) Waste water treatment capacity : 30 million m^3 per year
(d) Volume of recycling water: 6 million m^3 per year(Case 3)
(e) Annual operating days : 300 days
(f) Annual operating hours : 7,200 hours (24 hours per day)

(2) Escalation of costs and prices

All costs and prices used in the financial analysis are assumed to be fixed in the end of 1992, and no escalation factors are applied.

(3) Corporate income tax

Corporate income tax will be imposed at a rate of 10 % of taxable income. This preferential rate is provided to an operator of environment protection facilities under the regulation.

(4) Depreciation and amortization

Depreciable assets are assumed to be depreciate as follows.

(a) Mode : Declining balance method
(b) Period : 15 years
(c) Salvage value : 10 percent

Also, interest during construction are amortized for five years in the declining balance method.

4.2.2 Financial Plan

Total capital requirements and operating costs are assumed to be financed locally. An equity portion is assumed to be 30 percent for the total capital requirements. On the other hand, a portion by a long term loan is assumed to be 70 percent of them.

Unit: million won

	ratio	Case 1	Case 2	Case 3
Equity	30%	20,738	24,639	27,080
Debt (long term loan)	70%	48,389	57,491	63,186
Total	100%	69,127	82,131	90,267

4.2.3 Method of Financial Analysis

(1) Fixed profitability

In this financial analysis, emphasis is laid on whether or not the price of the discharged fee of waste water calculated based on the fixed level of Financial Internal Rate of Return on Investment (FIRROI) is viable. This means the price level of the fee is calculated in order to attain the target FIRROI. The applied rate is 10 percent.

(2) Internal Rate of Return (IRR) as applied indicators

In this analysis, two types of IRR are applied. One is Financial Internal Rate of Return on Investment (FIRROI) and the other is Financial Internal Rate of Return on Equity (FIRROE).

FIRROI is an indicator of the profitability in the total investment of the project. The total capital requirements except interest during construction, revenue, and operating costs in cash flow statements are components for calculating this indicator. The interest or repayment of debt is not included.

FIRROE, on the other hand, indicates the profitability of invested own funds (equity) in the project. Thus, this rate depends on financing conditions (interest, repayment amount and so on) as well as the total capital requirements, revenue, and operating costs.

4.2.4 Results of Financial Analysis

The levels of the discharged fee in order to attain the target FIRROI (10.0 %) for three cases are shown below. The levels of the fee for the case with land acquisition cost are also presented.

	Case 1	Case 2	Case 3
FIRROI	10.00	10.00	10.00
FIRROE	7.60	7.64	7.62
Price of Fee (won per m^3)	**625**	**1,000**	**860**
FIRROI (cases with Land Acquisition Cost)	10.00	10.00	10.00
Price of Fee (won per m^3)	**690**	**1,073**	**933**

4.3 Economic Analysis

Whereas financial analysis focuses primarily on market prices and cash flows, economic analysis should include the benefits and the costs of the effects that the project have on the environment.

However, the direct loss or damage to the environment in the Study Areas and the vicinity is not seen in this project because this is a conceptional design. As a result, the benefits based on market values can not been identified quantitatively except recycling water produced in Case 3. In this economic analysis, therefore, the introduction of generally applicable methods, the benefits of recycling water in Case 3 and the qualitative socio-economic impacts are discussed. The Economic Internal Rate of Return (EIRR) is not calculated.

4.3.1 Generally Applicable Techniques for the Analysis[1]

Three sets of valuation techniques using market prices, which are those of straightforward benefit-cost analysis, are used in

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1.The contents of this sub-section is mainly relied on "Economic Analysis of the Environmental Impacts of Development Projects" by the Asian Development Bank in 1986.

common in the economic analysis on the environmental project. The first one deals with changes in production and the value of output. The second one is the loss of earnings approach. And, the third one is the opportunity cost approach.

4.3.2 Benefits of recycling water

In Case 3, 6 million m^3 of recycling water is annually produced. This recycling water is the benefit under the change-in-production approach, which is discussed before. The benefits from the recycling water are calculated based on the alternative resource saved by avoiding the needs to provide clean water (presumably least costly). This means that the production costs on the equal amount of water supply is the benefit for recycling water. Since the unit cost of water supply is 305 won per m^3 according to the data for water production in Ansan area, the total savings (benefits) amount to 1,828 million won per year although this is very small compared with the total cost for the treatment plant. Since recycling water is not produced from Case 1 and Case 2, the savings for these two cases can not be calculated.

4.3.3 Socio-economic Impact Consideration

Industrial development (such as dyeing industrial estate) in general tends to cause the damage to the environment through the linkages. The development causes physical changes in water, air, soil and so on in terms of temperature, dissolved oxygen, nutrients, salinity, siltation, solid wastes and so on. These changes result in ecological changes such as biological displacement, change in species composition, lowered species diversity, reproduction failure, and so on. Then, these have the socio-economic consequences such as reduced incomes for fishermen and farmers through the reduction of the productivity, increased underemployment and unemployment, and increased incidence of human disease.

Therefore, the proposed project on the waste water treatment plant for dyeing industries is highly valuable in terms of protection of the environment, although a "with-and-without-project framework" is not simply applied to this project since the Korean Government has stringent standards for effluents.

IV. Overall Evaluation

IV Overall Evaluation

1. Plating Industrial Estate

1.1 Evaluation and Problems Concerning the Optimum Systems

1.1.1 Technical Evaluation and Problems Concerning the System

The proposed optimum system is intended to perform complete treatment of wastewater produced in the industrial estate of electroplating factories. The system has the following characteristics.

(1) The system can well cope with variable quantities and qualities of the expected wastewater.

The stabilization tank has an adequate capacity for any amounts of water coming from the estate. Furthermore, all components of the treatment process are made with certain capacity margins. Thus, the system as a whole is flexible enough to cope with variable quantities and qualities of wastewater.

(2) The operation of the system is fully automated.

While the existing system is operated manually for the most part and hence requires many operators, the operation of the proposed optimum system is fully automated so that the number of operators can be reduced greatly.

(3) The system is equipped with an adequate number of monitoring instruments.

Monitoring instruments installed at each stage of the optimum system allow the operator to check water quality and operational state of the stage concerned. The existing system has few monitoring instruments installed and hence the operation depends on visual inspection by individual operators. As mentioned before, this has given rise to various problems. The optimum system will virtually eliminate such problems.

(4) The layout of the system is very compact.

The layout of equipment and machinery of the proposed system is designed for easy operation and minimum space requirement . As a result, the space necessary for the optimum system (approx. 700 m^2) is only marginally larger than that of the existing system, while the operation is much improved compared with the existing system.

Perfect though the system planning may be, it cannot realize its functions unless the assumptions for the planning are met. In planning the system, the following assumptions are made:

(1) The factories in the industrial estate use electroplating.

Our survey shows that one factory in the estate uses an anodized aluminum plating method and another uses a chemical plating method. Wastewater from those two factories, however, accounts for only marginal percentage of the whole wastewater, so it does not affect the treatment of wastewater.

Even at the same stage, the agents used for chemical plating are different from those used in electroplating, and they produce very different type of waste water. That is why only those factories which have similar manufacturing processes should be selected in forming an industrial estate.

(2) Each factory will take appropriate measures to reduce the amount wastewater.

For wastewater treatment to be effective, it is important that each factory takes measures to reduce the discharge of wastewater so that only highly concentrated wastewater flows into the central treatment plant. Such measures must be planned before factories start operating and discharging wastewater.

(3) Various types of wastewater coming from factories are separated from each other according to their contents and concentration.

As stated before, wastewater discharged by plating factories is classified into (1) cyanic, (2) chrome, and (3) acid/alkaline water. Any wastewater treatment plant is built on the assumption that incoming wastewater is separated based in accordance with classification. Unless wastewater being thus separated,in this way, the treatment would become impossible. Moreover, if cyanic water and acid/alkaline water are mixed, extremely poisonous cyanide gas may be produced. The separation, therefore, must be rigorously applied.

With the above assumption being met, the proposed system offers the best solution to the central treatment of wastewater in the industrial estate.

1.1.2. Economic Evaluation and Problems of Concerning the Systems

As stated in "(4.2) Financial Analysis in (II) Plating Industrial Estate" of this report, the proposed optimum system makes good economic sense. The reasons for this judgment are as follows:

(1) The rate for the treatment is high enough.

Disposal of wastewater produced by plating factories is difficult, and it is very dangerous if discharged into a river or sea without any treatment. For this reason, a relatively high rate may be charged for its treatment. The rate set by the law (i.e.legal rates for subcontracting the disposal) is considerably higher than the rate (according to CASE-3 of 4.2.4 of II, 4,763 Won/m^3) calculated for the proposed system.

(2) Running costs are reasonably low (i.e. consumption of electric power and chemicals is low).

Because of the high capacity required, the construction cost of the pro-posed system will be higher than the existing system.

In return, thanks to the installation of many instruments, operation and management is made much easier. As a result the proposed system eliminates unnecessary consumption of power and chemicals, thus keeping running cost to the minimum.

(3) The operation is fully automated.

Because of fully automated operation, labor cost necessary for running the system may greatly be reduced. The proposed system can be run by two operators, whereas the existing system requires six.

However, the economic advantages listed above can be realized only if the following conditions are met.

(1) Equipment and machinery are properly managed and maintained.

To realize the economic advantages of the system, it must be maintained and operated in good condition. It is, therefore, important to assign adequate money and workforce to the daily management and maintenance of the equipment and machinery.

(2) The rate for treatment is set reasonably high.

The cost for wastewater treatment may differ greatly depending on water's qualities (contents, concentration, etc.). So, it is important to charge appropriate rates for each type of water.

(3) Wastewater is appropriately accepted.

In accepting the inflow of wastewater, its quality and quantity must be measured to determine the rate. If water is beyond the treatment capacity of the system, refusal of inflow may be necessary in order to keep the system running economically.

(4) Measures are taken to prevent troubles in treatment

Even if Step (3) above is taken, some factories may, inadvertently or intentionally, still discharge prohibited waste water, which may put the system in disorder. Apart from technical measures to be taken in such cases, some provision should be made to punish the factory concerned, such as refusal of further inflow of wastewater, high amount of a fine, and the like.

The technical evaluation is closely related to the economic one. In general, a technically excellent system will also have an excellent economic evaluation. The proposed system is the very example of this.

1.2. Suggestions Regarding the Introduction of the Optimum Systems

Since considerations in introducing the optimum system are already explained (see II and 1.1 of this chapter), we will make some more suggestions briefly.

(1) Adequate preparatory studies should be conducted sufficiently.

Before constructing the central treatment plant, its basic design conditions must be established properly by carefully studying expected amounts and qualities of wastewater.

Nonetheless, in the case of an industrial complex that is yet to be constructed, there are no data available to study. In such a case, as shown in this report, estimate must be made as accurately as possible by analyzing data gathered from existing factories of similar type.

(2) Each factory should be well informed about wastewater treatment.

Whether the central treatment plant works properly depends on every factory discharging its wastewater as planned. In other words, each factory must take wastewater treatment into account in its production activities. To serve this purpose, the central treatment plant should make the utmost effort to improve each factory's knowledge and technique concerning wastewater treatment.

(3) Appropriate rate should be charged for wastewater treat- treatment.

As stated in 1.1.2 of this chapter, once a rate is set, it becomes difficult to change. That is why appropriate rate should be determined in consultation with the factories prior to starting the treatment system.

(4) The inflow of wastewater should be monitored constantly.

Even a well-planned wastewater treatment system (with appropriate rates) may not bring the expected effects if the amounts and qualities of incoming wastewater are not monitored. So, the inflow of wastewater must be continuously monitored with instruments, and the monitored data must be promptly reflected in the running of the system.

(5) The importance of the technicians and operators of the wastewater treatment plant should be fully understood and proper training should be provided.

There is a tendency to attach less importance to the technicians and operators working for waste water treatment than those working in a manufacturing process. However, in the manufacturing process, production is carried out using materials with more or less the same quality. In contrast, in wastewater treatment, a high quality products (treated water which meets certain standards) must be realized using materials (raw waste water) of various qualities. In consequence, the technical standard for wastewater treatment must be high enough to cope with the wide variation of quantities and qualities of discharged water. For this reason, competent technicians and operators must be assigned to the treatment plant, and sufficient training must be given.

(6) Management/maintenance should be meticulously carried out.

As mentioned in 1.1.2 of this chapter, improper

management/maintenance may hinder even the optimum system from functioning as planned.
In order to realize the economic advantages of the system, expense should not be spared as far as management/maintenance is concerned. If possible, as practiced in a manufacturing process, periodical maintenance (once or twice a year) should be carried out.

(7) Cooperative relations should be established between the wastewater treatment plant and the factories.

As mentioned before, wastewater treatment is closely related to a manufacturing process. To keep the treatment system running in good condition, cooperative relations between the treatment plant and each factory is indispensable. One way to achieve this may be to establish a committee consisting of the staff of the treatment plant and the personnel from each factory, thus providing an opportunity to discuss matters of mutual interest and exchange information.

(8) The treatment plant should participate in some way in the manufacturing process of each factory.

The treatment plant should not limit its responsibility to the treatment of wastewater, but should actively participate in the manufacturing process from the standpoint of wastewater treatment. Thus, the treatment plant should not hesitate to give advice, if any, for improving the manufacturing process of each factory.

1.3. Other Problems and Suggestions

The following are problems and suggestions concerning matters other than wastewater treatment.

(1) Managing structure of the industrial estate

At present, the relationship between the central wastewater treatment plant and each factory is that of a landlord and its tenant, which makes it difficult to establish cooperative relations between the two. As is the case in the dyeing industrial estate, it may help if the wastewater treatment plant is managed by a cooperative association consisting of all the factories.

(2) Enlargement of joint work by the industrial estate

At present, wastewater and exhaust gas disposal (using scrubbers for gas disposal) are the only joint project of the estate. By extending joint projects to the supply of utilities (industrial water, cooling water, steam, etc.) and the disposal of industrial wastes, the management of the estate will become more stable and the gain of each factory will increase.

(3) Technical training for the factories

The factories in the estate are small in scale. Therefore, although keen to introduce the latest technologies to improve manufacturing methods, they have little means. It may help a lot if a technical center is established in the estate to give appropriate guidance and training to each factory.

In the existing industrial estate, it may be difficult to implement the suggestions listed above. In case an estate is newly established, however, those suggestions should be taken into consideration.

2. Dyeing Industrial Estate

2.1. Evaluation and Problems Concerning the Optimum Systems

The evaluation and problems concerning the dyeing industrial estate are basically the same as those concerning the plating industrial estate shown in 1. of this chapter. In the following, only those points that are unique to the former are described in detail, other points which are the same as in the plating estate being only listed.

2.1.1. Technical Evaluation and Problems Concerning the System

The proposed optimum system is intended to perform complete treatment of wastewater produced in dyeing factories (where dyeing of synthetic fibers such as polyester is also carried out). The system has the following characteristics.

(1) The system can well cope with the variable quantities and qualities of the expected wastewater.

(2) The operation of the system is fully automated.

While the existing system has not been automated completely and hence requires many operators, the operation of the proposed optimum system is fully automated so that the number of operators can be greatly reduced.

(3) The system is equipped with an adequate number of monitoring instruments.

Monitoring instruments installed at each stage of the optimum system allow the operator to check water quality and operational state of the stage concerned. With the existing system, too, quite a few monitoring instruments are already installed and are operated from a control room. The proposed system, however, gives greater consideration to the instrumentation.

(4) The layout of the system is designed to allow sufficient space for each component.

At present, owing to the narrowness of the building site, and as a result of the extension work, equipment and machinery of the existing system are placed too close to each other. In contrast, the layout of the proposed optimum system is spacious enough to allow easy operation. The building site for the proposed system is consequently larger than the existing one. The present site is too small to accommodate a system which is expected to treat 100,000 m^3 of waste water a day.

(5) The system makes the final sewage treatment plant redundant.

Currently, water discharged from the central treatment plant is sent to the final sewage plant run by the municipal government of Ansan. As mentioned in 1.2 of I, however, this sewage plant is not working properly. The proposed system is designed to make treated water purer, so that the final sewage plant will become redundant. In particular, the high-degree treatment system for COD elements (CASE-2) will make the final sewage plant totally unnecessary for treating industrial wastes.

Perfect though the system planning may be , it cannot make full use of its functions unless the assumptions for the planning are met. In planning the system, the following assumptions are made:

(1) The estate consists of factories which are mostly engaged in the dyeing of cotton and only partly in the dyeing of synthetic fibers such as polyester.

Our survey has shown that the estate has one factory which carries out leather tanning alongside dyeing. Although the amount of wastewater from this factory is very small, a tiny amount of chrome metal contained in it has an obiouse adverse effect on the operation of the central treatment plant. The existence of a factory of a different nature clearly affects the whole system.

Among the dyeing factories themselves, those which conduct the dyeing of wool or polyester produce a different type of wastewater from the those which are engaged in the dyeing of cotton. Wastewater coming from the wool dyeing factories contains substances (oil, fat, protein, etc.) removed from wool, while waste water of polyester dyeing contains elements (such as ethylene glycol and terephthal acid) that are resolved from polyester when the marcerization method is applied. The treatment of the former is not very difficult, but the latter cannot be removed by the biological treatment alone. See the example shown in 3.4.3 (11) of chapter 5

In creating an industrial estate, therefore, it is important to select only those factories which have more or less the same manufacturing processes.

(2) Each factory will take appropriate measures to reduce the amount of wastewater.

(3) Substances which are hard to process in the central treatment plant are removed from wastewater in advance at the factory level.

As explained in (1) above, all substances (for example, chrome metal) which are hard to process in the central treatment plant must be removed in advance by the factory concerned.

(4) Amounts and qualities of waste water do not fluctuate greatly.

As mentioned before, the proposed system is designed to cope with a wide range of amounts and qualities of wastewater. Nonetheless, since the amount to be processed is enormous, the stabilization tank allows at most a four hour stay of wastewater. Thus, if a huge amount of wastewater flows into the tank at once, it becomes impossible for the tank to accept all of it.

So long as the conditions listed above are met, the proposed system offers the best solution to the central treatment of wastewater in the dyeing industrial complex.

2.1.2. Economic Evaluation and Problems Concerning the System

As stated in 4.2. Financial Analysis in "III, Dyeing Industrial Estate" of this report, the proposed optimum system is evaluated as being fairly economic, although the rate for treatment will be higher than the current one (about 1.4 times in CASE-1). The reasons for this evaluation are as follows:

(1) The proposed optimum system is improved system compared with the current system. So,the higher rate for treatment is natural.

(2) The present plant was completed 5 years ago, and it has

already been depreciated to some extent.

On other hand, this study is made on the assumption that the treatment plant is newly constructed.

(3) In this study, in CASE-1 ,the treatment rate will be drop to about 358Won/m^3 after 9 years. This value is about 80% of the current rate.

The reason for the proposed optimum system obtaining a fairy economic evaluation are as follows.

(1) The treatment capacity is very large.

The proposed system has a treatment capacity of 100,000 m^3 a day, which ranks among the top class as a treatment system for industrial wastewater. Scale merit relative to the construction costs is considerable. That is one of the reasons why the proposed system makes good economic sense.

(2) Running costs ares reasonably low (i.e. consumption of electric power and chemicals is low).

(3) The operation is fully automated.

Because of the fully automated operation, the number of operators necessary for running the system can be greatly reduced. The proposed system can be run by three operators, whereas the existing system requires around six.

However, the economic advantages listed above can be realized only if the following conditions are met.

(1) Equipment and machinery should be properly managed and maintained.

(2) The rate for treatment should be set appropriately.

(3) Wastewater should be appropriately accepted.

(4) Measures should be taken to prevent troubles in treatment.

The technical evaluation is closely related to the economic one. In general, a technically excellent system will also have an excellent economic evaluation. The proposed system is the very example of this.

2.2. Suggestions Regarding the Introduction of the Optimum Systems

Since considerations in introducing the optimum system are already explained (see II and 2.1 of this chapter), here we will limit the explanation to those matters which are unique to the dyeing industrial estate (those which are already explained in the section of the plating industrial estate will only be listed).

(1) Adquate preparatory studies should be conducted sufficiently.

(2) Each factory should be well informed about wastewater treatment.

(3) Appropriate rates should be charged for wastewater treatment.

At present, the rates are set in accordance with quantity (450 Won/m^3), an extra rate being charged only when the pH exceeds 11. And yet, besides pH, the COD value and color have significant effects on the actual cost of treatment. These two factors should also be reflected in the rates.

The degrees of color are hard to measure, but are roughly proportional to COD values. Therefore, the COD value may be regarded as a practical criterion of water quality for determining the treatment rate. The pH value and COD value can be measured and recorded continuously by installing appropriate measuring devices at each factory. These values, if they are sent to the central treatment plant through a remote device, are useful not only for determining the rates, but also for monitoring the incoming waste water.

(4) The inflow of wastewater should be monitored constantly.

With the existing system, the qualities of wastewater discharged to the central treatment plant are measured reasonably well. Monitoring of the qualities of incoming wastewater is an indispensable factor for the efficiency of the central treatment plant. As mentioned in (3) above, the installation of a continuos measuring device at each factory will serve this purpose.

(5) The importance of the technicians and operators of the wastewater treatment system should be fully understood and proper training should be provided.

(6) Management/maintenance should be meticulously carried out.

(7) Cooperative relations should be established between the waste treatment plant and the factories.

(8) The treatment plant should participate in some way in the manufacturing process of each factory.

2.3. Other Problems and Suggestions

The following are problems and suggestions concerning matters other than wastewater treatment.

(1) Managing structure of the industrial estate

In the dyeing industrial estate, at present, wastewater treatment is conducted by the cooperative, but industrial water and steam are supplied by the city of Ansan and the Industrial Estate Corporation respectively. In constructing a new industrial estate, if there are no organizations to supply utilities such as industrial water and steam, the cooperative of factories may take charge. The cooperative may take charge of the disposal of industrial wastes, too.

(2) Improvement of positioning of Central Wastewater Treatment Plant

As is stated in section 2.1 of III above, the present central wastewater treatment plant is positioned as a pre-treatment plant for the sewage treatment plant. However the actual water quality is better than that of water discharged from the sewage treatment plant. When it is considered that these two plants comprise one system, it is hardly an efficient system. To rectify this situation, the following approaches shall be considered.

A. As shown in section 3.2.2 of III above, by using advanced treatment of COD, make the wastewater treatment plant capable of discharging treated water into public water.

B. Try to balance the loads of both plants by relaxing water quality standards of the water discharged from the central wastewater treatment plant. The hazard for elimination standard of sewage in Japan is a useful standard for water quality. (Refer to Table 3.6 of I. Introduction)

These approaches have the following advantages and disadvantages.

A. Advantage: It enables to plan a wastewater treatment plant regardless of the existing sewage treatment plant. There is no sewage charge

Disadvantage: Treatment cost is expensive (refer to CASE-2 of Optimum System). Capacity of the existing sewage treatment plant is wasted.

B. Advantage: Central wastewater treatment plant operation becomes easier and cost of the existing sewage treatment plant capacity can be used effectively.
Disadvantage: Present effluent standard can not be satisfied. A modification of the legal regulations is required.

Although as explained in B. this approach can not be implemented under current laws, it is worth considering as a future assignment as it has technical and economic advantages.

(3) Promotion for the reclamation of wastewater

CASE-3 of the optimum system suggests the reclamation of wastewater. In that case, the cost for regenerated water amounts to 860 Won/m^3 (see 4.2 of III), which is significantly higher than city water or industrial water. However, the effects of water reclamation cannot be measured with an economic rule alone. It may bring about the following benefits.

A. Reclamation of wastewater makes it possible to create an industrial estate where the water supply is inadequate.

B. Reclamation reduces the discharge of wastewater, with a consequent reduction in the amount of pollutant discharge (reduction rate is 20% in CASE-3 of III).

C. Where ground water is used, the reclamation of wastewater prevents land subsidence caused by excessive pumping .

Since the reclamation of wastewater brings about such benefits, its introduction should be taken into account when an industrial estate is newly created.

3. Summary of Evaluations

The following is a summary of the evaluations mentioned above.

(1) Technical evaluation

For both the plating and dyeing industrial estates, the optimum system offers a perfect solution to the problems of the existing systems. As stated many times, however, in order to make full use of the advantages of the optimum system, certain assumptions that are made for the planning of the systems must be met.

(2) Economic evaluation

A. In the case of the plating industrial estate, the optimum system make good economic sense, partly because the rates can be reasonably high. Here too, however, the assumptions must be met.

B. In the case of the dyeing industrial estate, the optimum system requires higher rates for treatment than those currently charged. Nonetheless, taking into account of the improvement of treatment and the inflation-adjusted construction costs, the optimum system still makes economic sense.

(3) Proposals

The proposals consist of (1) selection of the optimum system, (2) management of the industrial estate, and (3) enlargement of the activities of the industrial estate. Some of these proposals can be applied to the existing industrial estates immediately, but most are to be realized in the future. In case an industrial estate is newly created, the proposals may be applied more thoroughly.

V. Guidelines for Wastewater Treatment and Reclamation

V. Guidelines for Wastewater Treatment and Reclamation

1. Outline

The purpose of preparing these guidelines and their organization are as follows:

As has already been shown in II. and III., models were set for plating and dyeing industrial industrial estates in this Study, and optimum systems were selected for each of them. However, products and manufacturing processes involved in both industries are so diverse that the descriptions in II. and III. alone are not sufficient for the purpose of planning new wastewater treatment and reclamation plants.

As a result, it was decided to prepare more general guidelines for use in the planning of new wastewater treatment and reclamation plants for plating and dyeing industrial estates.

Special consideration is made here to suit the current situations of the two industries in Korea, while fully utilizing the investigation results in II. and III.

(2) Organization

Guidelines are divided into two major parts, covering plating and dyeing industries, respectively, with matters relating to production processes and wastewater treatment and reclamation described along with new treatment techniques.

One of the special features of these guidelines is emphasis on production processes and wastewater reclamation, subjects rarely explained in detail in traditional similar guidelines.

While these guidelines are closely related to the selection of optimum systems, they are also readily available as separate reference material.

2. Metal Plating Industry

Plating coats the surface of any object to be plated with metal films for the purpose of decoration, corrosion resistance, heat resistance or wear resistance. It is used for the produts and parts widely ranging from automobiles, electric cars, TV sets, radio sets, cameras and electronic apparatus to personal decorations and accessories.

Roughly speaking, the plating industry is classified as electroplating industry, melt plating industry, plated steel pipe manufacturing industry and other metal manufacturing industries. Of them, the electroplating industry is required to take special care for water and wastewater treatment. In some cases, electroplating is done as a part of any other process in a factory in which metal products are manufactured, and in the othres it is sone by an exclusive enterprise which is engaged mainly in processing only. The exclusive enterprises works on a processing fee basis and does not manufacture independent products. Therefore, exclusive enterprises are located for the convenience of entrusting metal products manufacturing or automobile manufacturing factories for which they do processing. These exclusive enterproses are very small in scale, but their number is very large as compared with the number of large-scale factories for which they do processing.

For exclusive enterprises, the construction cost and running cost for having their own wastewater treatment facilities are an economically heavy burden. Further, shortage of engineers in charge of operation and maintenance of these facilities, and of shortage or difficult acquirement of construction sites, etc. impose economically and technically serious problems on them. In addition, wastewater and exhaust gases discharged from plating factories contain much substances which are harmful to the human health, If the treatment of them has a problem, there may be serious influences on the surroundings of the factory. Therefore, scrupulous care is needed to prevent pollution.

From the viewpoint as mentioned above, it will be economically and technically advantageous to collect wastewater and exhaust gases from the workshops in the plating industrial estate and treat them in a central treatment plant, as compared with separate treatment by each exclusive enterprise. Moreover, if exclusive enterprises are gathered in the plating industrial estate, the risk of pollution generation may be reduced from a plane to a point. This is the reason why the spread of the plating industrial estate has been strongly desired.

However, the workshops in the plating industrial estate carry out diferent kinds of plating from each other, and therefore, it has also been pointed out that new problems unique to the wastewater treatment of the plating industrial estate should be liable to occur.

With the foregoing in mind, this chapter for guidelines describes the basis of plating wastewater treatment, such as main production processes and wastewaters generated and thier qunatity, the measures to be taken in production processes for reducing polutant loading, etc., fundamental wastewater treatment technologies, reclamation technologiesm and sludge tretment technologies, and an introduction of new technologies using membrane separation, together with other points to be cared about.

In Japan, many pollution problems with plating wastewaters occured in the past, but it is very rare at present that any wastewater unable to meet the control limits should be finally discharged. This is mainly due to technological developments made by research and development activities on pollution control technologies at government and local government testing institutes and laboratories, and also by environmental equipment enterprises' activities. On the other hand, devoted guidance and training activities of technical staff of local government research organizations and non-profit foundations directed for plating enterprises for a long time have also been effective. Since the wastewater treatment for plating factories is deeply related with the plating technology, the employees of plating enterprises have consulted with the staff about lthe watewater tretment problems and plating technologies to solve these problems and improve the technologies. It is desired that such testing and research organs should also be installed in Korea.

3. Dyeing Industry

Features of the dyeing industry and its waste water are as follows.

(1) Majority of the business is entrusted processing assignee so that they can hardly change the processing process independently.

(2) Small processing lot causes wide fluctuation in a day and also the season and the fashion causes wide seasonal fluctuation.

(3) Most of the processing process requires chemical treatment.

(4) The process uses a variety of chemicals such as dye, pigment, acid, alkali, oxidizer, reductant, sizing agent surface active agent, solvent, metallic chloride which have all different chemical properties.

(5) Waste water is colored by dye, pigment and impurities in fibers.

(6) pH of the total waste water is unstable for the irregular continuation of the acid and alkaline operation process.

(7) Residue of casein and lanolin, sizing agent and surface active agent raise BOD, COD level of waste water and make it effervescent.

(8) Chloride concentration in waste water is high because various chlorides are used in the process.

(9) The concentration of phenol and n-hexane extract in waste water is high because of the solvent.

(10) The level of BOD, COD and n-hexane extracts in the waste water is high because of the loss of oil an desizing agent in the process of fiber manufacturing, spinning and weaving.

(11) SS concentration of the waste water is high because of the loss of flocks and so on.

(12) Main process is conducted mostly batchwise and it intermittently discharges high-contaminated waste water. Consequently amount and quality of waste water fluctuate widely and it is difficult to grasp the water quality because of the mutual chemical action among chemicals.

Thus treatment of waste water of dyeing industry is more difficult than that of the other manufacturers' and combination of several treatment process is required for the sufficient treatment. Dyeing industry which is water-oriented industry discharges huge amount of waste water. For the above mentioned reasons, the waste water treatment in dyeing industry requires massive capital investment and operation cost which constitute significant burden for the management.

The following part summarizes the features of dyeing industry and describes the guideline to implement the economic waste water treatment and the reclamation.

JICA