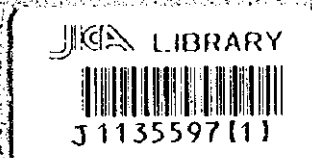


No. 40

JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)
MUNICIPALITY OF MARIBOR
MINISTRY OF ENVIRONMENTAL AND PHYSICAL PLANNING
REPUBLIC OF SLOVENIA

THE STUDY
FOR
THE SANITATION OF THE DRAVA RIVER
BY
WASTE WATER PRETREATMENT
AND WATER CONSERVATION IN INDUSTRY
IN
THE CITY OF MARIBOR,
REPUBLIC OF SLOVENIA

FINAL REPORT (SUMMARY)



MARCH 1997

WATER RE-USE PROMOTION CENTER JAPAN

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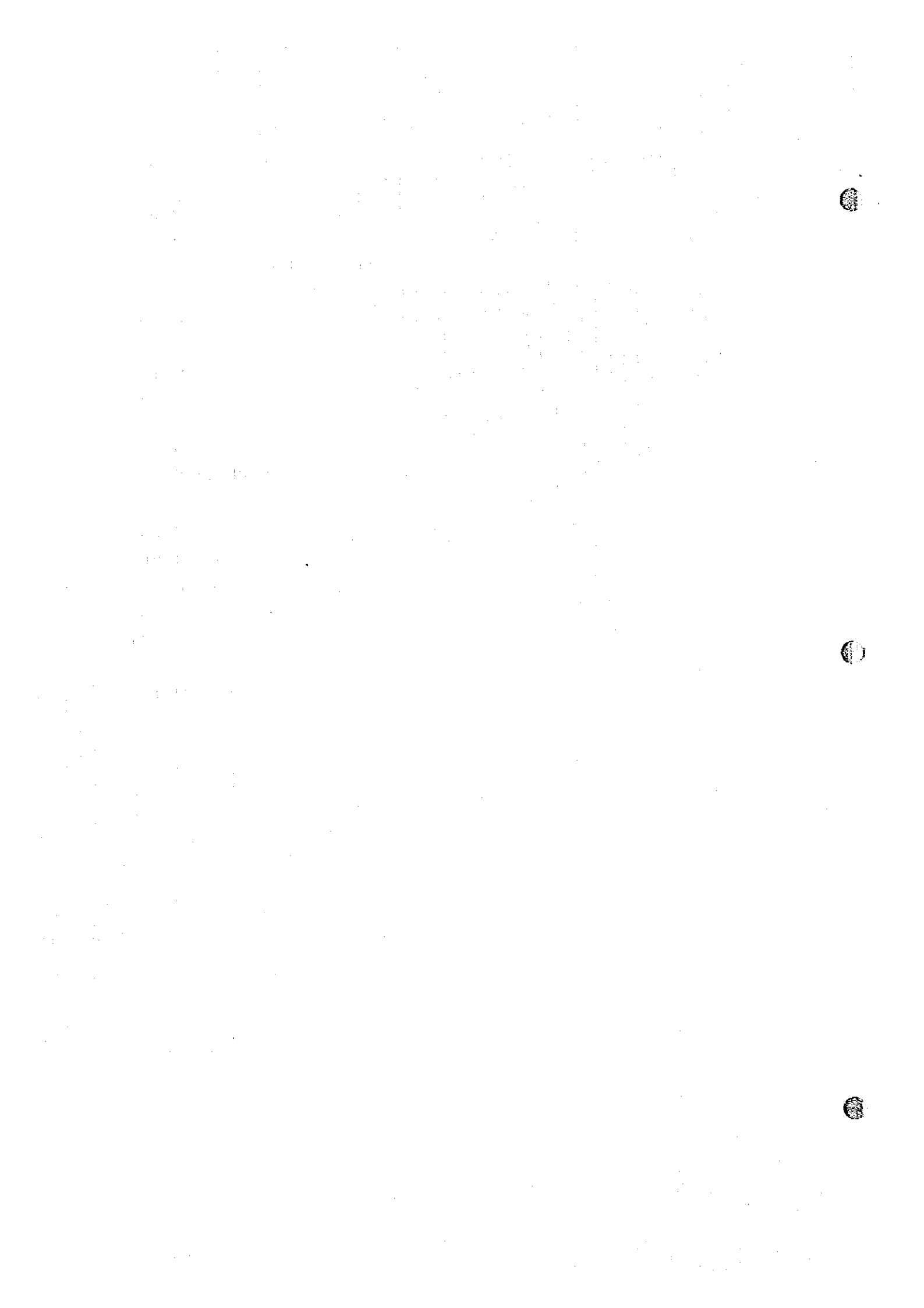
TABLE OF CONTENTS

Summary

I. Objectives of Study	I - 1
II. Outline of Study Region	II - 1
1. Natural and Socioeconomic Conditions	II - 1
1.1 General	II - 1
1.2 Socioeconomic Condition of Slovenia	II - 2
1.3 City of Maribor	II - 4
2. The Status Quo of Pollution in the Drava Region	II - 5
2.1 Ground Water and Water Springs	II - 5
2.2 Surface Water	II - 6
3. Water Supply and Use Conditions	II - 8
3.1 State Level	II - 8
3.2 Maribor level	II - 8
III. Environment Administration	III - 1
1. National Organizations and Their Roles	III - 2
1.1 National Background	III - 2
1.2 Environmental Administrative Organization of the Republic of Slovenia	III - 2
2. Laws Pertaining to Environmental Protection	III - 4
3. Industrial Emission Standards	III - 6
4. Monitoring of Environment	III - 8
5. Fiscal Measures	III - 8
6. Environmental Administration Issues	III - 9
7. Environment Administration of Maribor City	III - 10
IV. Results of Comprehensive Studies	IV - 1
1. Industrial Wastewater Treatment and Pretreatment	IV - 4
1.1 Industrial Wastewater Volume and Pollutant Load	IV - 4
1.2 Wastewater Treatment and Pretreatment	IV - 11
1.3 Pretreatment by Industries	IV - 17
2. Water Conservation	IV - 29
2.1 Expenses Required for Water and Sewage	IV - 29
2.2 Results of Water Conservation Studies on Individual Factories	IV - 35
2.3 Amounts of Conservable Water by Industry	IV - 39
2.4 Total Amount of Conservable Water in All Industrial Water	IV - 40
3. WWTP Project	IV - 41
3.1 Outline of Project	IV - 41
3.2 Study of Fee Systems	IV - 42

3.3	Removal of Nitrogen and Phosphor	IV-53
V.	Recommendations	V-1
1.	Treatment of Industrial Wastewater and Pretreatment	V-2
1.1	Necessity of Studying the Actual Condition of Industrial Wastewater	V-2
1.2	Continuous Study of Technology	V-2
1.3	Education on Substances Hazardous to the WWTP	V-3
2.	Water Conservation	V-4
2.1	Effects of Water Conservation	V-4
2.2	Recommendations on Water Conservation	V-5
3.	The WWTP	V-7
3.1	Setting of Rates	V-7
3.2	Removal of CODCr	V-9
4.	Measures Required of the Government	V-11
4.1	Fundamental Policy	V-11
4.2	Personnel Development	V-11
4.3	Incentive Systems for Investment in Environmental Measures	V-12
4.4	Promotion of Engineering Companies	V-12
VI.	Current Condition and Model Systems of Factories and Economic Evaluation ..	VI-1
1.	General Summary	VI-1
1.1	Outline	VI-1
1.2	Water Conservation	VI-11
1.3	Pretreatment and Waste Water Treatment	VI-12
1.4	Assumptions for Financial Analysis	VI-13
1.5	Preconditions for Economic Evaluation	VI-19
2.	Model Factories	VI-20
2.1	M-1 SVILA, TEKSTILNA TOVARNA d.d.MARIBOR.....	VI-20
2.2	M-2 MARLES HOLDING d.d. MARLESPOHISTVO .d.o.o.....	VI-28
2.3	M-3 LIVARNA Maribor. ARMAL	VI-35
2.4	M-4 STAJERSKA PIVOVARNA d.d.	VI-40
2.5	M-5 VINAG VI NARSSTVO-SADJARTVO	VI-46
2.6	M-6 KOSAKI TOVARNA MESNIH IZDELKOV	VI-51
2.7	M-7 MARIBORSKA MLEKARNA d.o.o.MM.MARIBORSKA MLEKARNA d.o.o	VI-58

3. Secondary Beneficiary Factories	VI-64
3.1 S-1 TOVARNA VOLENIH TKANIN, P.O. (TVT MERINKA)	VI-64
3.2 S-2 TEKSTILNA TOVARNA TABOR d.o.o.....	VI-67
3.3 S-3 MARIBORSKA TEKSTILNA TOVARNA, MELJE d.d.	VI-73
(MTT MELJE), d.d., TOVARNA TKANIN MELJE d.o.o	
3.4 S-4 TOVARNA SUKANECEV IN TRAKOV TSP p.o.....	VI-77
3.5 S-5 METALNA, STROJE-GRANDNJA, KONSTRUKCIJE, MONTAZA INSTORITVE, d.d.	VI-81
3.6 S-6 MERKATOR-SLOSAD d.d.	VI-84
3.7 S-7 INTES MLIN TESTENINE	VI-87
4. Tertiary Factories	VI-90
4.1 A-1 TVT-TOVARNA VOZIL IN TOPLPTNE TEHNIKE-BORIS KIDRIC- TIRNA VOZILA d.o.o.	VI-90
4.2 A-2 ELEKTROKOVINA SVETILA	VI-93
4.3 A-3 PRIMAT- TOVARNA KOVINSKE OPREME	VI-96
4.4 A-4 ELEKTROKOVINA ELEKTROMOTORJI.....	VI-100
4.5 A-5 HENKEL-ZLATOROG	VI-103
4.6 A-6 SWATY TOVARNA UMETNIH BRUSOV.	VI-107
 VII. Conclusion	 VII-1



TABLES OF CONTENTS

Relative Information

1. Nitrogen-Phosphorus Removal Technology	1
1.1 Necessity of Nitrogen-Phosphorus Removal	1
1.2 Nitrogen Removal Technology	1
1.3 Phosphorus Removal	7
2. Color Removal Technology	21
2.1 Activated-carbon Adsorption	23
2.2 Oxidation by Ozone	24
3. Toxic Substance Treatment Technology	25
3.1 Treatment of Heavy Metal	25
3.2 Treatment of Hexavalent Chromium	27
3.3 Treatment of Mercury	28
3.4 Treatment of Arsenic	31
3.5 Treatment of Cynogen	32
3.6 Treatment of Organochlorine Compounds	33
4. Proposals for Harmful Chemical Substances & Chemical Substances	35
4.1 How Industrial Effluents Affect Sewer System	35
4.2 Effluents & Waste From Hospitals	45
4.3 Toxicological Tests	51
4.4 Heavy Metals	54
4.5 Comments on Nitrogen & Phosphorus Removal Technique	58
5. Application Examples of Wastewater-treatment Systems in Japan	59
5.1 Metal Machining Industry	59
5.2 Fiber and Dyeing Industry	62
5.3 Beer Brewing Industry	67
5.4 Meat Industry	70
6. Guideline for Conservation of Industrial Water	75
6.1 Preconditions for water conservation	75
6.2 Water-Conservation Procedure	76

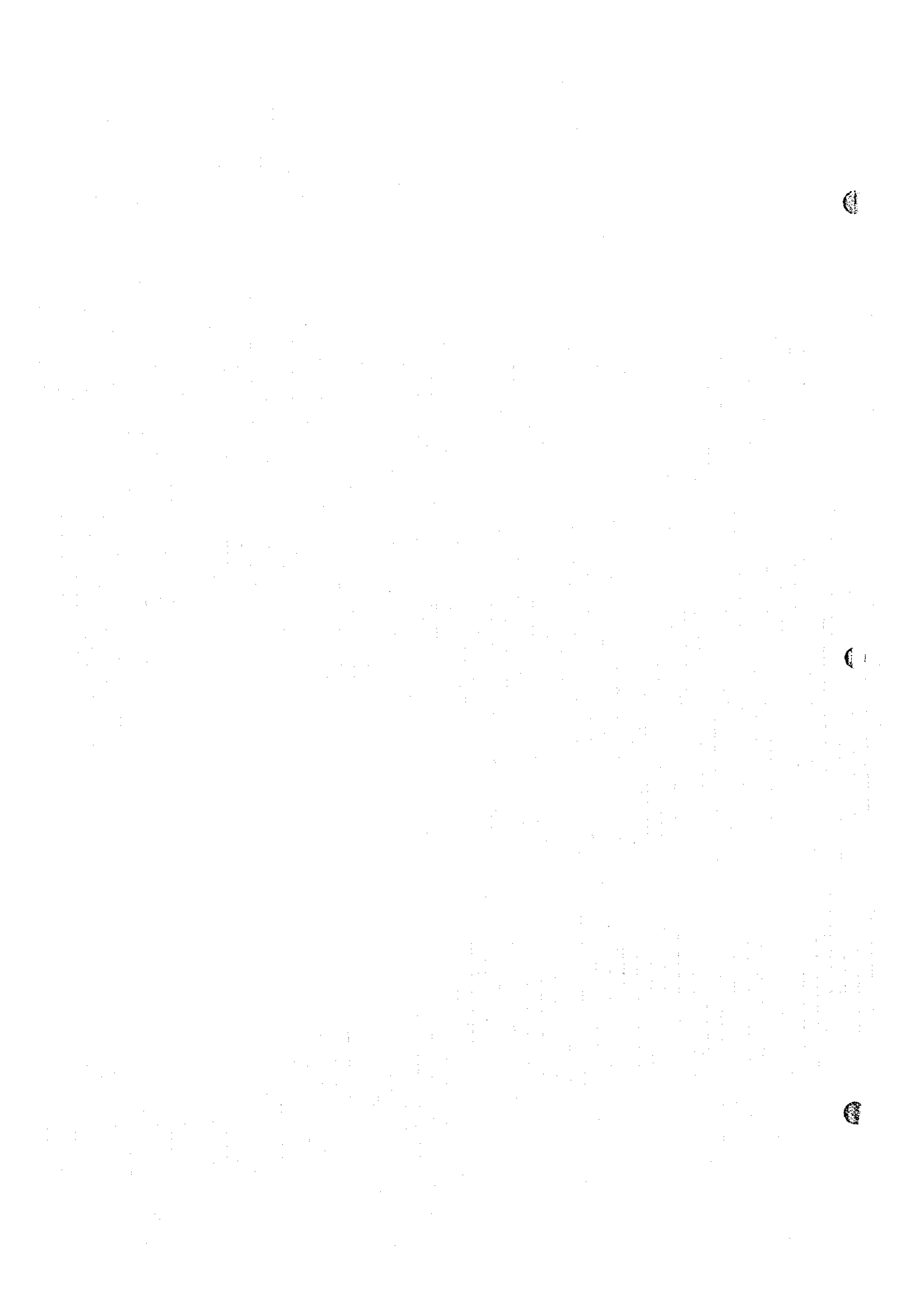
7. Japanese Environmental Administration	89
7.1 Transitions in Environmental Administration	89
7.2 Environmental Standards and Industrial Wastewater Standards	92
7.3 The Role of Local Public Bodies	99
7.4 Transitions of Land Subsidence and Countermeasures	100
7.5 Pollution Control Systems	105
7.6 Private Enterprise Environmental Management Systems	115
8. Introduction of Sewage Systems in Japan	121
8.1 Wakagawa Sewage System of Wakayama City	121
8.2 Kashima Littoral Specified Public Sewage System	128
8.3 Ariake Sewage System in Tokyo Metropolis	133

I . Objectives of Study



I . Objectives of Study

The objectives of the Study are the preparation of plans for standard waste water treatment systems and water conservation systems to improve waste water treatment and to promote water conservation in the main industrial sectors in Maribor and the recommendation of measures to be taken by the competent authority in Slovenia with a view to promoting the dissemination of these systems.



II. Outline of Study Region



II. Outline of Study Region

To effectively fulfill the purposes of this study, it is of course essential to become familiar with the outline of our study subjects, the country of Slovenia and the city of Maribor. Accordingly, we focused the study on the country and city levels, on (1) the state of the natural conditions and social economy, (2) the state of pollution of the waters of the Drava River valley, and (3) the state of the supply and demand of water.

An understanding of the natural conditions is requisite for the design of treatment plants, and an awareness of the conditions of the social economy is needed to accurately depict the background conditions which require investigation and to prevent errors in judgment midway through the survey. Maribor City, the subject of this survey, is the largest of all the industrial cities related to the Drava River in Slovenia, and it is believed to be the largest source of pollutants discharged into the Drava River. Thus, we next investigated the state of pollution of the Drava River valley to clarify the levels of environmental pollution originating from Maribor City. Finally, we investigated the supply and demand of water, especially industrial water, and clearly defined the reasons for the need for pretreatment of industrial wastewater and conservation of industrial water (whether it was merely an environmental problem or involved also problems of water shortage). We used these data as the reference material for establishing the basic plan for our survey.

1. Natural and Socioeconomic Conditions

1. 1 General ⁽¹⁾

The Republic of Slovenia is a young country in Central Europe whose independence was declared in 1991. The republic is located to the south of the Alps, and borders Italy, Austria, Hungary and Croatia. It has an area of 20,256 km² with a population of about two million.

Slovenia's climate is quite diverse. The narrow coastal regions enjoy the sub-Mediterranean climate with relatively hot and dry summers and mild winters.

Towards the east, the climate slowly changes to the Pannonian type, i.e., a continental climate with cold winters and warm summers (in Murska Sobota, the average

temperature is -2.7°C in January, 19.4°C in July and 800-1,200 mm of precipitation).

The geological location enables a quick and easy access to the European market. Therefore, Slovenia was traditionally oriented towards exports to the developed market economies even before the breakdown of the former Yugoslavia. Currently, around 75% of the total export goes to Western Europe.

Slovenia embarked on a path of transformation to a market economy and integration into the European economy with its independence in 1991. Through EU membership, it aims at :

- 1) faster economic growth, bridging the gap with the developed countries of Western Europe
- 2) a more competitive Slovene economy
- 3) permanent sustenance of economic growth from the ecological and ethnic standpoints.

A report by the Bank of Slovenia says that Slovenia's per capita GDP reached 9,348 U.S. dollars in 1995. Thus, Slovenia can be regarded as a rather advanced country in Europe.

1.2 Socioeconomic Condition of Slovenia ⁽¹⁾

The essential factors of economic development are human resources, capital, technology and entrepreneurship. It is a basic policy that the role of the state is to give a positive impact on the development of all the four factors.

i) Human resources

In the early 1990s, the birth rate of the Slovene population was far below the level which assures simple reproduction. The average family has only one or two children. Life expectancy is 69.5 years for men and 77.4 years for women. It seems that the reduction of the population is a long-term tendency in Slovenia. The decreased birth rate and small probability of an immediate improvement forecast a reduction and even a lack of available labor force at the beginning of the 21st century.

2) Capital and investment

Slovenia's business fixed capital is outdated and depreciated. The structure is inadequate and the market value is very low. This is a consequence of low investment activity in the last decade. The share of investment in GDP has been only 15 to 17%. The stronger investment activity in the next decade aims at restructuring capacities and at technological up-grading of capital assets.

3) Technical development

In the 1980's, Slovenia invested over 1.3% of its GDP in research and development. At the beginning of the 1990's, the situation in Slovene manufacturing worsened substantially. Only 6% of enterprises have R&D sectors and invest in production innovation.

After the establishment of the Slovene patent office in 1992, the number of registered patents doubled in 1993 (30 are domestic and 458 are foreign patents). The technological balance of payment reflects the international trade of technology. Slovenia has a deficit in balance.

4) Development of domestic entrepreneurship

Entrepreneurship is of vital importance to industrial development because it introduces innovations in the production processes. Entrepreneurship can be defined as the process in which individuals and groups discover business opportunities. A seed capital and a venture capital are needed to support domestic entrepreneurs. In a small country like Slovenia, such capital is available only in limited amounts. Slovenia will stimulate the development of entrepreneurship in two ways:

- (a) by creating a favorable environment for fast growing enterprises-high quality education, communications, and housing
- (b) by supporting programs for the development of entrepreneurship and provision of information about business opportunities.

1.3 City of Maribor ^(a)

Maribor is the second largest city in Slovenia, with a population of 152,326 in 1994. The city has 357 km² of land area, and an elevation of 265m above sea level. The Drava divides the city into the north part—an old town, and the south part—a newly developed area.

The climate is rather mild with somewhat cold weather in winter. Therefore, we need antifreezing measures in building a wastewater treatment plant. Some parts of the plant should be kept inside the main building.

The population distribution by age has the largest share between 40 and 49 years of age. The population is showing a tendency towards decrease, with a falling from the maximum of 157,078 in 1988 to 152,326 in 1994.

Table 1-1 Structure of Employment

Activity	Employees in 1984		Employees in 1994		Index % 1994/1984
		%		%	
TOTAL ECONOMIC SECTOR	72,512	85.1	41,116	74.2	56.7
Industry	35,080	41.2	18,927	34.2	54.0
Agriculture, fish farming	740	0.9	418	0.8	56.5
Forestry	342	0.4	68	0.1	19.9
Water commercial	0	0.0	58	0.1	0.0
Construction	10,383	12.0	4,602	8.3	44.3
Transport, communications	4,609	5.4	2,982	5.4	64.7
Trade	8,865	10.4	6,035	10.9	68.1
Catering, tourism	2,181	2.6	1,153	2.1	52.9
Craft, services	4,080	4.8	2,185	3.9	53.6
Residential, public utility services	1,429	1.7	1,103	2.0	77.2
Financial, technical, business services	4,803	5.6	3,585	6.5	74.6
TOTAL PUBLIC SECTOR	12,699	14.9	14,301	25.8	112.6
Education, science and culture	4,553	5.3	5,085	9.2	111.7
Health care, social protection	5,818	6.8	6,076	11.0	104.4
Others	2,328	2.7	3,140	5.7	134.9
TOTAL	85,211	100.0	55,417	100.0	65.0

Table 1-1 shows the structure of employment in 1984 and in 1994. As a whole, the

total public sector increased from 14.9% to 25.8% during the decade. In the total economic sector, industry occupied the largest share with a decreasing trend, but the large shares were held by trade and business services, the latter of which increased from 5.6% to 6.5% between 1984 and 1994. In the total public sector, there was a high increase in all parts. It seems that the manufacturing industry will continue to play an important role in the employment in future, and that the structure of employment will change from a secondary industry to a tertiary industry at Maribor in the long run.

The city imports basic iron, steel and non-ferrous metals, and exports metal products, machinery, non-ferrous metal products, transport equipment, etc. The city imports basic chemicals, and exports yarn, textiles, knitted fabrics, and finished textile products. In processing of chemical products, the balance of exports and imports is almost equivalent, at 8.1% (exports) to 10.2% (import). Finished wooden products are another competitive field. Naturally agriculture is not in good balance in a large city like Maribor. In short, Maribor is an industrialized city which buys basic materials outside, and processes them, and sells them outside, and which is shifting from secondary to tertiary industries.

2. The Status Quo of Pollution in the Drava Region ⁽³⁾

Groundwater and water springs are the nation's major natural resources and must be protected against pollution and excess use. A number of measures are being taken to curb the excessive or improper use of the natural resources. The basis for these measures are the data on the water condition and quality.

The Ministry of Environmental and Physical Planning entrusts the task of monitoring the water quality to the Hydrometeorological Institute of the Republic of Slovenia. Flowing and groundwater springs, lakes, and the sea are being monitored.

2.1 Ground Water and Water Springs

The information given on the quality of groundwater and water springs in the previous years is also valid for 1994. The groundwater in Slovenia is particularly threatened by agriculture, since entire areas are polluted with nitrates and pesticides, including Dravsko Polje. The water quality of water springs analyzed in 1994 was good. However, the analyses of sediment in the seven samples of 1993 showed that pollution from the hinterlands was present and that water quality may suffer abrupt deteriorations due to

heavy metals, PCB, and polycyclic aromatic hydrocarbons.

2.2 Surface Water

The Slovene regulations for estimating the quality of surface water were still under preparation and two obsolete and lacking Yugoslavian regulations were still in force in 1994.

The regulation classifies flowing water into the following four quality classes with regard to its potential utilization.

1st class : waters which in their natural state or following disinfection may be used as drinking water, in the food-processing industry, and in breeding high class fish species (Salmonidae);

2nd class : waters which in their natural state may be used for bathing, water sports, breeding other species of fish (Ciprinidae), or which following normal treatment (coagulation, filtration and disinfection), may be used as drinking water or in the food-processing industry;

3rd class : water which may be used in irrigation, or following normal treatment, in industries other than the food-processing industry;

4th class : waters which must be given an adequate treatment before it is used for any purpose.

Evaluations of the water quality for individual samples as well as the total estimate for individual sampling points, determined on the basis of the analyses performed in 1994, have been compiled. According to the evaluations, the quality of water at most of the Drava sampling points is between the 2nd and 3rd classes.

A comparison of final evaluation for the quality of surface water since 1989 shows that the Drava has improved to a small extent. The highest COD value at all sampling points on the Drava was measured in August. The highest COD in 1994 was observed in Dravograd, Borl, and Ptuj. The BOD₅'s in the upper stream were low in comparison with the COD. The pollution of the Drava downstream from Mariborski Otok rose gradually along the course of the river to reach its highest value in Borl (downstream of Maribor) where both COD as well as BOD₅ were high. This proves the presence of large amounts of easily decomposable organic matter. This was due both to the pollution and to the reduced discharge in the old river-bed of the Drava due to redirection of water into the power plant channel. Oxygen supersaturation was measured in the Duplek-

Ormoz section at almost all sampling points, and an excessive growth of algae due to the inflow of nutrients in the wastewater from Maribor was found.

A similar condition was observed for nitrogen compounds, the contents of which were increased downstream of Maribor reaching their highest values in Borl. The presence of both total phenols and mineral oils was constant along the course of the river. The maximum value of the phenol content was measured in the Mariborski Otok in February 1994 (0.011 mg/l). The highest contents of mineral oils were measured at the Mariborski Otok (0.013mg/l) and at Dravograd in February, 1994.

The Drava is not heavily polluted with phenol, aromatic compounds, PCB or pesticides. Moderately high contents of these pollutants were measured only rarely. In 1994, the analyzed polycyclic aromatic hydrocarbons (PAH) in the Drava were close to the bottom detection limit for the applied method. PAH concentrations in the last three years have seen their sharpest fall in Ormoz in particular, where in 1994, they remained below the detection level. It is likewise important to stress the reduction of concentrations of highly toxic PAH which had been detected in Ormoz as late as 1990.

The bacteriological picture of the Drava deteriorated sharply downstream from Maribor below the inflow of the excessively polluted Strazunsk Kanal. Bacteriological pollutions were observed in all of the Drava River with the highest levels found in the Duplek. Bacteria of fecal origin were constantly present at all sampling points. The Strazunsk Kanal carried the wastewater of the greater part of Maribor, and was classified as an excessively polluted water course, that is, as a water course of the 4th quality class.

Chemical, sapogenic and bacteriological analyses of 1994 samples showed the quality of individual sampling points or sections of the water courses. Generally the trend of the reduction of the pollution of surface water courses in Slovenia continues. Gradually diminishing levels of metal pollutants and organic compounds were also determined in some rivers. The observed improvement may be partly attributed to the reduction of the wastewater due to the decrease in the industrial production, and partly to the implementation of rehabilitation measures. However, there are still some sections of the water courses classified in the worst, that is, the 4th quality class. Also, inadequate quality of water for drinking found in five water courses whose water infiltrates the ground, including the Drava-Mariborski Otok.

3. Water Supply and Use Conditions

3.1 State Level ⁽⁴⁾

Slovenia is a land of forests. More than half of its territory is wooded, a ratio of which is well above the European average (33%). There are also many pastures, meadows, and fields. Many branch rivers of the Danube flow among them. Annual precipitation ranges from 800 to 1,600 mm, and provides agriculture with fresh water.

The republic abounds in natural water. The two major sources are underground water and springs.

The use of water in public water supply is also shown in Table 3-1.

Table 3-1 Water Supplied from Public Water Supply
(Annual Values in 1,000 m³ Unit)

Use	1980	1985	1990	1991	1992
Household	60,065	75,655	86,217	85,378	80,326
Activities	99,927	83,002	78,834	76,686	66,016
Other water supply systems		8,568	16,304	15,420	6,266
Loss within waterworks network	71,486	77,466	79,789	79,187	106,689
Total	159,992	167,225	182,355	177,484	152,608

There are three major water sources for the industries, i.e., underground water, surface water, and water works.

However, springs sometimes supply a considerable amount of water, which shows water abundance in Slovenia. As far as our investigation is concerned, there is no sign that a water shortage would cause a bottleneck for the Slovenian manufacturing industries. The problem is the pollution of surface water; most rivers are already of the 2nd and 3rd quality class, sometimes 4th quality class.

3.2 Maribor Level ⁽⁵⁾

The only sources for the Maribor water supply system is groundwater. Table 3-2 gives the figures from 1985-1994.

Table 3-2 Water Supply System of Maribor
(Annual Values in 1,000m³ Unit)

Year	Pumping-up	Sale	Industry	Household	Loss
1985	18,426	13,768	7,291	6,576	4,190
1986	17,742	13,845	7,600	6,244	3,897
1987	18,907	14,675	6,282	8,393	4,231
1988	18,677	13,743	5,321	8,421	4,871
1989	18,632	14,491	5,894	8,597	3,736
1990	18,941	14,140	5,304	8,835	4,798
1991	18,339	13,070	4,422	8,648	5,267
1992	18,631	12,966	4,190	8,776	5,666
1993	19,473	13,394	4,257	9,137	6,080
1994	19,027	13,015	3,773	9,247	6,014

On the other hand, the household consumption per capita per day is obtained by use of population statistics from 1985 to 1994 and shown in Table 3-3. According to the data in the table, the consumption increases steadily regardless of socioeconomic conditions. This is a common trend in the world, and the basis of the gradual expansion of water supply system for household use. The mean increase rate from 1985 to 1994 is 4.83% in the case of Maribor.

Table 3-3 Water Consumption for Household Use
(liters/person, day)

Year	Population	Household Consumption
1985	155,634	116
1986	155,933	110
1987	156,703	147
1988	157,078	147
1989	156,200	151
1990	156,399	155
1991	156,438	151
1992	155,318	155
1993	152,506	164
1994	152,326	166

In the case of Japan, in 1965 when the Japanese economy was growing rapidly, the household water consumption was 169 liters/day per person and the increase rate was 4.7%⁽⁶⁾. However, in 1975 or later, the increase rates were reduced to 1.2%, with the

consumption reaching 335 liter/day in 1993.

If the increase rates of Maribor in the years from 1995 to 2000 are 4.8, 4.6, 4.4, 4.2, 4.0, and 3.8%, respectively, the water consumption could reach 214 liter/day per person in 2000. One estimate predicts annual consumption of 11 million cubic meters in 2000⁽⁹⁾. If this is true, the population of Maribor will be 140,827. No one can foretell the size of the population in 2000, but the figures indicate that we should prepare an expansion of the water supply system even if the population decreases.

The demand of industrial water for the water supply system of Maribor decreased from 7,291,000m³ in 1985 to 3,213,000m³ in 1995.

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III. Environmental Administration

III. Environmental Administration

- Organization for environmental administration of the Republic of Slovenia

The Ministry of Environment and Physical Planning (MEPP), which manages the administration of the environment of the Republic of Slovenia, has three vice-ministers, one of whom is in charge of the environment. The Ministry also has an Environmental Legislation Department which takes the lead in drawing up and deciding on basic policies and plans regarding the environment.

- Preparation of National Environmental Action Plan (NEAP)

The government is expected to finish preparing a National Environmental Action Plan at the beginning of 1997. Priorities will be assigned to Slovenia's environmental measures on the basis of this plan, and a large framework for technical assistance and investment programs will be decided.

- Environmental inspectorate system

As part of Slovenia's strategy for preparing to join the European Union, the country must strengthen its environmental monitoring and enforcement capabilities. An Integrated Environmental Inspectorate with nine regional centers was established within MEPP in accordance with the Government Restructuring Act of January 1996. However, due to financial restrictions, the situation with respect to personnel, equipment, and skills is still not satisfactory.

- Environment protection laws

Upgrading Slovenia's laws regarding the protection of the environment to a level approaching that of the European Union is an important issue for the country. The framework of Slovenia's environment protection is declared in its constitution of 1991 and its Environment Protection Act of 1993. Many related laws have been enacted in order to achieve the objectives of the 1993 Act.

- Water quality control

The effluent standards issued on June 12, 1996, specify the maximum permissible water quality values for effluent discharged into rivers, other public water areas, and the sewerage. The standard for the former is extremely strict, while that for the latter is quite loose.

- Financial measures

In 1993, the Eco-Fund was established as a financial institution to promote investment in environmental protection by providing loans at favorable interest rates. The funds are allotted from the national budget and are not directly connected to environmental related-income.

- Maribor City's environmental administration

Maribor City is protecting its groundwater as its main potable water source and is grappling with the task of preserving the environment of the Drava River by designating the control and improvement of the city's household effluent and industrial wastewater as a top priority issue.

1. National Organizations and Their Roles ^{(1) (2)}

1.1 National Background

Slovenia is a relatively young country, having obtained its independence from the Federation of Yugoslavia as recently as 1991. Prior to the country's independence, decentralized government was strong, with considerable power vested in 65 Communes and local administrations. Similarly, the administration of environmental protection and management was widely decentralized during this period.

The strong local power and vested interests resulting from the government's decentralization gave rise to regional variation in the enforcement of environmental pollution regulations.

It was in this climate and culture that Slovenia emerged as a fledgling democracy and that the Ministry of Environment and Physical Planning of Slovenia (MEPP) was established as the key agency responsible for environmental protection and management.

1.2 Environmental Administrative Organization of the Republic of Slovenia

The organization of the Ministry of Environment and Physical Planning (MEPP), the ministry responsible for environmental protection and management of the environment of the Republic of Slovenia, is shown in Fig. 1.1. As shown in the Figure, of the three Secretaries, one is in charge of the environment. The core group that plans and decides environmental policies is the Environmental Legislation Department.

(1) National Environmental Action Plan (NEAP)

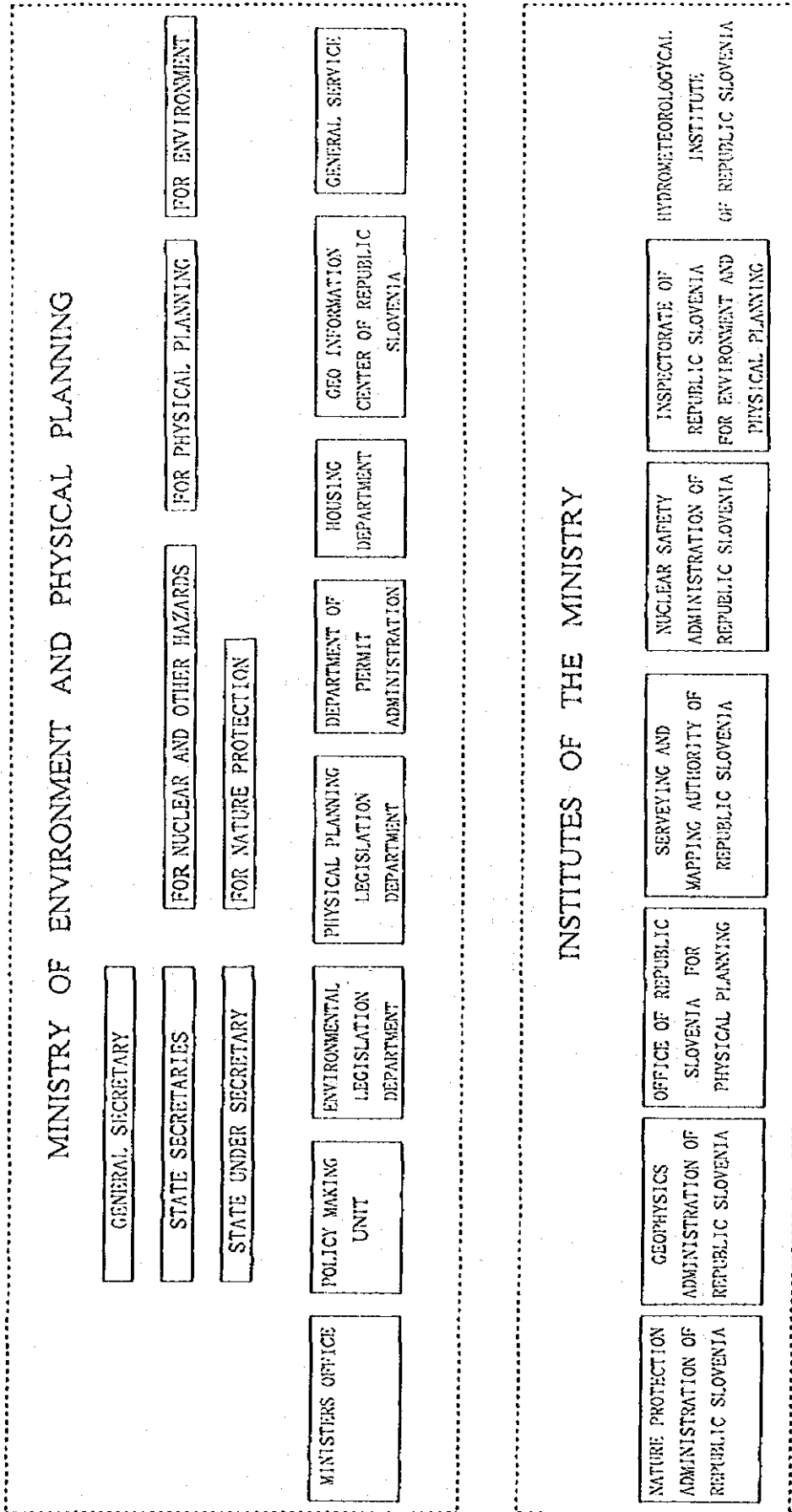
The National State of the Environment, a report updated by the government in 1995, is currently being used to provide baseline data for the preparation of the National Environmental Action Plan (NEAP). Slated for completion at the beginning of 1997, the NEAP will identify and prioritize issues and present outlines for technical assistance and solutions for investment programs.

(2) Environmental Inspectorate

To ensure that Slovenian environmental legislation complies with the EU legislation both in substance and form, the country's efforts to upgrade its environmental monitoring and enforcement capabilities must be administered in parallel with efforts to approximate its national environmental legislation to that of the EU.

Inspectorate is in particular need of institutional strengthening under the Pre-Accession Strategy. Up until 1994, the inspection functions were highly dispersed, with each municipality responsible for monitoring compliance under the guidance of four ministries, i.e., the MEPP (water), the Ministry of Health (air and waste), the Ministry of Agriculture (forestry), and the Ministry of Culture (protection of nature). This situation was altered by the Government Restructuring Act in January 1996, which established an Integrated Environmental Inspectorate within the MEPP with nine regional centers. Unfortunately, this new Inspectorate is considerably short of personnel, equipment, and skills. To cite an example, at the end of 1995, due to

Fig 1.1 Organization of Environment Administration in the Republic of Slovenia



financial constraints, only 40% of the 279 inspector positions deemed necessary for compulsory execution could be filled. In the short term, no substantial improvements of this situation are expected.

To strengthen the institutional structure of the Environmental Inspectorate and improve the effectiveness of its activities and inspectors, the NEAP is expected to implement programs geared towards the following:

- to streamline organizational structures and simplify operational procedures in order to improve the efficiency of allocation of decision-making responsibilities to the inspectors, etc.;
- to develop an integrated monitoring program which fully complies with national and EU requirements;
- to improve monitoring information links --improved data collection and transfer and processing of hardware and software;
- to provide training for the Inspectorate staff in best EU procedures and practices.

2. Laws Pertaining to Environmental Protection ^{(1) (3)}

The framework for environmental protection in Slovenia was provided by the 1991 Constitution and the 1993 Environmental Protection Act (EPA). The EPA is a framework act covering the principles of environmental protection and its implementation. In the future, however, the Act will have to be bolstered with enabling or subsidiary legislation before most of its requirements can be implemented. Significantly, the Act contains a summary of key economic instruments to be used as measures in support of environmental law enforcement, with the underlying basis founded on the 'polluter pays' principle. At present, the following laws, ordinances, decrees, and regulations pertaining to water quality have been enacted.

- ① Environmental-protection Law (OG 32/93,1/96)
- ② Ordinance on Projects Requiring Environmental Impact Assessment (OG 66/96)
- ③ Administration Law (OG 67/94)
- ④ Ministries Organization Law (OG 71/93)
- ⑤ Water Law (OG 38/81,29/86,15/91)
- ⑥ Decree on water pollution tax (OG 41/95,42/95,44/95)
- ⑦ Regulation of water refunds (OG 41/95,42/95)
- ⑧ Decree on determination of price per unit of water pollution for 1995 (OG 45/95)
- ⑨ Regulation of emissions of materials and heat in wastewater from sources of pollution (OG 35/96)
- ⑩ Regulation of emissions of materials in wastewater from sources of pollution in metal industries (OG 35/96)
- ⑪ Regulation of emissions of materials in wastewater from household wastewater treatment plants (OG 35/96)
- ⑫ Regulation of emissions of materials in wastewater from sources of pollution in the textile industry (OG 35/96)

- ⑬ Regulation of emissions of materials in wastewater from sources of pollution in the tanning and fur industries (OG 35/96)
- ⑭ Regulation of first measurements and monitoring of wastewater (OG 35/96)
- ⑮ Decree on the mode of operation for local water management service (OG 57/96)

OG: Official Gazette of the Republic of Slovenia

The composition and main items of the Environmental Protection Act are as follows.

- ① Chapter 1 Basic matters: Purpose, definitions, etc.
- ② Chapter 2 Preservation of natural environment
- ③ Chapter 3 Controls, control standards, types of control activities, Eco labeling in the field of environmental protection
- ④ Chapter 4 Environmental-protection measures
- ⑤ Chapter 5 Environmental-protection research and planning: Research and development carried out by the State, environmental programs that should be prepared, items that should be incorporated in programs, and programs of regional municipalities
- ⑥ Chapter 6 Activities and environmental restoration: Environmental effect evaluation, items of environmental effect evaluation, permits, participation of residents, environmental-restoration programs
- ⑦ Chapter 7 Environmental monitoring and environmental data system: Obligations of the State and regional municipalities
- ⑧ Chapter 8 Fiscal measures for environmental restoration: Compensation, surcharge, fiscal measures taken by the State, funds, organization and source of funds
- ⑨ Chapter 9 Conference on environmental protection
- ⑩ Chapter 10 Obligations of public bodies
- ⑪ Chapter 11 Cooperative organizations of economical bodies
- ⑫ Chapter 12 Penalties
- ⑬ Chapter 13 Interim measures

Recently, MEPP has commenced preparation of new subsidiary legislation. It has already updated the law regulating atmospheric emissions, and an integrated law on waste management is currently under preparation. The focus of waste management strategy and policy has shifted towards issues of technology and organization, i.e., minimization of waste vis-à-vis the previous approach, which focused on problems associated with locations for waste disposal. A particularly large number of new regulations have been enacted for the protection of nature, with an emphasis on preserving species and habitats, and participating in the European Ecological Network.

3. Industrial Emission Standards ⁽⁴⁾

Standards for effluents were officially promulgated on June 12, 1996. The contents were studied for more than one year in Slovenia.

The emission standards are indications of the maximum permissible water quality values for discharges into rivers, other public water areas, and sewers. The former is very strict while the latter is lenient. First, there are general controls and these literally are standards. Unless otherwise specified, all items are applied. Other standards have been specified for the textile industry, nine kinds of metal treatment processes, and other specially designated businesses. In addition, there are many supplemental explanatory clauses. The emission standards are shown in Table 3.1.

Table 3.1 Emission Standards for Industrial Wastewater

Item	Unit	River	Sewage
1 Temperature	°C	30	40
2 pH	-	6.5 ~ 9.0	6.5 ~ 9.5
3 SS	mg/l	80	(a)
4 SV ₃₀	ml/l	0.5	1.0
5 SAK (Color)			
436 nm	m ⁻¹	7.0	
525 nm	m ⁻¹	5.0	(b)
620 nm	m ⁻¹	3.0	
6 Toxicity Test (SD)	mg/l	3	-
7 Biodegradation	%	-	(c)
8 B	mg/l	1.0	10.0
9 Al	mg/l	3.0	(d)
10 As	mg/l	0.1	0.1
11 Cu	mg/l	0.5	0.5
12 Ba	mg/l	5.0	5.0
13 Zn	mg/l	2.0	2.0
14 Cd	mg/l	0.1	0.1
15 Co	mg/l	1.0	1.0
16 Sn	mg/l	2.0	2.0
17 T-Cr	mg/l	0.5	0.5
18 Cr	mg/l	0.1	0.1
19 Ni	mg/l	0.5	0.5
20 Ag	mg/l	0.1	0.1
21 Pb	mg/l	0.5	0.5
22 Fe	mg/l	2.0	(d)
23 Hg	mg/l	0.001	0.001
24 Cl ₂ (Free Chlorine)	mg/l	0.2	0.5
25 Cl ₂ (Total Available Chlorine)	mg/l	0.5	1.0
26 N-NH ₃	mg/l	1.0	(e)
27 N-NO ₂	mg/l	1.0	1.0
28 N-NO ₃	mg/l	(f)	-
29 T-CN	mg/l	0.5	1.0
30 Free CN	mg/l	0.1	0.1
31 F	mg/l	1.0	2.0
32 Cl ⁻	mg/l	(g)	-
33 T-P	mg/l	2.0 (1.0 (h))	-
34 SO ₄	mg/l	(i)	300
35 S	mg/l	0.1	1.0
36 SO ₂	mg/l	1.0	1.0
37 TOC	mg/l	30	-
38 COD _{Cr}	mg/l	120	-
39 BOD ₅	mg/l	25	-
40 Total Oil Content	mg/l	20	100
41 THC	mg/l	10	20
42 Aromatic Organochlorine	mg/l	0.1	1.0
43 Adsorptive Organochlorine	mg/l	0.5	0.5
44 Volatile Organochlorine	mg/l	0.1	0.1
45 Water-soluble Organochlorine	mg/l	(j)	(l)
46 Phenol	mg/l	0.1	1.0
47 Surfactant	mg/l	1.0	-

Note: (a) to (e) are notes for the application of the items and so have been omitted here.

4. Monitoring of Environment ^{(1) (2)}

According to Article 67 of the Environmental Protection Act, environmental monitoring of the Republic of Slovenia can be largely divided into the following three categories.

- ① Monitoring of natural phenomena
- ② Monitoring of emissions (environmental pollution): Soil, water, atmosphere, flora and fauna
- ③ Monitoring of emissions (state of discharge): Substances discharged into soil, water and atmosphere

The monitoring assigned to the State is ① and ② above, while that assigned to the regional municipalities is ③ and, as needs be, ②. The Environmental Protection Act stipulates that the person at the discharge source is to monitor each individual source and, as occasion demands, the emission level due to discharge.

Incidentally, according to Slovenia's 1993 annual report on water quality, the Hydrometeorological Institute had monitored river water, underground water, and other public water areas a total of 3,857 times.

Monitoring of the water quality at source is being carried out from the past in accordance with EU guidelines. With regard to surface water, water quality in four grades has been used in the Hydrometeorological Institute's 1993 report.

5. Fiscal Measures ⁽¹⁾

(1) Eco-Fund

The current Eco-Fund was established in 1993 as a financial institution to promote investment in environmental protection by providing loans at favorable interest rates. The Fund reports directly to the government. Since its launch at the end of 1994, most of the focus has been in organizing its asset base, appointing special staff, and initiating various preliminary operations.

Compared with the old Environmental Protection Fund instituted in 1990, the Eco-Fund differs in several important respects, including both the sources and the uses of its funding.

Currently, the use of economic instruments in the environmental sector in Slovenia is restricted to two environmental charges introduced in 1976; i.e., an emission charge on wastewater and a user charge on drinking water. Rather than being earmarked for environmental purposes, the revenues generated from these environmental charges are collected into the state budget (MECU 6.4 in 1993). Although the Eco-Fund receives funds from the state budget, the funds are not tied in any way to these revenues.

Another relevant point is that the state budget, independent of the Eco-Fund, provides subsidies (albeit very small ones) to both the public and industrial sectors for investment in environmental equipment. The 'bottom line' is that the 'polluter pays' principle is not transparent in the operation of the current monetary cycle in the environmental sector. On a positive note, however, the Slovenian government representatives at the Sofia Conference (1995) stated that the 'polluter pays' principle will be implemented whenever possible, although they gave no time frame.

(2) Economical measures on water resources management

Two types of economic instruments are currently used in the field of water resource management.

A tax for water pollution (Official Gazette No.41/95), a charge on use of water (Official Gazette No.41/95), and changes of the decree in Official Gazette No.8/96.

To advance as much as possible the 'polluter pays' principle, the government adopted the decree on tax for water pollution load as an economic instrument for the protection of water quality and the environment.

The decree on tax for water pollution load categorizes wastewater as 'technological,' 'communal,' or 'atmospheric.' Persons liable to taxation are defined in accordance with the wastewater they discharge and divided into two groups, i.e., 'direct' and 'indirect' polluters, to determine the actual payment of the taxes. Revenue from direct polluters, those who discharge technological wastewater, goes directly into the state budget, while revenue from indirect polluters, those who discharge communal or atmospheric wastewater, is allocated indirectly to public enterprises which clean and process the wastewater, calculate the tax, and pay it into the state budget.

The decree on tax for water pollution load also offers material incentives to the polluters for prevention of water pollution at source by making it possible to finance investments in environmental protection (wastewater purifying plants, new technologies, etc.) with revenues from the water pollution load tax.

To facilitate the adaptation of the new decree by industries, the types of pollution load subject to taxation will be introduced progressively. Taxation will be imposed on COD (chemical oxygen demand) pollution load units from January 1, 1995, heavy metals from January 1, 1997, organic halogen compounds from January 1, 2000, and phosphorus and nitrogen from January 1, 2003.

Enterprises exceeding the standard levels of permitted emissions are subject to fines. Environmental inspectors can order polluters to take measures to reduce emissions and impose fines for failing to adequately execute the measures. The polluter pays taxes for volume of effluent regardless of quality. Taxes collected are also increasing proportionally as the degree of pollution by effluents progresses.

6. Environmental Administration Issues ⁽¹⁾

(1) Strengthening of system

At present, the Master Plan for Institutional Development for Environmental Protection, a report published in October 1996, is being used as a blueprint for developing organizational structures in the MEPP and Eco-Fund. However, in spite of the structural changes that are taking place, the MEPP, Environmental Inspectorate, and Eco-Fund need to be further strengthened with enhanced operational skills and procedures.

(2) Adjustment of legal system

The main objectives of Phase I will be to facilitate early compliance with the White Paper and approximate other cornerstone legislation such as that of the EU. The horizontal issues addressed will affect all sectoral topics, with an emphasis on the following:

- development of sectoral legislation and action/implementation plans for priorities identified in the NEAP regarding water, waste, and bio-diversity;
- development of inspection and enforcement mechanisms; and
- development of financial and economic instruments facilitating the future implementation of the NEAP and required investments. This will include the development of economic incentive and disincentive mechanisms (i.e., the 'polluter pays' principle) required to secure policy implementation and the financial mechanisms required to implement the strategy (for example, the Eco-Fund).

(3) Financing and economic measures

As the realization of NEAP objectives will require large-scale investments in the course of execution, heavy demands will be placed on limited financial resources. To support national

budget allocations and ensure the sustainability of NEAP initiatives, it will therefore be imperative to develop effective financing schemes. At the fundamental level, these will include efforts to cooperate more fully with IFT's, the development of economic incentive and disincentive tools to stimulate private sector compliance (tax exemptions, fines, and penalties founded upon the 'polluter pays' principle), and the implementation of financial investment schemes to provide preferential loans to financially unviable projects which bear important environmental consequences. However, on the other hand, since these are accompanied by important obligations toward the environment, even closer cooperation with IFT will be required.

(4) Public participation

The successful implementation of the NEAP is heavily contingent on public and corporate participation and cooperation in planning and execution. As such, the NEAP will have to call together all the organizations involved and exert considerable sustained effort in promoting and explaining its objectives.

7. Environment Administration of Maribor City

(1) Regional background

Maribor City once supported highly developed textile, chemical, wood processing, metal, food processing, and automaking industries. Nevertheless, in spite of extremely intensive restructuring, even the city's larger enterprises (those employing over 3,000 people) have considerably stagnated and even disintegrated over the last ten years. As a result, 14,000 people are currently unemployed, and even among those who are employed, labor conditions are not good. Therefore there is limit to investment in environmental projects in environmental projects. On a positive note, however, the inhabitants of the city recognize the benefits of a higher-quality environment, and the very difficult economic and social situation is not precluding the strengthening of environmental initiatives.

Maribor City has set its environmental priorities on improving the management of its municipal and industrial wastewater in order to protect its groundwater, the main source of its potable water, and to keep the Drava River clean. These activities are implemented under three core projects:

- Extension and improvement of the sewerage system. Although the sewerage system is already about 70% complete, it remains unconnected at places, with more than 25% of its discharge released directly into the Drava River. As 75% of Maribor City is designated as a potable water protection area, this project is perhaps the city's most important.
- Industrial wastewater pretreatment technology and rational use of industrial water. The quantity and quality of industrial wastewater are to be regulated in accordance with the future approaches and technologies of the Central Wastewater Treatment Plant (WWTP).
- Construction and management of the WWTP.
- Improvement of the quality of the groundwater and water from the Drava River flowing from Slovenia towards Croatia through pretreatment of collected wastewater at the WWTP. Maribor is currently in the process of selecting a party to design, construct, and operate the WWTP in the future. At present, it has narrowed candidates down to three major consortia and a decision is expected to be made soon.

(2) Organization of environment administration in Maribor City

Maribor City's organization of environment administration is shown in Fig.7.1. The Vice Mayors in charge of the environment exercise control over the Environmental Protection Agency, Public Service Administration and City Inspection.

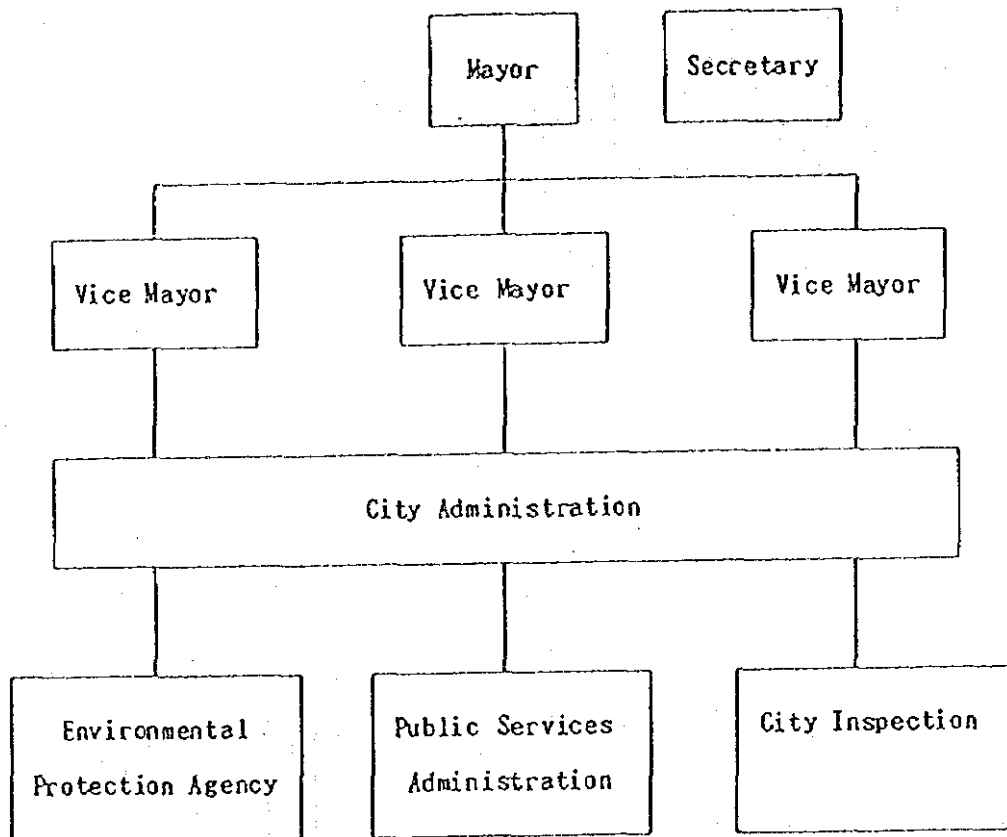
NIGRAD, Snaga, and Mariborski Vodovod, are also involved as related agencies.

The Environmental Protection Agency is the core department for administration of the environment. It plans and decides the basic policies pertaining to the environmental protection of Maribor City.

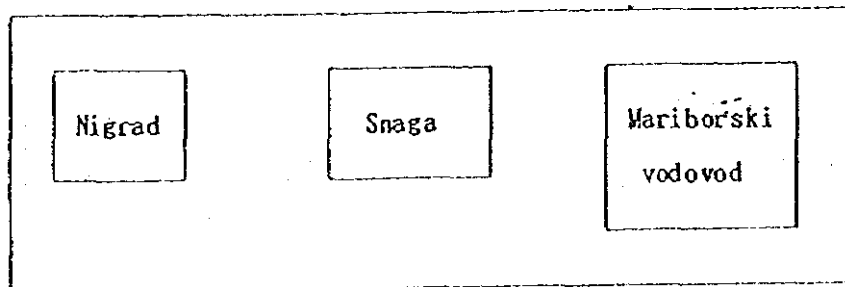
The Public Service Administration participates in the City's environmental administration while engaged in sewage, water supply, city waste, roads and other public services.

City Inspection carries out monitoring activities for the protection of the environment in accordance with Maribor City ordinances. NIGRAD is tackling environmental problems through the planning, designing and building of sewage-treatment facilities for processing household sewage and industrial effluent. Snaga is in charge of the disposition and recycling of city waste and the management of disposal plants. Mariborski Vodovod is building water supply facilities, securing sources of water supply, and controlling the quality of water.

Fig 7.1 Organization of Environment Administration in Maribor City



Public Companies



Reference Book

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IV. Results of Comprehensive Studies

IV. Results of Comprehensive Studies

This Chapter we will describe the results of our studies based on the outlines of our study subjects presented in the previous chapters. The study items are (1) treatment and pretreatment of industrial wastewater, (2) water conservation, and (3) the WWTP (Central Treatment Plant) project.

With regard to industrial wastewater treatment and pretreatment, Maribor City's entire industrial wastewater volume and the pollution load were estimated based on studies of the 20 main factories discharging more than 80% of the city's industrial wastewater. Next, on main seven plants that have been designated as model factories, a comparison was made of the merits and demerits, under the current effluent standards, of discharging their wastewater directly into the Drava River and discharging it into the WWTP. The results revealed that it would be economically advantageous for almost all the factories to discharge their wastewater into the WWTP.

It appears that consideration has been given to making the WWTP fully capable of treating present loads. However, based on future increase in loads, the rise of the polluter-pays principle, and other factors, it is conceivable that a fee structure based on pollutant loads or added restrictions to the effluent standards will be applied. Accordingly, studies were made of pretreatment for the purpose of reducing pollutant loads. Studies were made for each factory to determine how much reduction of pollutant load could be obtained using different process at different levels of investment. In addition, the results were summarized by industries -- textiles and dyeing, foods, chemicals, and machinery.

In water conservation, the first investigations focused on the costs to the factories for water consumption and wastewater, and what ratio those costs represented of the cost of the final shipped products. Next, for each factory, we clarified the water conservation method, the volume of water saved, the saved ratio and the cost. In addition, we summarized the volume of water saved by industries, pointed out their characteristics, and also estimated the volume that would be saved by each factory.

Note that in industrial wastewater treatment and pretreatment and in water conservation, we have totalized the data for each factory and show them by factory in Part II in order to observe the secrecy of the subject factories.

With respect to the WWTP, since Maribor City was in the process of evaluating the proposals of the bidding enterprises during the survey period, details were not revealed, and only an outline was given to. However, as a result of our pretreatment studies for reducing pollutants, it became clear that WWTP's wastewater treatment fee structure would be the most important factor for each factory in deciding whether or not it would pay for it to pretreat its wastewater. Therefore, we prepared simulation programs on what pretreatment would be carried out by which factory under what sort of fee structure. We then estimated the actions that would be taken by each factory to cope with various types of fee structures. As a result we were able to clarify factory's total investment amount and total pollution load amount. In addition, we introduced the basic concept behind sewer usage fee calculations in Japan and also the thinking with respect to the elimination of nitrogen and phosphorus.

Selection Reasons of Factories to be Surveyed

The factories investigated by our field surveys were selected for the following reasons.

The seven factories selected as the model factories (M Factory Group) consisted of one textile/dyeing factory, one furniture-making factory, one machine factory, and four food factories. Maribor City's main industries are textile/dyeing, food, and machines. Factories in these industries that use great amounts of water and have high wastewater pollution loads were selected.

From the food industry, four typical factories from the alcohol (beer and wine), meat, and dairy product businesses were selected. Therefore, it can be said that these seven factories are representative of the various industries of Maribor City.

The 13 factories comprising the secondary factories (S Factory Group) and tertiary factories (A Factory Group) consist of 4 textile/dyeing, 5 machine, 2 food, and 2 chemical plants. The criteria used for the selection of these factories are their wastewater pollution loads, which are the most severe in the city after those of the model factories. Four textile/dyeing factories are included because these consume large volumes of water and are part of one of Maribor City's typical industries.

Note that the tertiary factories are added partially in our surveys to further widen the range of factories selected. The tertiary factories are factories not included among the model or secondary factories which have large pollution loads or consume large volumes of water. Following is a breakdown of industries by selected factories.

Textile/dyeing	5 factories
Furniture making	1 factory
Machine manufacturing	6 factories
Food	6 factories
<u>Chemical</u>	<u>2 factories</u>
Total	20 factories

The names of the above 20 factories are listed in the table on the next page. In the table, both full name and abbreviations are shown and the abbreviations will be used hereafter.

Name of Selected Factories

No.	Industry	Full Name	Abbreviation
M-1	Textile(Knitting)	SVILA TEKSTILNA TOVARNA, d. d.	SVILA
M-2	Furniture	MARLES HOLDING, d. d. MARLES POHISTVO, d. o. o.	MARLES
M-3	Machine & Metal Processing	LIVARNA Maribor ARMAL	ARMAL
M-4	Food(Brewery)	STAJERSKA PIVOVARNA, d. d.	PIVOVARNA
M-5	Food(Wine Cellar)	VINAG VINARSTVO-SADJARTVO	VINAG
M-6	Food(Slaughter House)	KOSAKI TOVARNA MESNIH IZDELKOV	KOSAKI
M-7	Food(Dairy Product)	MARIBORSKA MLEKARNA, d. o. o. MM MARIBORSKA MLEKARNA, d. o. o.	MLEKARNA
S-1	Textile	Tovarna Volnenih tkanin MERINKA, p. o. (TVT MERINKA)	MERINKA
S-2	ditto.	Tekstilna Tovarna TABOR, d. o. o.	TABOR
S-3	ditto.	Mariborska tekstilna tovarna Melje, d. d. (MTT MELJE), d. d. Tovarna tkanin MELJE, d. o. o.	MTT
S-4	ditto.	Tovarna sukancev in trakov TSP, p. o.	TSP
S-5	Machine & Metal Processing	METALNA, STROJE-GRADNJA, KONSTRUKCIJE MONTAZA IN STORITVE, d. d.	METALNA
S-6	Food	MERKATOR-SLOSAD, d. d.	SLOSAD
S-7	ditto.	INTES MLIN TESTENINE	INTES
A-1	Machine & Metal Processing	TVT-Tovarna Vozil in toplotne tehnike- Boris Kidric-TIRNA YOZILA	TVT
A-2	ditto.	ELEKTROKOVINA-SVETILA	SVETILXE
A-3	ditto.	PRIMAT-Tovarna kovinske opreme	PRIMAT
A-4	ditto.	ELEKTROKOVINA Elektromotorji	ELKO
A-5	Chemical	HENKEL ZLATOROG	HENKEL
A-6	ditto.	SWATY Tovarna umetnih brusov	SWATY

1. Industrial Wastewater Treatment and Pretreatment

1.1 Industrial Wastewater Volume and Pollutant Load

1) Wastewater volume

(1) Industrial wastewater volume

The term industrial wastewater mentioned here means the wastewater that is discharged by factories producing various products. It does not include the wastewater that is discharged from enterprises that do not produce anything such as public utilities, communication businesses, wholesalers, retailers, restaurants, etc.

Estimation of the volume of discharge of industrial wastewater is extremely important when studying the treatment capacity of the WWTP. The JICA survey team took the following measures in order to obtain that figure.

- ① Totalized the water consumption of the 20 factories surveyed by the team, and estimated the volume of wastewater.
- ② Checked the data possessed by Maribor City and by its agencies.

As a result, based mainly on ① and partly supplemented by ②, the total volume of wastewater discharged by Maribor City was estimated to be about 14,600m³/day.

The amount of industrial wastewater discharged is the amount consumed by the factories (water that becomes part of the products, evaporates, seeps into the ground, etc.) deducted from the water consumption. In Japan, standard runoff coefficients depending on purpose, individual surface characteristics, type of business, and other factors for the area are adopted based on experience. However, in this survey, we took the wastewater volume as the same as the water consumption volume.

However, there are daily and seasonal fluctuations in the volume of water consumed by factories. Therefore, some room should be made for this purpose in the WWTP's treatment capacity. We refer to this point in 2) below.

(2) Estimation of total volume of wastewater, household wastewater, and Industrial wastewater to flow into the WWTP

NIGRAD and the JICA survey team checked the total volume of wastewater, household wastewater, and industrial wastewater to be discharged into the WWTP. As a result, it was agreed from the city water consumption data controlled by NIGRAD, that the volume of water consumed by small-scale users would be estimated as being equal to the volume of household wastewater.

Also, it was revealed that NIGRAD was still in the process of investigating the volume of industrial wastewater and did not yet have any reliable data on it. As a result of the two parties checking the results obtained by the present survey of the JICA survey team, it was confirmed that, at the moment, JICA's survey results were the most detailed available.

The results checked by the two parties can be summarized as follows.

Total wastewater to flow into the WWTP = 39,600 m³/day

Household wastewater (25,000 x 0.9 - 0.95) = About 22,500 - 23,750 m³/day

Industrial wastewater (14,600 + 1,250 - 2,500) = About 17,100 - 15,850 m³/day

Note that the designed value of the total volume of wastewater to flow into the WWTP indicated to us by Maribor City is 36,500 m³/day. There is a difference of about 3,000 m³ between this figure and ours shown above. The reasons for this difference are considered to be as follows.

In JICA's survey, wastewater that is at present being discharged into rivers and streams is included in the amount that would be discharged into the WWTP in the future. Also, actual measurements show that there are seasonal fluctuations in wastewater, so the volume of wastewater was calculated from the annual water consumption.

On the other hand, the designed value indicated by Maribor City of 36,500 m³/day was estimated from actual measurements (at five places) taken over a short period (3 months) of some of the sewage wastewater. This method does not include the wastewater volume currently being discharged into rivers by factories. Also, since the actual measurements were not made over an entire year, we believe there is some error in the figure.

When designing the WWTP, we would recommend that, for the sake of safety, a figure of about 10% in excess be used.

Note that we believe the WWTP should be designed for a total wastewater volume estimated at 16,000 to 17,000 m³/day. This is because the volume of small-scale factory users is not included in NIGRAD's small-scale user data, while the total wastewater volume (of 14,500 m³/day) obtained through JICA's survey is estimated to cover 80 to 90% of the full amount.

Note: (1) Water supply source data is as follows:

Small-scale city water consumers	25,000 m ³ /d (NIGRAD's data)
Large-scale city water consumers	7,200 m ³ /d (JICA's data)
Ground water consumers (factories)	5,000 m ³ /d (JICA's data)
River water consumers (factories)	2,400 m ³ /d (JICA's data)
Total	39,600 m ³ /d

- (2) According to JICA's survey data, the total waste water volume of the 20 factories is 14,600 m³/d. Of this, 3,000 m³/d is the total waste water volume of 20 enterprises which make up MPP (formerly TAM).

2) Pollutant load

This survey covered a total of 20 factories (seven model factories, seven secondary factories, and six tertiary factories). The pollutant concentrations and pollutant loads for these twenty factories are shown in Table 1.1.2.

For the pollutant concentrations of the model factories, we took the actual measurements made during our second field survey or the designed values of the model wastewater-treatment systems. For the secondary and tertiary factories, we took the actual measurements made during our fourth field survey. For some factories which have more than one discharge outlet, we used values calculated from the flow rates. The pollutant loads were calculated by multiplying the wastewater volume by the pollutant concentration. The wastewater volumes are the same as those shown in Table 1.1.1.

The four textile factories have a large water volume. The total wastewater volume of the twenty factories is about 11,500m³. This may be 80% or more than the total industrial wastewater volume. Also, it may be about 1/3 of the sewerage water volume initially estimated by the WWTP.

3) Comparison of water quality of sewerage water and factory wastewater

Data is available on water volume and quality at five main sewage discharge outlets measured in 1993. We calculated the pollutant load of these measurements in the same manner and compared the results with the total industrial wastewater of the 20 factories surveyed. The results are shown Table 1.1.3.

According to this Table, the water quality of the industrial wastewater and the overall sewage are practically the same. Moreover, the industrial wastewater shows lower figures than overall sewage for SS and P. In other words, it can be said that the overall pollutant load of the present industrial wastewater is about the same as the normal sewage for the WWTP.

However, some industrial wastewater have pollutant loads very much higher than general sewage or contain substances that are difficult to treat by sewage treatment. Close attention must be given to these factors.

Table 1.1.3 Comparison of Water Quality between Sewage Water and Effluent from Factories

Wastewater Sources	Quantity	Concentration of Pollutants						Pollutant Load												
		m ³ /d	COD mg/L	BOD mg/L	SS mg/L	T-P mg/L	T-N mg/L	COD kg/d	BOD kg/d	SS kg/d	T-P kg/d	T-N kg/d								
1 Sewer																				
Gorkera	1523	590	206	232	38	38	899	314	353	17	58									
Melje	8886	462	197	216	7	27	4105	1751	1919	62	240									
Studenci	1368	369	143	164	13	30	505	196	224	18	41									
Tabar	8452	635	266	296	11	47	5367	2248	2502	93	397									
Itenzo	9177	437	190	161	9	25	4010	1744	1477	83	229									
Total	29406						14886	6252	6476	272	966									
Average		506	213	220	9	33														
2 Factory																				
Total	11558						5784	2467	1986	64	330									
Average		500	213	172	6	29														

Note: (1) The data of Sewer water are from WASTEWATER TREATMENT PROJECT AND CONCESSION - REQUEST FOR PROPOSALS, Appendices, 27. September 1995.

(2) The data of Factory are from the JICA Survey Team. It is the total and average of the twenty factories s

4) COD_{Cr} and COD_{Mn}

The technical formation of wastewater treatment in Japan has been based on COD_{Mn}. Therefore, this point needs to be watched when referring to Japan's wastewater-treatment technology or achievements. For our fourth field survey, COD_{Cr} and COD_{Mn} were jointly measured.

Table 1.1.4 shows the results of analysis of industrial wastewater and Table 1.1.5 shows that of sewerage consisting mainly of household wastewater.

Table 1.1.4 COD_{Cr} and COD_{Mn} in the Industrial Wastewater

unit = mg/L							
	Name	Sample	COD _{Cr}	COD _{Mn}	Cr/Mn	BOD	SS
M-1	SVILA	Print	270	240	1.1	90	70
M-2	MARLES	Total	33	19	1.7	20	< 30
M-5	VING	Final tank	13,900	6,800	2.0	3,100	3,900
M-6	KOSAKI	Slaughter	2,400	770	3.1	1,200	550
M-7	MLEKARNA	Total	16,600	2,900	5.7	1,100	6,600
S-1	MERINKA	Total	650	300	2.2	150	37
S-2	TABOR	Total	34	15	2.3	25	< 30
S-3	MTT	Total	340	120	2.8	140	340
		Textile dye	230	100	2.3		58
		Yarn dye	100	48	2.1		< 30
S-4	TSP	Total	360	190	1.9	100	32
S-5	METALNA	ECCE	19	15	1.3	< 5	80
		Palfinger	77	32	2.4	< 5	< 30
		Vanishing	1,800	750	2.4	300	85
S-6	SLOSAD	Tank 1	7,000	3,200	2.2	2,500	850
		Tank 2	1,600	630	2.5	250	80
A-1	TVT		16	10	1.6	< 5	55
A-2	SVETILKE	Tank	16	10	1.6	< 5	65
A-3	PRIMAT		380	200	1.9	230	180
A-4	ELKO		47	15	3.1	< 5	18
A-5	HENKEL	TPD	910	360	2.5	180	460
		outlet 4a	660	240	2.5	300	130
		outlet 5	2,400	810	3.0	1,400	310
A-6	SWATY	Total	130	32	4.1	50	47

Table 1.1.5 COD_{Cr} and COD_{Mn} in the Household Sewerage

Characterization of the sample			1 *	2 *	3 *	4 *
Type of the sample			spot	spot	spot	spot
Date of sampling			19.12.1996	19.12.1996	20.12.1996	20.12.1996
Parameter	expr.as	Unit				
Suspended solids		mg/l	150	240	140	230
Total nitrogen:	N	mg/l	33	69	122	88
- ammonium nitrogen	N	mg/l	27	48	72	44
- Kjeldahl nitrogen	N	mg/l	29	66	120	85
- nitrite nitrogen	N	mg/l	0.4	< 0.01	< 0.01	< 0.01
- nitrate nitrogen	N	mg/l	4.4	3.1	2.2	2.5
Total phosphorus	P	mg/l	1.2	6.6	7.0	5.0
COD _{Cr}	O ₂	mg/l	280	720	900	780
COD _{Mn}	O ₂	mg/l	80	150	150	190
BOD ₅	O ₂	mg/l	100	260	400	440

- * 1 - Poborska ulica - the area of "Rožna dolina"
- 2 - the corner of Ulica Pariške komune and Radvanjska cesta - the "Tabor" area
- 3 - the corner of Ulica Proleterskih brigad and Ljubljanska cesta - the "Tabor" area
- 4 - Ulica borca (at the end) - the "Brezje" area

When COD_{Cr}/COD_{Mn} or COD_{Cr}/BOD is large, it may mean that substances of poor biodegradability are contained in the waste water. When the COD removal rate is bad after start of operations of WWTP, it will probably be necessary to carry out studies about making it compulsory for factories, discharging waste water with large ratios of these substances, to install pretreatment facilities to reduce the pollution load.

1.2 Wastewater Treatment and Pretreatment

1.2.1 Design Conditions (Common for All Model Factories)

1) Treatment system

As the quality of raw water is designed based on the field analysis results, some of the numerical values may differ from those of the questionnaire which was distributed to each factory prior to the field analysis.

The quality of the treated waste water is designed to meet Slovenia's Emission Standards which the Study Team received on June 12th, 1996. Past experience and results in Japan were also used to determine the design treated waste water quality. However, industrial waste water requires different treatment levels depending on the product type and raw materials and secondary raw materials used. Consequently, the necessary tests to obtain design data before proceeding to the actual design stage of a waste water treatment system, are essential.

2) Treatment plant site

Waste water treatment plant construction is planned on an empty site and no special site constraints are assumed unless stated otherwise.

3) Plant installation conditions

In view of easy plant maintenance in winter, the plant will be installed inside a building which is heated for 3 months in winter. An outdoor minimum temperature of -20° C and snow cover of 1 m in winter are assumed.

4) Scope of Estimation

The plant cost is estimated on the turn key basis. The following items are, however, excluded from the estimate.

- a. Piping work outside the battery limit range
- b. Power cabling work on the primary supply side
- c. Substation
- d. Piling and surplus soil removal
- e. Spare parts

5) Utility costs

(1) Electricity : 15 SIT/kwh

(2) Water : 200 SIT/m³

(3) Heating oil : 60 SIT/litre

(4) Chemicals

a. Urea H ₂ NCONH ₂ 100%	:	52 SIT/kg
b. K ₂ HPO ₄ 100%	:	394 SIT/kg
c. PAC 11% Al ₂ O ₃	:	74.7 SIT/kg
d. Al ₂ (SO ₄) ₃ 18 H ₂ O	:	39.15 SIT/kg
e. Ferric chloride 13% Fe	:	64 SIT/kg
f. Polymer (nonion type) 100%	:	990 SIT/kg
g. Polymer (anion type) 100%	:	990 SIT/kg
h. Polymer (cation type) 100%	:	2,000 SIT/kg
i. NaHSO ₃ 32%	:	113.6 SIT/kg
j. NaOCl 11% - 13% as Cl ₂	:	54 SIT/kg
k. H ₂ SO ₄ 98%	:	70.2 SIT/kg
l. HCl 30%	:	22 SIT/kg
m. NaOH 100%	:	83.2 SIT/kg
n. Na ₂ CO ₃ 100%	:	40 SIT/kg

o. Granular activated carbon : 930 SIT/kg

6) Waste disposal cost

General waste : 1,423 SIT/m³

Harmful waste: 49,683 SIT/m³

(Disposed of at the waste disposal site located 10 km from Maribor.)

7) Control system

(1) pH control : automated

(2) Tank liquid level control : automated

(3) Sand filter : automated

(All other operations are conducted manually.)

8) Operation staff

When the waste water plant is in operation for 24 hours/day, 2 operators will supervise the operation for 8 hours each and no operator will be assigned to the over-night operation of 8 hours unless otherwise stated. A communication system to inform of any breakdown or accident during the unmanned night operation must be installed as a necessary condition for continuous operation.

9) Materials and symbols

The equipment symbols have the following meanings.

- FC : Cast iron
- FC13Cr : Cast iron (13 Cr)
- SUS : Stainless steel
- SS : Mild steel
- SS/EP : Mild steel inside epoxi-tar lining
- PVC : Polyvinyl chloride resin
- PE : Polyethylene
- VP : Vinyl pipe
- FC + RL : Cast iron inside rubber lining
- SGP : Steel gas pipe
- FRP : Fibre reinforced plastic
- RC : Reinforced concrete

10) Miscellaneous

- (1) Voltage : 220 V/380 V
Frequency : 50 Hz

(2) Rainwater, domestic waste water are treated separately and, therefore, are not mixed with the industrial waste water treatment plant, unless it's specially mentioned.

1.2.2 Model System of Wastewater Treatment

On the seven model factories, detailed design and economic evaluations were made on the wastewater-treatment equipment for discharging directly into rivers based on the results of the second field survey.

The results are shown in Table 1.2.1. The Table shows the equipment cost, depreciation, interest, running cost, etc. Looking at the total treatment costs per water volume, all are higher than the estimated cost for discharge into sewers. Moreover, it can be seen that the costs are exceptionally higher in all but two factories.

The following can be cited as the main reasons for the high costs.

- (1) The emission standard for discharging directly into rivers is very strict.
- (2) The systems are small in scale so the cost per treated water volume becomes comparatively higher.
- (3) As model systems, their performance was designed on the safe side.

1.2.3 Pretreatment to Satisfy the WWTP's Emission Standard

The items set as the emission standard for discharging into the WWTP are temperature, pH, immediate-settling SS, heavy metals, chlorine and chlorine compounds, cyanide, fluorine, sulfur and sulfur oxides, and oil content. All of these are substances that are injurious to the WWTP or substances that are difficult to treat by the WWTP. There are no standards for TOC, COD, BOD, and standard SS that can be treated by the WWTP.

The seven model factories already have pretreatment facilities for heavy metals or oil. However, the facilities of four factories are insufficient and require new installation. The details are comparatively simple and the cost is not high.

The cost per flow rate is shown at the lower part of Table 1.2.1. Note that the sewage fee given to us for this survey, 160 SIT/m³, is not definite.

The figures in () in 4, Total Treatment Cost, of Table 1.2.1, are figures for reference in case the interest becomes 1.0% due to financial aid or other policies. If the interest is reduced or exempt, there will be cases in which the wastewater-treatment cost will be on a par with the charge for discharge into sewers.

As a conclusion of the studies of the model factories, if the WWTP emission standards are applied with no change, it will be economically more advantageous for those factories to discharge into the WWTP than directly into rivers. The same holds true for the secondary and tertiary factories.

Table 1.2.1 Cost Comparison of Waste Water Treatment for Model Factories

	K-1 SVILA	K-2 MARLES	K-3 ARNAL	K-4 PIVOVARNA	K-5 VINAG	K-6 KOSAKI	K-7 MLEKARNA
1. Volume of waste water m ³ /d	1,500	304	150	720	90	400	474
2. Operation condition, d/y	252	239	256	216	251	250	365
3. Equipment cost SIT ①+②+③+④+⑤	506,050,000	92,779,000	243,317,000	189,573,000	81,214,000	296,076,000	148,120,000
①Equipments	176,142,000	35,731,000	124,966,000	49,549,000	27,969,000	122,625,000	60,133,000
②Equipment installation & Electrical works	88,743,000	20,383,000	56,725,000	23,119,000	15,294,000	46,224,000	32,774,000
③Civil engineering & Building works	227,113,000	30,000,000	48,125,000	109,750,000	33,125,000	111,390,000	48,125,000
④Trial run cost	3,150,000	1,890,000	1,463,000	3,555,000	1,238,000	3,150,000	2,475,000
⑤Design cost	5,625,000	4,725,000	7,988,000	3,600,000	3,488,000	5,062,000	4,613,000
4. Total treatment cost ⑥+⑦+⑧ 合計, SIT/m ³	548(476)	237(180)	1,291(1,006)	223(168)	711(550)	565(432)	208(170)
⑥Depreciation	64	67	370	52	179	151	45
⑦Interest	80(S)	64(7)	317(32)	61(6)	179(18)	148(15)	43(S)
⑧Running Cost	404	106	604	110	353	266	120
5. WTP Discharge rate ①+② SIT/m ³	170	223	160	160	164	160	188
① Sewage System	160	160	160	160	160	160	160
② Pretreatment	10	63	-	-	4	-	28

Note: Values in () show in case of 1.0 % interest.

1.2.4 Pretreatment for Reducing Pollutant Load

The planned WWTP capacity seems fully adequate to treat the present load. However, we believe consideration must be given to a load increase in the future and the growing of "those-who-benefit-should-pay" consciousness among users. For this, we think a fee system in accordance with the pollutant load or additional control of emission standards may be applied.

From the above viewpoint, we conducted wastewater analysis surveys, preliminary treatment tests and equipment design studies on pretreatment for reducing the main pollutant items, COD, BOD, dye waste of textile industry, and SS. These surveys, tests, and studies were conducted not only on the seven model factories, but also on the seven secondary factories and six tertiary factories.

As pretreatment facilities for reducing pollutant load, we studied coagulating sedimentation, coagulating pressure flotation, and other chemical treatment processes, and anaerobic, fixed bed, and other biological treatment processes suitable for high BOD loads.

For designing the pretreatment facilities, we did not establish target water qualities as the preconditions. Instead, we made it our main objective to accumulate and present information regarding what sort of water quality could be obtained, at what cost, and with what type of treatment, etc.

We describe "the pretreatment required for reducing the pollution load" of each factory of Part II and the details and results of the respective studies.

Table 1.2.2 summarizes the treatment processes, equipment costs, treatment costs, and the anticipated water quality after treatment of the pretreatment facilities studied for each factory. This Table gives information which will be useful for the WWTP when a fee system based on pollutant load or extra control of emission standards is studied.

Note that for harmful substances, pretreatment is imperative, and unique equipment and technology for satisfying the emission standard for each of these substances have now been standardized. Pretreatment facilities for treating harmful substances are already installed at the factories of Maribor City. Details on the difficulties of harmful substances and information about their elimination technology are given in Part III of this report.

Table 1.2.2 Examples of Applicable Pretreatment System for Each Factory

NO.	Factory Name	Quantity			Wastewater Quality			Pretreatment Equipment			Water Condition after Pretreatment		
		m ³ /d	COD mg/L	BOD mg/L	SS mg/L	Case	Process	Const. cost/1000SIT	Pretr. Cost/m ³ (l)	Quantity m ³ /d	COD mg/L	BOD mg/L	SS mg/L
M-1	SVILA Textile	1500	500	300	40	Case-1 Coa & Sedi	154.400	147	1.500	300	200	30	
		1500	500	300	40	Case-2 Coa & Sedi	55.000	103	1.500	200	100	100	
		1500	500	300	40	Case-3 Coa & Sedi	43.200	82	1.500	200	100	100	
M-2	MARLES Furniture	298	141	60	36	Case-1 Coa & Sedi	23.955	63	298	117	56	22	
		298	141	60	36	Case-2 Case1+Aero	44.000	174	298	28	1	6	
M-3	ARMAL Metal	372	20	8	0	-	-	-	372	20	8	0	
M-4	PIVOVARNA Food	515	890	260	76	Case-1 Anaerobic	39.300	117	515	249	74	76	
		515	890	260	76	Case-2 Aerobic	35.960	61	515	400	74	113	
		515	890	260	76	Case-3 Aerobic	43.500	71	515	400	74	113	
M-5	VINAG Food	90	750	510	90	Case-1 Aerobic	24.630	226	90	220	100	172	
M-6	KOSAKI Food	400	1500	1000	1000	Case-1 Oil Sepa.	0	0	400	1.500	800	600	
		400	1500	1000	1000	Case-2 Coa & Flo	50.000	140	400	800	400	30	
		400	1500	1000	1000	Case-4 Case2+Aero	80.000	188	400	250	100	30	
M-7	MLEKARNA Food	476	2443	866	414	Case-1 Neutra.	13.605	28	476	2.443	866	414	
		476	2443	866	414	Case-2 Coa & Flo	19.000	65	476	1.397	464	13	
		476	2443	866	414	Case-3 Case2+Anaer	40.000	158	476	446	141	38	
		476	2443	866	414	Case-4 Case2+Aero	36.000	106	476	1.032	473	39	
S-1	MERINKA Textile	1200	650	150	37	Case-1 Coa & Sedi	143.800	152	1.200	350	80	30	
S-2	TABOR Textile	1200	100	25	30	Case-1 Coa & Sedi	50.000	265	400	100	25	30	
		1200	100	25	30	Case-2 Coa & Sedi	18.000	55	400	100	25	30	
S-3	MTT Textile	3000	340	140	340	Case-1 Coa & Sedi	50.000	18	3.000	330	130	340	
S-4	TSP Textile	200	400	200	40	Case-1 Coa & Sedi	40.000	225	200	250	80	30	
		200	400	200	40	Case-2 Coagulate.	10.000	55	200	300	120	100	
S-5	METALNA Metal	222	146	62	32	Case-1 Coa & Sedi	24.000	95	222	128	59	30	
S-6	SLOSAD Food	35	4300	1400	500	Case-1 Anaerobic	12.000	140	35	2.150	700	250	
S-7	INTES Food	126	212	82	67	-	-	-	126	212	82	67	
A-1	TVT Metal	620	25.6	10.1	33.2	-	-	-	620	26	10	33	
A-2	SVETILKE Metal	130	70	5	30	-	-	-	130	70	5	30	
A-3	PRIMAT Metal	109	161	46	17	Case-1 Coa & Sedi	10.000	64	109	137	41	7	
A-4	ELKO Metal	155	47	5	18	-	-	-	155	47	5	18	
A-5	HENKEL Chemical	651	740	400	200	Case-1 Anaerobic	39.300	50	651	340	180	200	
A-6	SWATY Chemical	149	130	50	47	-	-	-	149	130	50	47	

1.3 Pretreatment by Industries

We summarize herewith, by main industries of Maribor City, the results of studies on the state of their effluent and pretreatment. Our detailed studies for each factory are shown in the part II. As prescribed above, the results of our studies on pretreatment are shown in the Table 1.2.2.

1.3.1 Textile/Dyeing Industry

(1) Positioning of business category

There are only five textile companies with plants in Maribor City, but they are important because their effluent amounts to 20% of the total sewage.

Each of the five companies has its own characteristics, so it is difficult to make a sweeping statement. However, problems such as colored effluent and large fluctuation in drainage volumes and pollutant loads are common to all five.

(2) Likelihood of discharge into rivers

Since a strict emission standard has been set separately for the textile industry, the costs of wastewater treatment and equipment in this case rise far above the costs for plants discharging wastewater into sewage. As can be seen from Table 1.3.1, at present, two companies are discharging directly into rivers. S-2 Tabor is already more or less meeting the emission standards.

(3) Infringements of WWTP emission standards

In the emission standard for discharging into WWTP, there are controls on temperature, pH, heavy metals, oil content, sulfur content, and halogen. All of these concentrations in the wastewater of the five companies, except some of the pH levels which have to be monitored carefully, are well within the existing standards.

(4) Methods of reducing pollution load

Coloring of effluent is a form of pollution unique to the textile industry. The coloring fluctuates greatly depending on the time, but as a whole, absorbance of the strictest controlled value of 620nm is estimated to be 30 or less. This falls to 1/10 when it is diluted five times with other sewage and halved again by the WWTP. In other words, it will meet the emission standard. The measured value of color by absorbance, in the light range, is more or less proportionate to concentration. If coagulating sedimentation is adopted by WWTP, the color will be reduced to a much greater degree. Azotic dyes, which are frequently used in synthetic textiles, are known to be efficiently decomposed by anaerobic biological treatment. If the WWTP adopts the anaerobic biological treatment process, the problem of color will be alleviated even further. According to the above reasoning, pretreatment for the purpose of eliminating color at each factory will not be required.

However, in the future, there is a possibility that the WWTP may have to demand that textile factories which discharge colored wastewater carry out the necessary decoloring pretreatment so that the wastewater meets the emission standard for discharge into rivers. We list below the processes that are generally used for decoloring the wastewater of dyeing factories. ① Activated carbon adsorption: Decoloring by the biochemical adsorption property of activated carbon. ② Ozone treatment: Decoloring by the oxidative decomposition property of ozone. ③ Coagulating-sedimentation treatment: By mixing inorganic and organic flocculants, the coloring substances are coagulated into floc. ④ Fenton treatment: Decoloring by processes such as the oxidative decomposition of hydrogen peroxide in the presence of an iron catalyst.

Table 1.3.1 Wastewater of Textile Industries

Company	M-1	S-1		S-2		S-3		S-4		Emission Standard	
		SVILA	MERINKA	TABOR	TABOR	MITT	MITT	TSP	TSP	Discharge to River	Discharge to Sewage
Material	Rayon	Wool	PET	PET	PET	PET	PET	PET	PET		
Quantity m ³ /d	1,587	1,200	1,250	1,250	3,000	3,000	3,000	343	343		
Discharge to	River	Sewage	River	River	Sewage	Sewage	Sewage				
Sampling date	Jun.05.1996	Dec.10.1996	Dec.08.1996	Dec.08.1996	Dec.16.1996	Dec.16.1996	Dec.16.1996	Dec.05.1996	Dec.05.1996		
pH	7.8 - 10.0	8.2	7.9	7.9	11.3	11.3	11.3	8.8	8.8	6.5 - 9.0	6.5 - 9.5
SS mg/L	< 30	37	< 30	< 30	340	340	340	32	32	80	-
Color											
α (436nm) m ⁻¹	42 / 14	37	2.6	2.6	17	17	17	31	31	7	7
α (525nm)	33 / 15	30	1.9	1.9	14	14	14	30	30	5	5
α (620nm)	25 / 18	25	1.5	1.5	13	13	13	27	27	3	3
T-N mg/L	13.5 / 7.3	24	23	23	22	22	22	14	14		
T-P mg/L	0.3 / 8.7	3.1	1.3	1.3	0.5	0.5	0.5	0.7	0.7	1.0	-
COD _{Cr} mg/L	140	650	34	34	340	340	340	360	360	200	
COD _{Mn} mg/L		300	15	15	120	120	120	190	190		
BOD ₅ mg/L	50	150	25	25	140	140	140	100	100	30	
T-Fat mg/L	5	30	30	30	12	12	12	19	19		
mineral oil										10	20

A good rate of removal of about 90% can be obtained from both ① activated carbon adsorption and ② ozone treatment. Efficiency is poor if there is COD and SS, so these processes are used as the final treatment after COD and SS are removed. Treatment costs depend on concentrations, but generally speaking, they are very high.

Since the controlled value is extremely strict when the color of wastewater is regulated in Japan, one of these two methods is used.

With ③ coagulating-sedimentation treatment, there are various cases that can occur depending on the properties of the wastewater. Sometimes good decoloring is achieved with just inorganic flocculants, and sometimes decoloring becomes effective by adding a dicyandiamide-based organic decoloring flocculant. In special cases, the flocculant cannot decolor because it does not form floc. Generally speaking, this process is frequently used in Japan for pretreatment of waste dyeing water as it can also remove BOD, COD, SS, and especially P, while removing the color.

④ Fenton treatment can decolor very well if the conditions are right. It is also effective for changing conspicuously bright colors into inconspicuous colors such gray or white. The reaction pH condition is on the acidic side of about 3.5. Therefore, the process is quite expensive because of the costs for the pH-adjusting acid, the neutralizing alkali, and the oxidizing agent, hydrogen peroxide. Also, unless coagulation is carried out, there is the problem of an overall increase in pollutants in spite of the successful decoloring of the wastewater.

5) Coagulation-treatment test

As mentioned before, the most usual and economical pretreatment process is the coagulating-sedimentation treatment. Moreover, this treatment becomes even more economical if only the thick wastewater after dyeing is treated. However if only the dye liquid is separated, there are times when the coagulant does not form floc. In most cases, pH neutralizing and decoloring is done when the dye liquid is mixed with the 1st washing water, and flocculation is more likely to take place at such times. Also, coagulating treatment may be difficult for wastewater which contains a lot of surface-active agent, so care is required.

Although the coloring must be decreased, one method which can be used when there is a margin in SS is to floc the color with the coagulating treatment and then discharge the water without any sedimentation separation. Since this method does not require the installation of a dehydrator, no cost or labor is involved. It is an especially convenient method that can be adopted when discharging wastewater into sewers.

In this survey, we carried out coagulating-sedimentation tests on the wastewater of five companies and additionally conducted a Fenton treatment jar tests on some samples. When actually designing pretreatment facilities in the future, further wastewater treatment tests should be carried out to fully check the conditions and effectiveness of the treatment.

1.3.2 Food Industry

We studied four kinds of food industry factories. The total water volume of the four factories comprises about 10% of the total for the 20 factories investigated in this survey. All of them have high pollutant loads, but those of BOD and COD are by far the highest, each taking up about 40% of the share on average. Following is a summary of the respective items by business category.

1) Beer brewery (M-4, STAJERSKA)

(1) Positioning of business category

This is the only brewery in Maribor City. It is said to have the second largest output in Slovenia, but the output is relatively small.

The ratio of its pollution load to that of the 20 factories is 3.6% by water volume, 6.3% by COD, and 4.3% by BOD. The main source of wastewater is the bottle-washing machinery. Because the equipment is old, the wastewater volume is large compared to the quantity of production.

(2) Likelihood of discharging into rivers

As emission standards for discharging into rivers are strict (especially for T-P, which is restricted to 2 mg/L), the treatment cost comes to 223 SIT/m³. Since the factory is also located quite a distance from a river, the prohibitive cost of laying a pipeline makes it advantageous for the brewery to discharge into the WWTP at present, and the possibility of discharge into rivers remains slim.

(3) Infringements of WWTP emission standards

From the result of our survey, the water quality of the wastewater at the final stage is within the WWTP emission standards and there is no particular problem.

(4) Methods of reducing pollutant load

Generally, physico-chemical treatment (coagulating-sedimentation method) is mostly used for the pretreatment system for reducing pollutant load. Although this treatment will remove SS from this wastewater, it is not very effective in removing soluble organic pollutants. Therefore, we studied the use of the biological treatment method, formulating conceptual designs of three cases; i.e., Case 1 for separating thick wastewater and subjecting it to anaerobic treatment, Case 2 for aerobic treatment, and Case 3 for further aerobic treatment of the general drainage.

The result was that the treatment cost of Case 2 was the lowest at 61 SIT/m³. This reduction was enabled by our selection of the biofilm-filter process, a process which removes high loads, for the aerobic treatment. Although the use of such a process increases electricity costs, it reduces equipment costs by a considerable margin. Another factor for the low treatment cost in Case 2 was the absence of any need for a heat source to heat the raw wastewater. The order by treatment cost was Case 2 < Case 3 < Case 1.

Also, the anaerobic treatment became the most expensive because the heat source cost for heating the raw wastewater took up a large share of the treatment costs (the anaerobic treatment method becomes advantageous when organic pollutant concentrations are high).

Note that the quantity of excess sludge that is created in the aerobic treatment tank is small. Therefore, in order to keep equipment costs as low as possible, it is better to discharge the sludge into the WWTP together with the treated wastewater than to install sludge-treatment facilities. However, the SS concentration in the treated wastewater will increase slightly due to the added amount untreated sludge.

2) Winery (M-5, VINAG)

(1) Positioning of business category

This is a winery located in the center of Maribor City. The squeezed juice is brought to the winery by tank trucks, stored in underground tanks and allowed to mature. The matured wine is then bottled and shipped out.

The scale of production is small and its ratio of pollution load to that of the 20 factories is only 0.6% by water volume, 0.9% by COD, and 1.5% by BOD.

(2) Likelihood of discharging into rivers

As with the brewery, the standards for discharging into rivers are strict (especially for T-P, which is restricted 2mg/l), so the treatment cost is a high 711 SIT/m³. Major factors for this relatively high cost of treatment per unit volume are that the amount treated is small, and that the winery stays in operation on only a limited number of days per year (216 days/year).

Therefore, at present, it would be advantageous to discharge into the WWTP. Also, this factory is located in the heart of Maribor City, so it would be extremely difficult to lay a pipeline to a river. Thus, discharge into rivers is a virtual impossibility.

(3) Infringements of WWTP emission standards

Neutralizing facilities are already installed and the treated water quality is within WWTP emission standards, so there is no particular problem. The wastewater generated by the factory is separated into acid and alkaline wastewater and stored in separate tanks. Since there is a possibility of reducing, to a certain degree, the amount of the neutralizing agents being currently used if the two liquids are mixed and discharged, there is room for study on this point.

(4) Methods for reducing pollutant load

With regard to pretreatment facilities for lowering the pollutant load by the physico-chemical treatment method (coagulating sedimentation), SS can be removed using the same method applied by the beer producer. However, as not much can be expected with regard to removal of soluble organic pollutants, we studied the biological treatment method.

There are two biological treatment methods; i.e., the aerobic and anaerobic methods. However, if the anaerobic method is selected, a heating source for heating this wastewater will be required since its organic pollutants concentration is low and only a small amount of bio-gas will be generated. Thus, in this case, the cost of treatment by the anaerobic method will become greater than that for treatment by the aerobic method.

Therefore, the low-cost biofilm-filter process is more suitable as the pretreatment system since, in spite of its increased electricity cost, it will remove high loads without causing bulking.

Note that the quantity of excess sludge created in the aerobic treatment tank is small. Therefore, in order to keep equipment costs as low as possible, it is better not to install sludge-treatment facilities, and to instead discharge the sludge into WWTP together with the treated wastewater. However, the SS concentration in the treated wastewater will increase slightly due to the added amount of untreated sludge.

3) Meat producer (M-6, KOSAKI)

(1) Positioning of business category

This enterprise is the only slaughterhouse in the Maribor area. It produces fresh beef and pork. The plant is located very close to the Drava River. Since the factory works only in the daytime, the generation of its wastewater is concentrated during that time zone. Its pollution load is high, comprising 3.2% of the total by water volume, 9.5% of the total by COD, and 15% of the total by BOD.

(2) Likelihood of discharge into rivers

The factory is close to a river, so we believe the cost of installing a pipeline will be cheap. However, since the emission standards are strict, the cost of treatment becomes a high 565 SIT/m³. Thus, discharge into the WWTP is far more advantageous.

(3) Infringements of WWTP emission standards

The existing oil-water separation equipment is functioning very well and the treated water quality is within the WWTP emission standards, so there is no particular problem.

(4) Methods of reducing pollutant load

As the pretreatment facility for reducing pollutant loads, we studied the coagulating-pressure-flotation method, and a physico-chemical treatment process. The reason for opting for this method instead of the coagulating-sedimentation method is that it is suitable for removing oil content which, by nature, has a tendency to float. The sludge separated by coagulating pressure flotation contains a large amount of oil. We compared the disposal of this sludge with and without dewatering it. The latter is naturally cheaper in equipment and running costs. However, there are some indefinite points in this method regarding how the sludge can be received without dewatering and what the cost will be.

When BOD and COD have to be reduced further, biological treatment is applied. Anaerobic biological treatment is frequently employed when the pollutant load is high, but it does not work so well when the oil content is high. Anaerobic biological treatment becomes advantageous after coagulating-pressure-flotation treatment has been carried out since the load is reduced. As the SS will have decreased, fixed-bed biological contact aeration treatment would be most suitable. As only a small quantity of excess sludge is created in the aerobic treatment tank, it is discharged as is without being separated.

The pollutant load is greatly reduced by the coagulating-pressure-flotation treatment, but the treatment cost is about the same as the standard sewage fee. Pretreatment for the purpose of reducing load will not become economically viable unless the progressive fee based on pollutant load becomes about twice the standard fee. In other words, unless there is a system of additional controls on the emission standard, it will be more economical to pay the sewage for as long as the additional fee is small.

4) Dairy products producer (M-7, MLEKARNA)

(1) Positioning of business category

MARIBORSKA MLEKARNA p.o is the only dairy products producer located in Maribor City. Of the 756m³/day used by its factory, 280m³/day is recycled for use as boiler water and refrigeration water. Thus, the net volume of water

supplied is 476m³/day. The wastewater volume is the same as the supplied 476m³/day. Among the 20 factories, it comprises 4.1% of the total industrial water and 1.3% of overall sewage water.

The cause of pollution of the wastewater is loss due to washing of dairy products and the acid and alkaline washing agents. In manufacture of city milk and cream, there is CIP wastewater, and in manufacture of cheese, there is whey wastewater and loss of cheese. The latter manufacturing wastewater in particular has high concentrations of both COD and BOD. Also, the main cause of N and P in the wastewater is washing agents. The only way to lower the pollution load of wastewater in the production of cheese is to improve the shop work methods and discharging process so that loss of whey and cheese is kept to the minimum.

(2) Likelihood of discharging into rivers

The cost of treating wastewater with pretreatment equipment for neutralizing wastewater and discharging it into the WWTP (Case 1) is 205 SIT/m³. Since the cost of wastewater treatment with pretreatment equipment for discharging into rivers is 208 SIT/m³, if improvement of work methods to prevent the loss of cheese is successful, it will be cheaper to discharge into the WWTP. However, because the cost of treating wastewater with pretreatment equipment for reducing the pollution load is higher than the cost of pretreatment with equipment for discharging into rivers, there is the possibility that wastewater-treatment equipment for discharging into rivers will be installed.

The COD of wastewater from dairy product manufacturing can be reduced to a low level by biological treatment which runs on low load. For wastewater-treatment equipment for the purpose of discharging into rivers, we took into consideration the prevention of bulking and proposed the anaerobic/aerobic (AO) system. However, COD is still left in water that is treated biologically, of which 40 to 50% is humic acid-like substances which do not have biodegradation properties. Due to this, the recycling of treated water is said to be difficult for reasons of economy and safety rather than problems of technology.

(3) Infringements of WWTP emission standards

Water quality conditions that, depending on the discharge conditions of the wastewater, may possibly infringe on the WWTP emission standards are pH and oil content. However, if the loss of cheese can be prevented, oil content will no longer pose any potential problem, and the only concern will be the pH.

(4) Methods of Reducing Pollution Load

We proposed as Case 2, pretreatment equipment for the coagulating pressure flotation method which removes oil content and SS as well as neutralizes wastewater. This was on the assumption that the effectiveness of preventing the loss of cheese would be low.

Furthermore, in order to reduce the BOD and COD pollution load due to organic materials, we proposed as Case 3, the addition of anaerobic biological treatment, and, as Case 4, the addition of biofilm-filtering treatment. The removal rate of the biofilm-filtering method is low but both the cost of its facilities and treatment are low.

1.3.3 Chemical Industry

(1) Positioning of business category

The chemical industry of Maribor City consists only of factories that use chemicals as raw materials. In the current survey, we studied two factories. One is a maker of household chemicals who prepares the chemicals and then puts them into containers. Effluent from the washing of the containers is produced when changing over from the manufacture of one product to another. The other factory is a maker of grindstones that uses binders and other chemical materials.

(2) Likelihood of discharging into rivers

Both are discharging into sewers. For these factories also, there is no likelihood of discharge into rivers in the future.

(3) Infringements of WWTP emission standards

The former factory has a high pollution load but at present it meets the WWTP -- emission standards. In the latter, the pollution load was low in all of its effluent but that produced from a grindstone material mixer. However, the effluent from the mixer amounts only to a few cubic meters a day, and even by itself, it satisfies the WWTP's emission standards.

(4) Methods of reducing pollutant load

In order to cope with the future sewage fee based on COD, BOD and other loads, we studied the following pretreatment systems for treatment of the high pollution loads at the former factory.

Recovery and reuse:	Closed system
Separation removal:	Concentrated separation Coagulating separation
Decomposition:	Chemical decomposition Ozone treatment Anaerobic treatment

① In the case of powdered detergent, a completely closed system is possible with just a little more effort. At present, city water is being replenished in a recycled water tank. However, by controlling the replenished water at a lower level than the present one, there is room, at the time of changing over, etc., for absorbing the 1 to 2m³ of recycled water that is overflowing irregularly but constantly.

② As the wastewater volume is a large 180m³/day, concentrated separation is difficult when producing cosmetics. However, in the case of the hair dye being planned, a wastewater volume as small as 1m³/day can be realized using this method. This method is also effective for coping with oil content, which is essential. Unlike the case with powdered detergent, reuse of the concentrated content is believed to be difficult for hair dye products because of their delicate function and color. Normally, the content is evaporation-dried and incinerated or otherwise disposed of as solid waste. If there is ample heat, the concentrated liquid can be mixed with boiler fuel and burnt off.

③ Coagulation treatment of the wastewater is difficult in the case of cosmetics and hair dyes. A wide range of conditions was tested by jar tests, but the inorganic coagulants formed no floc at all.

④ Oxidative decomposition by the Fenton treatment showed a distinct change in color, but the measured values of absorbance and COD did not drop. Moreover, the method is not suitable because of problems such as high cost and the increase in overall pollutant load it causes.

⑤ As seen from the test results of the Fenton treatment, decomposition by ozone treatment is also difficult.

⑥ Anaerobic biological treatment is a method worth considering for wastewater treatment of cosmetics. If the treatment results are good, we believe it can also be applied to the wastewater treatment of hair dyes.

Based on the above study, for the pretreatment system, we planned the anaerobic biological treatment mainly for cosmetics wastewater. This has the aim of removing the extremely high COD, BOD and fat. The pH of the raw water is about neutral, and as there is no coarse SS, it is heated as is to about 35°C and treated in an anaerobic biological reaction tank. We made the reaction tank a fixed-bed type. To conserve the heat source for heating, the treated water and the wastewater were liquid-liquid heat exchanged, and heat that was insufficient was augmented by steam. The gas generated in the reaction tank can be recovered as a heat source for the boiler.

The treated water quality can be lowered to a COD of about 1/4 and BOD of about 1/5. The treatment cost comes to 117 SIT/m³ for 300m³ of cosmetics wastewater. If calculated to the total wastewater volume of 700m³, inclusive of other wastewater, the cost comes to 50 SIT/m³.

1.3.4 Machine & Metal Processors

The sources of wastewater of the machine and metal processors can be largely divided into the metal processing, surface treatment (including plating), and painting processes. Also, since MARLES POHISTVO, a company in the business of making wooden furniture, also has a painting process, we decided to include that business category in this section.

1) Positioning of business category

The primary six companies engaged in the machine and metal processing business in Maribor City are ARMAL (manufactures water faucets, flush toilet fixing outlets, castings for heating and cooling, etc.), METALNA Group (manufactures all types of hydroelectric power equipment other than turbines, construction and transportation equipment, and industrial machinery), TVT Group (manufactures and repairs rolling stock), ELEKTROKOVINA SVETILKE (manufactures lighting equipment, electric motors, and generators), PRIMAT (manufactures safes and steel furniture), and ELKO ELEKTROKOVINA (manufactures motors and pumps). There is an additional company, the TAM Group, which manufactures automobiles, but because it was impossible to visit and survey the factory and collect data, we will not refer to it here.

The machine and metal processing business as a whole consumes a total of 3,431m³ of water a day, of which 1,789m³/day is recycled. The total volume of wastewater generated, 1,598m³/day, comprises 13.8% of the total industrial wastewater and 4.4% of overall sewage.

(1) ARMAL

Total water consumption is 492m³/day, of which 120m³/day is being recycled as washing water, so the net volume of water supplied to the factory is 372m³/day. The wastewater volume is equal to the water consumption of 372m³/day, accounting for 3.2% of total industrial wastewater and 1.0% of overall sewage.

(2) METALNA Group

Total water supplied and total water consumed are the same, at 212m³/day. The wastewater volume is equal to the water consumption of 212m³/day, accounting for 1.8% of total industrial wastewater and 0.6% of overall sewage.

(3) TVT Group

Of the 2,169m³/day consumed, 1,549m³/day is recycled as boiler water, washing water, and cooling water, so the net volume of water supplied to the factory is 620m³/day. The wastewater volume is equal to the water consumption of 620m³/day, but 16m³/day of that volume is water leakage, so the actual volume is 600m³/day, accounting for 5.4% of total industrial wastewater and 1.7% of overall sewage.

(4) ELEKTROKOVINA SVETILKE

Of the total 250m³/day consumed, 120m³/day is being recycled as cooling water, so the net volume of water supplied to the factory is 130m³/day. The wastewater volume is equal to the water consumption of 130m³/day, accounting for 1.1% of total industrial wastewater and 0.4% of overall sewage.

(5) PRIMAT

Total water consumption and water supplied are the same, at 109m³/day. The wastewater volume is equal to the water consumption of 109m³/day, accounting for 0.9% of total industrial wastewater and 0.3% of overall sewage.

(6) ELKO ELEKTROKOVINA

Total water consumption, water supplied, and wastewater volume are all the same, at 199m³/day. However of this total wastewater volume, 44m³/day is being treated at a joint wastewater-treatment plant and the balance of 155m³/day is being discharged. Therefore, the wastewater volume accounts for 1.3% of total industrial wastewater and 0.4% of overall sewage.

(7) MARLES POHISTVO

MARLES POHISTVO is the only company in Maribor City which makes wooden furniture. Of the 519.7m³/day of water consumed, 222m³/day is being recycled as boiler water, so the net volume of water supplied to the factory is 297.7m³/day. The wastewater volume is equal to the net volume of water supplied of 297.7m³/day, accounting for 2.6% of total industrial wastewater and 0.8% of overall sewage.

2) Likelihood of discharging into rivers

The only company with the likelihood of discharging into rivers is the wooden furniture manufacturer, MARLES POHISTVO.

(1) ARMAL

The wastewater that must be treated is waste cutting oil, waste perchloroethylene (PEC), and plating wastewater. The waste cutting oil is recovered and disposed of as industrial waste by a contractor. The waste PEC is recovered, and, after its impurities are removed with solvent regeneration equipment, it is reused as PEC. The plating wastewater is treated in a wastewater-treatment plant. Therefore, there is no need to study the likelihood of discharge into rivers.

(2) METALNA Group

The wastewater that must be treated is waste cutting oil and the painting booth waste washing water. The waste cutting oil is recovered and is disposed of as industrial waste by a contractor. The painting booth waste washing water has a high COD concentration and contains organic compounds with anti-biodegradation properties, but the frequency of occurrence of the wastewater is extremely small. Due to this, the treatment of wastewater for the purpose of discharging into rivers would be mainly on domestic wastewater, thus making the installation of comprehensive wastewater-treatment facilities uneconomical. Therefore, there is no likelihood of the wastewater being discharged into rivers.

(3) TIV Group

There is no discharge of wastewater that would have to be treated prior to discharge into rivers. The plating wastewater is treated by treatment equipment and the car waste washing water is recycled. Therefore there is no need to study the likelihood of discharge into rivers.

(4) ELEKTROKOVINA SVEFILKE

The wastewater that must be treated is being treated at a joint wastewater-treatment plant. Therefore, there is no need to study the likelihood of discharge into rivers.

(5) PRIMAT

The wastewater that must be treated for discharge into rivers is from the painting booth washing water and the pre-painting treatment. The pollution concentration of the pre-painting treatment wastewater is low. Also, by changing the painting method from the current booth water washing system to a dry powder coating system, wastewater will no longer be produced. Due to this, the treatment of wastewater for the purpose of discharge into rivers would be mainly on domestic wastewater, thus making the installation of comprehensive wastewater-treatment facilities uneconomical. Therefore, there is no likelihood of the wastewater being discharged into rivers.

(6) ELKO ELEKTROKOVINA

The wastewater that must be treated is being treated in a joint wastewater-treatment plant. Therefore, there is no need to study the likelihood of discharge into rivers.

(7) MARLES POHISTVO

The cost of treating wastewater with wastewater-treatment facilities for the purpose of discharge into rivers is cheaper than the cost of treating wastewater with pretreatment facilities for reducing the pollutant load. Thus, there is a good likelihood of the wastewater being discharged into rivers. The wastewater-treatment equipment for the discharge of wastewater into rivers will process the painting booth waste washing water and the gluing machine waste washing water with coagulating sedimentation. The treated water will then be mixed with domestic wastewater and treated by the contact aeration method. Subsequently, it will be subjected to further coagulating sedimentation treatment to remove P.

3) Infringements of WWTP emission standards

The water quality items of the total wastewater discharged that infringe on the WWTP's emission standards are the pH which results from the pre-painting treatment wastewater at PRIMAT, and the heavy metals and organic compounds

which result from the painting booth waste washing water at METALNA, PRIMAT, and MARLES POHISTVO.

(1) ARMAL

Basically there are no water quality items in the overall wastewater that infringe on the WWTP's emission standards. However, heavy metals somewhat exceeding the standard are detected in the water treated by the plating wastewater treatment facilities. Some of the conceivable causes for this are ① inadequate pH adjustment, ② creation of complex chemicals due to mixed discharge of wastewater, and ③ outflow of SS containing hydroxides of heavy metals. Accordingly, appropriate countermeasures are ① reappraisal of the chemicals being used, ② change of operating conditions, ③ separate discharge or separate treatment of the wastewater, ④ use of appropriate high-molecular coagulants, ⑤ installation of a filtering tower, ⑥ installation of a chelate-resin tower, etc. It is hoped that the causes be determined and appropriate measures be taken to improve the treatment into more rational systems.

(2) METALNA Group

The heavy metals and organic compounds contained in the wastewater, when painting booth waste washing water is discharged, infringe on the WWTP's emission standards.

(3) TVT Group

Basically there are no water quality items in the overall wastewater that infringe on the WWTP's emission standards. However, heavy metals somewhat exceeding the standard are detected in the water treated by the plating wastewater treatment facilities. Some of the conceivable causes of this are ① inadequate pH adjustment, ② creation of complex chemicals due mixed discharge of wastewater, and ③ outflow of SS containing hydroxides of heavy metals. Accordingly, appropriate countermeasures are ① reappraisal of the chemicals being used, ② change of operating conditions, ③ separate discharge or separate treatment of the wastewater, ④ control of operations by means of equipment, ⑤ use of appropriate high-molecular coagulants, ⑥ improvement of reaction tank into a completely mixed type, ⑦ installation of a filtering tower, ⑧ installation of a chelate-resin tower, etc. It is hoped that causes be determined and appropriate measures be taken to improve the treatment into more rational systems.

(4) ELEKTROKOVINA SVETILKE

The water quality items that could possibly infringe on the WWTP's emission standards are the oil content and heavy metals resulting from the waste cutting oil, and the heavy metals and organic compounds resulting from the painting booth waste washing water. However, these wastewaters are being treated in a joint treatment plant, so there are no water quality items that infringe on the WWTP's emission standards.

(5) PRIMAT

The water quality item that could possibly infringe on the WWTP's emission standards is the pH resulting from the pre-painting treatment wastewater. At present, there are heavy metals and organic compounds that result from the painting booth waste washing water, but these problems will be eliminated by changing the painting process.

(6) ELKO ELEKTROKOVINA

The water quality items that could possibly infringe on the WWTP's emission standards are the oil content and heavy metals resulting from the waste cutting oil, the pH and heavy metals resulting from the alumite processing wastewater, and the heavy metals and organic compounds resulting from the painting booth waste washing water. However, these wastewaters are being treated in a joint treatment plant, so there are no water quality items that infringe on the WWTP's emission standards.

(7) MARLES POHISTVO

The water quality items that infringe on the WWTP's emission standards are the heavy metals and organic compounds resulting from the painting booth waste washing water.

4) Methods of Reducing Pollutant Load Both BOD and COD concentrations of the overall wastewater of the machine and metal processing industry are low so there is no need to install pretreatment facilities for reducing the pollutant load.

Note that at MARLES POHISTVO, the wooden furniture maker, there is painting booth and gluing machine waste washing waters which, although small in volume, have high concentrations of both BOD and COD. For this reason, we proposed pretreatment equipment that would treat these wastewaters by coagulating sedimentation, mix the treated water with domestic wastewater, and then treat it by the contact-aeration process.

2. Water Conservation

2.1 Expenses Required for Water and Sewage

Industries bear the following water and sewage expenses for their activities:

① City Water rate	97.4 SIT/m ³
② Sewage rate	58.8 SIT/m ³
③ Local tax on sewage	40.8 SIT/m ³
④ National tax on sewage	16.8 SIT/m ³

In addition to the above, there are expenses that are generated within the business such as the costs of power, maintenance of equipment, labor, etc., but we will not touch on these costs here.

The shipment prices of the products of 12 of the factories subjected to this survey were revealed. We calculated the costs of the water and sewage for these 12 factories and obtained their ratio to the shipment prices of the products. The results are shown in Table 2.1. The following can be seen from that Table.

- ① The average ratio to the shipment prices of the 12 factories is 0.98%, but there is a considerable variation depending on the type of business.
- ② The highest ratio was the textile industry, which came to 2.15%. This is because this industry consumes large volumes of water for its shipment price.
- ③ The lowest ratio was held by chemicals and furniture. The products of these factories are unique so there is no data that can be used for comparisons. However, even when compared to the non-water using industries, machine and metal processing, their ratios are considerably lower. So they may be called non-water using types of factories.

④ Machine and metal processing are typical non-water using industries, but the ratio to the shipment price was 0.82%. This is about 40% of the corresponding ratio in the textile industry, which consumes large volumes of water. This figure is very high when it is compared to that of Japan (about 20%).

⑤ The above ratios are much higher than the corresponding ratios for Japanese factories in the same types of businesses. In the textile industry, for example, the ratio is double, and in the machine and metal-processing industry, it is quadruple.

⑥ For one food factory we could not make clear comparisons with the same type of factory in Japan (brewery) because of lack of adequate data, but we estimate that it is more or less on the same level. At Japanese food and beverage factories, the ratio of use of costly city water is high, so the ratio of the charges for water used and wastewater against the shipment value is high compared to other businesses.

Table 2.1 Ratio of Water Use and Waste Water Discharge Cost to Production (1/3)

Unit of Water Volume: m³/day, Unit Cost of Water: SIT/m³

Industry	Machine & Metal Processing						Sub- Total				
	M-3 ARMAL	A-1 TVT		A-2 SVETILKE		A-3 PRIMAT		A-4 ELKO			
Name of Factory	Water Volume	Unit Cost	Water Volume	Unit Cost	Water Volume	Unit Cost	Water Volume	Unit Cost	Water Volume	Unit Cost	
City Water	372	213.5	517	213.5	130	213.5	109	213.5	155	213.5	1.283
Well Water			103	116.1							103
River Water			620	197.3	130		109		155		1.386
Total	372		620	197.3	130		109		155		1.386
Waste Water is discharged to	Sewerage		Sewerage		Sewerage		Sewerage		Sewerage		
Total Water Cost	19,356		30,584		6,939		5,818		8,273		71,470
1,000 SIT/yea											
Annual Production	2,675		2,000		2,269		885		920		8,749
Million SIT/year											
Cost/Production	0.75		1.53		0.31		0.66		0.90		0.82
Ratio %											

Table 2.1 Ratio of Water Use and Waste Water Discharge Cost to Production (2/3)

Industry		Unit of Water Volume : m ³ /day, Unit Cost of Water : SIT/m ³												
Name of Factory	Food	Textile						S-4 TSP						Sub- Total
		M-4 PIVOVARNA		M-1 SVILA		S-2 TABOR		S-3 MTT		S-4 TSP		S-4 TSP		
Water Source	Water Volume	Unit Cost	Water Volume	Unit Cost	Water Volume	Unit Cost	Water Volume	Unit Cost	Water Volume	Unit Cost	Water Volume	Unit Cost	Water Volume	Unit Cost
City Water	411	116.1	1.587	57.3	93	154.7	538	213.5	36	213.5	667			
Well Water					1.158	57.3	731	116.1	29	116.1	3.505			
River Water							1.707	116.1	278	116.1	1.985			
Total	411		1.587		1.251	54.5	2.976	133.7	343	126.3	6.157			
Waste Water is discharged to			River		River		Sewerage		River		Sewerage			
Total Water Cost 1.000 SIT/yea	11.929		22.734		20.185		99.479		10.833		153.231			
Annual Production Million SIT/year	1.900		2.404		941		3.200		597		7.142			
Cost/Production Ratio %	0.63		0.95		2.15		3.11		1.82		2.15			

Table 2.1 Ratio of Water Use and Waste Water Discharge Cost to Production (3/3)

Industry	Unit of Water Volume: m ³ /day, Unit Cost of Water: SIT/m ³					
	Furniture & Chemical Industry			Total		
Name of Factory	M-2 MARLES	A-5 HENKEL	Sub-Total		Total	
Water Source	Water Volume	Unit Cost	Water Volume	Unit Cost	Water Volume	Water Volume
City Water			339	213.5	339	2,289
Well Water	298	57.3			298	4,214
River Water			312	116.1	312	2,400
Total	298		651	166.8	949	8,903
Waste Water is discharged to	Rive		Sewerage			
Total Water Cost	4,269		27,150		31,419	268,049
1,000 SIT/yea						
Annual Production	1,155		8,317		9,472	27,263
Million SIT/year						
Cost/Production	0.37		0.33		0.33	0.98
Ratio %						

Note:

1. The Costs of Water Use and Waste Water Discharge here mean payment to the outside, and do not include the inside cost, e.g. power, maintenance, labor etc.
2. The costs are estimated on the assumption that necessary charge, tax etc. are paid.

The reasons for the high ratio to the shipment price are believed to be the limited scale of recovery/reuse activities, the low shipment price of the products, and the high unit prices of water and wastewater.

In the case of the textile industry, the water consumption per production quantity is about the same as Japan's, so the reasons are believed to lie in the shipment production price and the unit prices of water and wastewater.

Also in the case of machinery and metal processing, based on the size of the factories, water consumption cannot be said to be excessive. Therefore, the reasons are believed to be same as those of the textile industry. However, as not much recovery/reuse is being done, there is much room to lower the ratio by water conservation.

For reference, we show in Table 2.2 the average water and wastewater unit price by industries for the 20 factories that were studied.

Table 2.2 Average Cost of Water Use and Waste Water Discharge

Unit of Water Volume: m³/day.

Industry	Machine & Metal Processing	Food	Textile	Furniture & Chemical Industry	Total
No. of Factories	6	6	5	3	20
City Water	1,495	1,094	1,092	488	4,169
Well Water		426	4,265	298	4,989
River Water	103		1,985	312	2,400
Total	1,598	1,520	7,342	1,098	11,558
Total Water Cost 1,000 SIT/year	82,786	70,243	180,555	39,372	381,956
Average Water Cost SIT/m ³	207.2	184.9	98.4	143.4	132.2

2.2 Results of Water Conservation Studies on Individual Factories

The possibility of water conservation was studied respectively for the seven model factories, seven secondary factories, and the six tertiary factories (total of 20 factories). The results are shown Tables 2.3 to 2.5.

The quantities of water conserved shown in these Tables are volumes of water that are, in economic terms, fully capable of being conserved based on the present prices for water and wastewater.

The possible water-conservation ratio is 25.1% for the model factories, 14.7% for the secondary factories, and 30.3% for the tertiary factories. The differences in these ratios are due mainly to differences in type of business composition, as described below.

Among the conservation methods, the "installation of a water meter" is mentioned as a basic method for the study of rationalization. Therefore, the amount of water that can be conserved by that method is not listed.

The standard for judging the feasibility of conserving water is the cost of the water consumed and wastewater discharged shown in Table 2.1. This figure will naturally go up if the sewage rate goes up. The result will be that the feasibility of conserving water will widen and the volume of water that can be conserved will most likely increase. However, the costs required for conserving different types of water vary in the following ways.

- ① The cost of conserving water that practically never becomes dirty such as indirect cooling water, air conditioning water, etc., is very cheap.
- ② The cost of conserving water whose wastewater is dirty and whose quality has a direct effect on the quality of the product, for example, product-processing water, washing water, etc., is very high.
- ③ There is a considerable difference between the above two, and the feasibility of conserving water based on cost is clearly divisible into two groups.

From the results of our conservation studies, it became clear that, on the basis of current water and wastewater charges, most of the indirect cooling water and air conditioning mentioned in Group ① would be conservable.

As for conservation plans pertaining to group ②, factories M-1, S-3, and S-4 are looking into the reclaiming the wastewater from the textile industry. Of these, M-1's plan, shown in Table 2.3, is considered to be implementable.

If, in the future, sewage rates go up, we believe that the feasibility of reclaiming the wastewater of the other textile industry factories will improve considerably.

Even if sewage rates go up, the progress which can be expected in the reclaiming of wastewater in industries other than the textile industry is limited since the water volumes are small, the water quality required is very strict (foodstuff, metal finishing process, etc.), the wastewater is very dirty (chemicals), etc.

Table 2.3 Possible Water Conservation for Model Factories

Unit of Water Volume: m³/day

Name of Factory	M-1 SVILA	M-2 MARLES	M-3 ARMAL	M-4 PIVOVARNA	M-5 VINAG	M-6 KOSAKI	M-7 MLEKARNA	Total
City Water			372		71	365	476	1,284
Well Water	1,587	298		411				2,296
River Wat.								
Total	1,587	298	372	411	71	365	476	3,580
Water Conservation Plan	1. Recycling of cooling water for oil cooler by a cooling tower 2. Saving of air conditioning water by flow regulator 3. Reclamation of dying waste water(500)	1. Installation of flow meter 2. Recycling of cooling water by a cooling tower	Cascade use of PEC cooling water to cooling water of a casting plant	1. Installation of flow meter 2. Renewal of bottle washing machines to water saving type	Renewal of bottle washing machines to water saving type	No margin for water conservation	Sufficient control of water use	
Cons. Vol.	593	43	71	120	20		50	897
Cons. Rate%	37.3	13.7	19.1	29.2	28.2		10.5	25.1
Remarks	Possibility of reclamation is fairly difficult.			Possible when the equipment is renewed	Possible when the equipment is renewed			

Table 2.4 Possible Water Conservation for Secondary Beneficiary Factories

Unit of Water Volume: m³/day

Name of Factory	S-1 MERINKA	S-2 TABOR	S-3 MTT	S-4 TSP	S-5 METALNA	S-6 SLOSAD	S-7 INTES	Total
City Water	425	93	538	36	212	20	162	1,486
Well Water	760	1,158	731	29		15		2,693
River Wat.			1,707	278				1,985
Total	1,185	1,251	2,976	343	212	35	162	6,164
Water Conservation Plan	1. Sufficient control of washing water for dyeing 2. Sufficient control of domestic water 3. Prevention of water leak	1. Installation of flow meter to well water 2. Sufficient control of washing water for dyeing	1. Installation of flow meter to well water 2. Recycling of cool. water for compressor 3. Sufficient control of washing water for dyeing 4. Sufficient control of domestic water	No margin for water conservation	Recycling of cooling water	1. Installation of flow meter to well water 2. No margin for water conservation	No margin for water conservation	
Cons. Vol.	182	188	458		80			908
Cons. Rate%	15.3	15.0	15.3		37.8			14.7
Remarks	Estimated Cons. Rate for dyeing water is 15%, for Domestic water is 20%	Average water Conservation rate estimated at 15%.	Estimated Cons. Rate for cooling water is 95%, dyeing is 15%, domestic is 20%		Estimated Conservation rate for cooling water is 80%			

Table 2.5 Possible Water Conservation for Tertiary Beneficiary Factories

Unit of Water Volume: m³/day

Name of Factory	A-1 TVT	A-2 SVETILXE	A-3 PRIMAT	A-4 ELEKO	A-5 HENKEL	A-6 SWATY	Total
City Water	517	130	109	155	339	149	1,399
Well Water	103				312		415
River Water	620	130	109	155	651	149	1,814
Water Conservation Plan	1. Grasping of water usage of small-scale business that use same water source. 2. Reduction of loss of city water	Install individual flow meter at all factories	Recycling use of cooling water for welders	1. Install individual flow meter at all factories 2. Recycling use of cooling water for casting 2. Recycling use of cooling water for molding machines	1. Installation of flow meter to river water 2. Recycling use of cooling water for compressors	Recycling use of cooling water for molding machines	
Cons. Volume	Ca. 100	0	Ca. 60	Ca. 100	Ca. 220	Ca. 70	Ca. 550
Cons. Rate%	16.1	0	55.0	64.5	33.7	47.0	30.3
Remarks	The small-scale business in the group are all independent enterprises.	At present, one flow meter is used for the whole group.		At present, one flow meter is used for the whole group.		As molding machines are scattered in different locations, complete recycling is very difficult.	

2.3 Amounts of Conservable Water by Industry

Table 2.6 shows the amount of water that can be conserved and the conservation ratio for the above 20 factories divided by type of business. The following can be seen from the Table.

① The highest conservation ratio is in the chemical industry followed by machinery and metal processing. Both of these businesses have a high consumption ratio of cooling water. Furthermore, the reason for the high conservation ratio is that recirculation of this water is not being fully carried out.

As mentioned in 2.1, the ratio of the cost of water and wastewater for machinery and metal processing to the shipment price of products is extremely high compared to that of the same industry of Japan. However, this ratio can be reduced by promoting the water conservation.

② The conservation ratio of the textile industry is close to 20%. This is because the reclamation of wastewater, which has many technical and economic problems, is included. If this was excluded, the conservation ratio would come down to the same level as that of the food business, i.e., 12.5%.

A large volume of washing water is used in the textile industry in order to maintain the quality of products at a high level. Since the conservation of that water is difficult, the conservation ratio is low.

The ratio of the cost of water and wastewater of this type of business to the shipment price of products is quite high. However, because the quantity of water that can be conserved is small, one of the only ways this ratio can be lowered is to promote the reclamation of wastewater, a measure which involves many technical and economical problems. An alternative is to increase the shipment price, that is, to make the product a high value added product.

③ The conservation ratio of the food business, 12.5%, is the lowest among all the types of businesses. The reasons of this low level are that a large quantity of cleaning water is necessary in order to maintain the sanitary state of food at a good level, and it is difficult to conserve that water.

The effect in the event of a future rise in fees is as described in 2.2. Viewed by type of business, an increase in the conservable water volume can be expected through the reclamation of wastewater.

Table 2.6 Expected Water Conservation for Industries

Unit of Water Volume; m³/day.

Industry	Machine & Metal Processing	Food	Textile	Furniture & Chemical Industry	Total
No. of Factories	6	6	5	3	20
City Water	1,495	1,094	1,092	488	4,169
Well Water		426	4,265	298	4,989
River Water	103		1,985	312	2,400
Total	1,598	1,520	7,342	1,098	11,558
Conserv. Volume	411	190	1,421	333	2,355
Conserv. Rate %	25.7	12.5	19.4	30.3	20.4
Note	There are many cases of once through use of cooling water.	Change of bottle washers is required.	1. Control of dyeing water is insufficient. 2. Including reclamation of dyeing waste water	There are many cases of once through use of cooling water.	

2.4 Total Amount of Conservable Water in All Industrial Water

Of the factories that did not become the subject of this survey, the main ones are the machinery and metal-processing factories, including the MPP Group (ex TAM). The volume of industrial water being used by these is estimated to be about 3,000m³/day. The conservation ratio that is possible in this type of business is about 25%, as shown in Table 2.6. Thus, a total quantity of about 750m³/day can be conservable in these factories.

The total of this estimated quantity for the 20 factories and the potentially conservable amount of about 2,355m³/day (Table 2.6), that is, about 3,100m³/day, is the estimated volume of industrial water that can be conservable.

3. WWTP Project

Background

A schematic survey of the WWTP project was made for the following reasons.

(1) As the ratio of factory wastewater to the total volume of inflow wastewater is high, the volume of flow of factory wastewater and the pollutant load (COD_{Cr}, BOD, SS, etc.) has to be grasped as accurately as possible when drawing up the plan of the WWTP project. This time, the JICA study team studied 20 factories whose combined wastewater volume was believed to make up more than 80% of the total factory wastewater. Based on that data, the study team will comment on any point that warranted comment in the WWTP project planned by Maribor City.

(2) We carried out a survey on measures to be taken on textile/dyeing factory wastewater which contains a great amount of difficult-to-decompose COD_{Cr}, because its share of this wastewater is high.

3.1 Outline of Project

A proposal was submitted on WWTP construction to various enterprises in 1995 and it is now being studied by Maribor City. The outline of the proposal is as follows.

(1) Inlet conditions

Wastewater volume:	36,600m ³ /d	
COD:	691mg/L	25,517kg/d
BOD:	311mg/L	11,400kg/d
SS :	342mg/L	12,517kg/d
T-P:	15mg/L	550kg/d
T-N:	47mg/L	1,730kg/d

(2) Treated water conditions

	Phase 1	Phase 2	Phase 3 & 4
COD mg/L		100	100
BOD mg/L		20	20
SS mg/L		35	35
T-P mg/L			2
T-N mg/L			10

(3) Population increase rate

1996 to 2000	0.25%
2000 to 2020	0.5%

(4) Sewer pipe laying rate

1996	78%
1997	81%
1998	83%
1999	85%
2000	89%
2001	91%
2002	93%
2003	95%
2004 to 2020	95%

(5) Rate of increase of industrial water consumption

1996 to 1997	0%
1999 to 2000	2%
2001 to 2020	1%

(6) Rate of collection of fees from households for use of sewers

1996 to 2000	80%
2001	83%
2002	86%
2003	89%
2004	92%
2005 to 2020	95%

(7) Construction schedule

Phase 1	2000
Phase 2	2002
Phase 3 & 4	2004

3.2 Study of Fee System

3.2.1 Fee System and Pretreatment for Reducing Pollutant Load

The total system for Maribor City's entire wastewater can be divided into the WWTP and factories. Therefore, if Maribor City's entire total system was to be optimized using some sort of evaluation function, detailed data of both the factories and WWTP are necessary. However, as the WWTP is in the bidding stage and there is no detailed data, studies on optimizing the total system cannot be made. We therefore decided to investigate what sort of effect various fee systems would have on the actions of the factories and to submit the results as material for evaluating what sort of fee system would be best for Maribor City to adopt in the future. In other words, the process of judging whether or not the pretreatment of the factory would ultimately be appropriate and, based on that result, the preparation of a proposal for the optimum pretreatment system, will have to be done in accordance with the steps shown in the flow chart of Fig.3.2.1(1). However, in the study made in this section, of those steps, we carry out the simulation of the setup of the WWTP fee-calculation formula and the pretreatment.

The effect of a fee system on factories is indicated by judging whether or not it would be advantageous, under the specified fee system, for factories to lower the WWTP discharge fee by pretreating their wastewater at their own cost. For this purpose, as a tentative plan, we studied setting up a trial fee system based on information of the actual state of affairs prevailing in Maribor City and Japan. We then studied what sort of actions (pretreatment) each factory could be expected to take when that fee system was applied. Also, based on those results, we obtained information such as the number of factories that would carry out pretreatment, the total investment amount, and the amount of pollutant load that would be reduced.

We used the data (Table 1.2.2) on pretreatment for reducing pollutant load in Part II as the pretreatment process to be used by each factory, and as the cost of construction of the equipment (investment amount), treatment costs, etc.

At present, in Maribor City, the sewage fee for factory wastewater after construction of the WWTP is tentatively set at an average of 160 SIT/m³. This is because it is the current outlook of Maribor City that the management and operation of the WWTP is possible with an average sewage fee of 160 SIT/m³. It is also said that a pollution

index for wastewater will be established and that a fee system increasing in proportion to that index is scheduled to be adopted. In other words, if the fee is Y and the pollution index is X, it can be expressed by the following equation.

$$Y = A \cdot X \quad (\text{where } A \text{ is a constant and the gradient of the pollutant index})$$

In this report, we generalized the above equation even further and employed the following equation.

$$Y = A \cdot X + B \quad (\text{where } B \text{ is a constant and the basic fee})$$

If the wastewater flowing into the WWTP is to meet the inflow standard, it is logical for the pollutant index X to consist of pollutant compositions that the WWTP can treat; that is, COD, BOD, and SS (phosphor and nitrogen that is be treated in the second phase are omitted). In this report, we established the pollutant index by the following equation. This type of equation was adopted because COD is usually a bigger figure than BOD and SS, and because the pollutant index now being considered by Maribor City places a weight on BOD that is double that of COD.

$$X = (\text{COD} + 2 \cdot \text{BOD} + 2 \cdot \text{SS})/5$$

We estimated, by computer calculations, the actions that would be taken by factories against various fee systems under the above sort of conditions. The result was that we made it a condition that the sewage fee after pretreatment should become 160 SIT/m³ by weighted average of the 20 factories that were studied. Of course, the above conditions, for example, the average fee of 160 SIT/m³ or the pollutant index factors, can be changed. The flowchart of the program is shown if in Fig.3.2.1(2), but the actual calculations are shown in the program itself (attached).

1) Establishing of Cases

As the following paragraph demonstrates, various approaches can be taken in deciding on the sewage fee system. In this report, we use a system which charges a high fee for wastewater with a high pollutant index. As mentioned before, this is done to urge factories that generate wastewater with high pollutant loads to make efforts to improve the quality of their wastewater. Also, since the fee for domestic effluent is assumed to be a uniform 80 SIT/m³, we studied a fee system for factory wastewater that would be in balance with that domestic effluent fee, as follows. Whenever the factory wastewater fee by the tentative fee system becomes less than 80 SIT/m³, it will be made a uniform 80 SIT/m³, and whenever the fee is higher than that, it will be charged at the calculated figure. In addition, we also studied plans for establishing tentative controls on COD, BOD and SS, in the event that a policy for actively reducing the pollutant load to the WWTP was to be taken, because the implementation of such controls was regarded as the most effective means of reducing pollution load. To sum up the above, the cases were set as follows.

Case 1: System for determining the sewage fee for each factory by the equation

$$Y = A \cdot X + B$$

Case 2: The sewage fee would be determined by the same method as above, but there would also be a minimum fee of 80 SIT/m³.

Case 3: Control figures would be set for COD, BOD, and SS, and the sewage fee would be determined by the equation $Y = A \cdot X + B$

2) Results of Studies

The fee-computing equation was as per the following, and a total of 96 calculations were respectively made and studied for each case.

Fee computing equation $Y = A \cdot X + B$, where,
 $X = (\text{COD} + 2 \cdot \text{BOD} + 2 \cdot \text{SS})/5$
 $A = 0.3 \text{ to } 1.0$ (in increments of 0.1)
 $B = 0 \text{ to } 110$ (in increments of 10)

With regard to Case 1 and Case 2, we checked the economical viability of the pretreatment (that is, whether or not the reduction of sewage fees as a result of pretreatment would exceed the pretreatment cost) of each factory against each computing equation. When doing this, if there was a plural number of pretreatment proposals for one factory, we made it a point to select the proposal which provided the largest sewage fee saving. However, the program has been set up so that the proposal which provides the lowest investment can also be selected.

Note that of variables A and B, variable A is the deciding factor that governs the economical viability of the pretreatment of each factory, and variable B is the factor that decides the sewage fee level.

(1) Results of Studies of Case 1

Ninety-six calculations were studied for Case 1. We extracted the cases for each gradient (A) where the calculation formulas resulted in average sewage fees of about 160 SIT/m³ as a result of each factory carrying out pretreatment that was economically practical (shown in Tables 3.2.1(1) and (2)). In these tables, we indicate the actions the factories could be expected to take when the respective calculation formulas were applied, their effects, and the resultant sewage fees.

Table 3.2.1(1) Factories for Which Pretreatment is Economically Practical

	Calculation Formula	Factories for which Pretreatment is Economically Practical		Total Investment Amount (1,000 SIT)
		No. of Factories	Names of Factories	
Case-1a	$0.3X + 100$	3	M-6, 7, A-5	1,38,300
Case-1b	$0.4X + 90$	4	M-4, 6, 7, A-5	195,260
Case-1c	$0.5X + 70$	4	M-4, 6, 7, A-5	195,260
Case-1d	$0.6X + 50$	4	M-4, 6, 7, A-5	195,260
Case-1e	$0.7X + 30$	4	M-4, 6, 7, A-5	195,260
Case-1f	$0.8X + 30$	5	M-1, 4, 6, 7, A-5	238,460
Case-1g	$0.9X + 10$	5	M-1, 4, 6, 7, A-5	238,460
Case-1h	$1.0X$	6	M-1, 4, 5, 6, 7, A-5	263,090

Table 3.2.1(2) Effect of Pretreatment and Resultant Sewage Fees

	Pollutant Load Reduction (kg/d)			Treatment Cost Original Unit	Sewage Fees (SIT/m ³)		
	COD	BOD	SS	See Note	Max.	Ave.	Min.
Case-1a	1,258	695	579	182	241	162	102
Case-1b	1,963	944	548	197	246	164	93
Case-1c	1,963	944	548	197	265	162	74
Case-1d	1,963	944	548	197	284	160	54
Case-1e	1,963	944	548	197	303	159	35
Case-1f	2,413	1,244	458	205	342	163	36
Case-1g	2,413	1,244	458	205	361	160	17
Case-1h	2,461	1,281	450	222	260	164	7

Note: Total Investment Amount (1,000 SIT)/Pollutant Load Reduction Index [(COD+2BOD+2SS)kg/d/5]

Figure 3.2.2 shows a graph of the relationship between total investment and pollutant load reduction based on the above tables. The effectiveness of reduction versus investment amount is low for SS and high for COD, but the tendency is for a leveling off from around 240 million SIT.

In the above eight calculation formulas, when the gradient (A) is gradual, there is the demerit that the number of factories for which pretreatment is economically practical is small. When the gradient (A) is steep, the number of factories for which pretreatment is economically practical increases, but there is the demerit that the minimum sewage fee becomes too small. Therefore, Cases 1b, 1c, 1d, and 1e are believed to be appropriate. However, the case believed to be the most representative with the lowest gradient (A) (so the sewage fee before pretreatment does not become excessive) and the most appropriate minimum sewage fee is Case 1b.

(2) Results of Studies of Case 2

Case 2 covers those cases in Case 1 in which factories with sewage fees of less than 80 SIT/m³ appear but are calculated as being 80 SIT/m³. The calculation formulas that apply to this were the five that are shown in the Tables 3.2.2(1) and (2) below. In these tables, we show the actions that the factory could be expected to take when the respective calculation formulas were applied, their effects, and the resultant sewage fees.

Table 3.2.2(1) Factories for Which Pretreatment is Economically Practical

	Calculation Formula	Factories for which Pretreatment is Economically Practical		Total Investment Amount(1,000 SIT)
		No. of Factories	Names of Factories	
Case-2a	0.5X+ 70	4	X-4, 6, 7, A-5	195,260
Case-2b	0.6X+ 50	4	X-4, 6, 7, A-5	195,260
Case-2c	0.7X+ 30	4	M-4, 6, 7, A-5	195,260
Case-2d	0.8X+ 20	5	M-1, 4, 6, 7, A-5	238,460
Case-2e	0.9X	5	M-1, 4, 6, 7, A-5	238,460

Table 3.2.2(2) Effect of Pretreatment and Resultant Sewage Fees

	Pollutant Load Reduction (kg/d)			Treatment Cost Original Unit	Sewage Fees (SI/m ³)		
	COD	BOD	SS	See Note	Max.	Ave.	Min.
Case-2a	1,963	944	548	197	265	162	80
Case-2b	1,963	944	548	197	284	163	80
Case-2c	1,963	944	548	197	303	164	80
Case-2d	2,413	1,244	457	205	332	160	80
Case-2e	2,413	1,244	457	205	351	160	80

Note: Total Investment Amount (1,000 SIT)/Pollutant Load Reduction Index [(COD+280B+2SS)kg/d/5]

In the above, Cases 2d and 2e have the higher pollutant load reductions. Of these, Case 2d has the more gradual gradient, so we will consider it as representative of Case 2.

(3) Results of studies of case 3

We studied Case 3 by assuming that control figures of COD ≤ 600 , BOD ≤ 300 and SS ≤ 300 would be set. These control figures are in accordance with the standard figures of the Sewerage Law of Japan. Also, they are values that somewhat exceed the water quality levels of the current sewage of Maribor City and are believed to be appropriate levels when imposing controls.

Of the 20 factories that were the subject of the current survey, there are seven whose wastewater pollution concentration exceeds this standard. Of these seven factories, two (S-1 and S-3) had only very slight excess pollutant concentration, and were therefore omitted from the factories needing pretreatment. In this Case 3, since it is a condition that the factories act to meet the controls, they all become uniform and only their sewage fees vary by the calculation formula. Of these, the representative calculation formulas are shown in Tables 3.2.3.

Table 3.2.3(1) Factories for Which Pretreatment is Economically Practical

	Calculation Formula	Factories for which Pretreatment is Economically Practical		Total Investment Amount(1,000 SIT)
		No. of Factories	Names of Factories	
Case-3a	0.3X+110	5	M-4, 5, 6, 7, A-5	219,890
Case-3b	0.5X+ 80	5	M-4, 5, 6, 7, A-5	219,890
Case-3c	0.6X+ 60	5	M-4, 5, 6, 7, A-5	219,890

Table 3.2.3(2) Effect of Pretreatment and Resultant Sewage Fees

	Pollutant Load Reduction (kg/d)			Treatment Cost Original Unit	Sewage Fees (SIT/m ³)		
	COD	BOD	SS	See Note	Max.	Ave.	Min.
Case-3a	2,011	981	541	217	188	160	112
Case-3b	2,011	981	541	217	210	163	84
Case-3c	2,011	981	541	217	216	160	64

Note: Total Investment Amount (1,000 SIT)/Pollutant Load Reduction Index [(COD+2BOD+2SS)kg/d/5]

Of the above, Case 3b has a minimum sewage fee of about 80 SIT/m³, so we will consider it as representative of Case 3.

(3) Summary of results of studies

A comparison of the representative calculation formulas, Case 1b, Case 2d, and Case 3b, obtained from the above case studies is shown in Table 3.2.4.

Of these, first, in the comparison of Case 1b and Case 2d, the latter has a big pretreatment promotion effect on the factories but has the demerit of having excessive sewage fees (especially before pretreatment). The maximum/minimum ratio of the sewage fees of the 20 factories before pretreatment is 5.7 times in Case-1b, but 11 times in Case-2d. In both cases, the fairness of the fee system will require explanation.

Case 3b does not differ too greatly from Cases 1b and Case 2d in terms of the effectiveness of pollution load reduction. This system promotes the active reduction of pollutant load and is being implemented in Japan.

3) Future issues

Studies were carried out on the precondition of promoting the reduction of pollutant loads by factories through pretreatment of their wastewater. From these studies, we were able to clarify the types of pretreatment factories would adopt under different fee calculation systems, as well as the levels of pollutant load reduction that would result from different levels of investment. In order to judge the effect of these results on the total system, including the WWTP, studies must be made in accordance with the steps shown in the previously-mentioned Fig.3.2.1(1), on how much impact they would have on the reduction of the construction and running costs of the WWTP. Also, forecasts must be made of the increase on pollutant loads that could be brought about by the future industrial growth and changes in the industrial structure of Maribor City. Careful studies will have to be conducted to determine whether or not the fee systems resulting from our studies will be effective as advance measures.

Fig.3.2.1(1) Flow Chart for Studying Pretreatment and Water Conservation

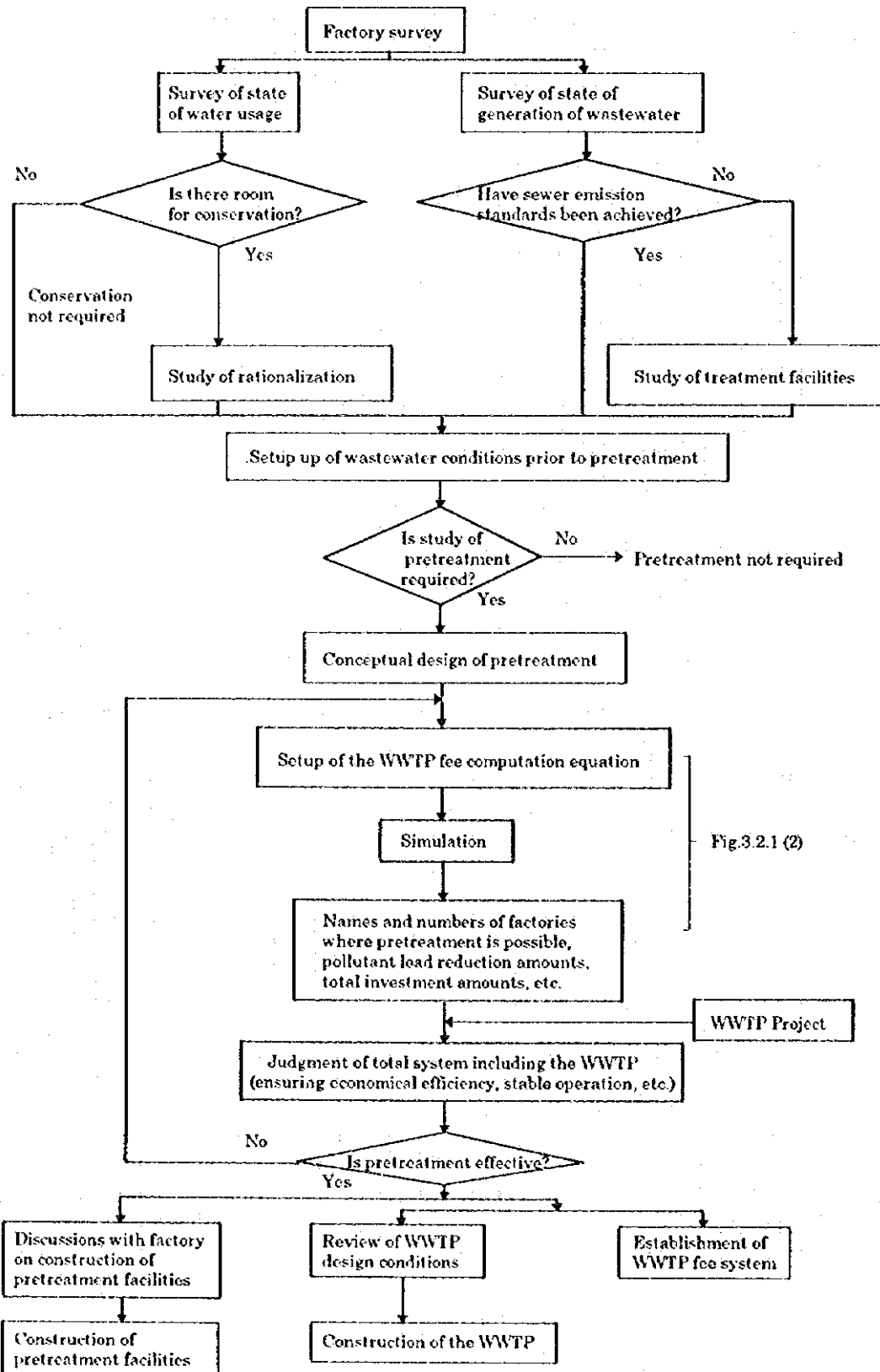


Fig.3.2.1 (2) Program Flowchart for Simulation of Pretreatment

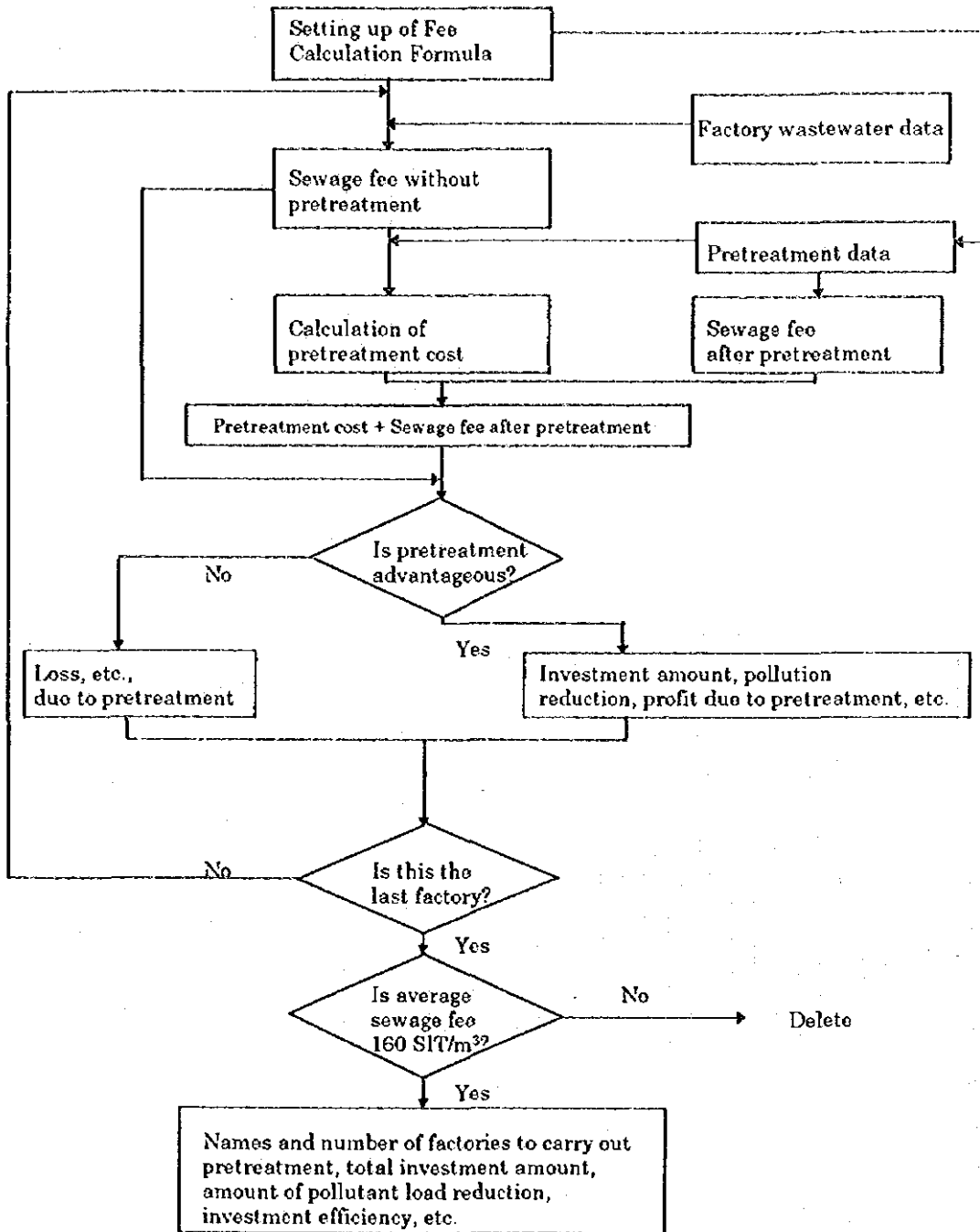


Fig. 3.2.2 Pollutant Reduction vs. Investment

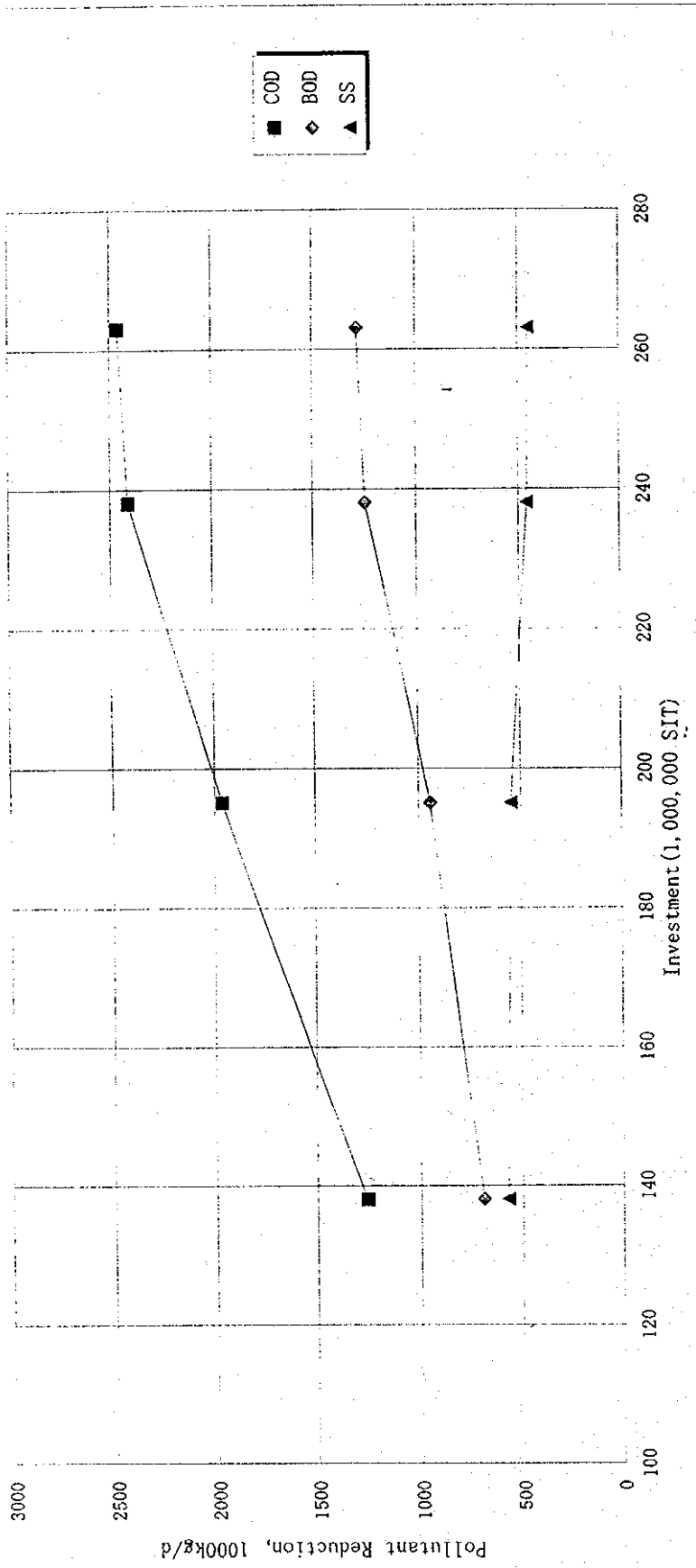


Table 3.2.4 Summary of Results of Studies

	Case-1	Case-2	Case-3
(1) Control figures	Not established	Not established	COD \leq 600 BOD \leq 300 SS \leq 300
(2) Minimum fee	Not established	80 SIT/m ³	Not established
(3) Representative case	Case-1b	Case-2d	Case-3b
Calculation formula	0.4X + 90	0.8X + 20	0.5X + 70
No. of factories installing pretreatment facilities	4	5	5
Nos. of above factories	X-4, 6, 7, A-5	X-1, 4, 6, 7 A-5	X-4, 5, 6, 7 A-5
Total investment amount (1,000 SIT)	195,260	238,460	219,890
Sewage fee: Max. (After pretreatment) Ave. (SIT/m ³) Min.	246 164 93	332 160 80	210 163 84
COD reduction (kg/d) BOD reduction (kg/d) SS reduction (kg/d)	1,963 944 548	2,413 1,244 458	2,011 981 541
Treatment Cost Original Unit (1,000 SIT/kg/d) Total Investment Amount (SIT) Pollutant Load Reduction Index [(COD+2BOD+2SS)kg/d/5]	197	205	217
(4) Characteristics and Problem Points	The maximum sewage fee before pretreatment is 530 SIT/m ³ and the ratio between maximum and minimum is 5.7 times. This is believed to be a relatively realistic system, but an explanation as to the fairness of the fee system is required.	As gradient (A) is steep, sewage fees become excessive. The maximum before pretreatment is 900 SIT/m ³ and the ratio between maximum and minimum is as large as 11 times. Explanation of the fairness is required.	This system promotes factories to be self-responsible for the active reduction of pollutant loads, and is being implemented in Japan.

3.2.2 Basic Thinking in Japan on Sewage Fee Calculations

According to the results of the fourth study, one of the systems that Maribor City is thinking of establishing is a WWTP fee system on the basis of the fee structure of the existing Domzale sewage-treatment plant. The fee structure of this sewage-treatment plant is a system in which the treatment fee is made higher as the degree of pollution of the wastewater increases. Also, COD/600+BOD/300 is included in a part of the pollution index to give BOD twice the weight of COD.

On the other hand, there was a request from Maribor City for an introduction of the Japanese system, so we would like to clarify its relation to the fee structures given in the previous section.

Summaries of the standard thinking in Japan regarding the fees for the use of the sewage system for factory wastewater are given below.

(1) Classification into normal wastewater and special wastewater

Effluent above a certain quantity that is discharged into sewers by factories and enterprises in the course of business activities is classified as special wastewater. The system charges a high fee for such effluent on the "polluter pays" principle. This system has been adopted by some municipalities. The standard for a certain quantity above which the effluent is classified as special wastewater is often 500 to 1,000m³/month.

(2) Basic fee and progressive fee

This system has a basic fee and a progressive fee jointly set up so that the unit fee rate becomes higher as the amount of use increases. This acts as an incentive to control demand. The degree of progression (maximum unit rate/basic unit rate) is often in the range of 1 to 3. Many municipalities have adopted this system. An example of its implementation is shown below.

(per one month)

Classification	Fee Rate
0m ³ - 10m ³	Basic fee: 600 yen
11 - 50	80 yen/m ³ *
51 - 200	100 yen/m ³ *
201 - 500..	125 yen/m ³ *
501 or more	150 yen/m ³ *

* Progressive fee

(3) Water quality fee

This system tries to be fair to ordinary users by imposing fees in accordance with the degree of pollution of the effluent over a certain standard. It acts as an incentive to improve the wastewater quality. It is set together with a progressive fee as shown above. A water quality fee should be charged against items that can be treated by the sewage-treatment plant, and is usually applied to COD, BOD, and SS. There are two ways of setting the water quality fee rate. One is against each water quality item, and the other is to charge against each pollution concentration index as calculated from the total concentration of the various water quality items. Also, the water quality to be applied the fee should be that exceeds the concentration of ordinary household effluent. This means that usually the applicable effluent is one with BOD of 200 mg/L or more and with SS of 200 mg/L or more. This system is employed by several municipalities which have large amounts of factory effluent.

These points summarize the standard thinking on the calculation of sewage fees. Their combinations can be largely divided, as shown below.

Specific examples are given in the Supplement.

(1) Basic fee + progressive fee system:

Refer to 8.3 of Relative information ; Ariake Treatment Plant

(2) Basic fee + progressive fee + water quality fee system:

Refer to 8.1 of Relative information ; Wakayama Treatment Plant

(3) Basic fee + water quality fee system:

Refer to 8.2 of Relative information ; Kashima Treatment Plant

Of the above, system (1) has an incentive to reduce water volume, system (3) has an incentive to improve water quality, and system (2) has a combination of the two. The calculation formula proposed in 3.2.1 belongs to system (3). Note that in Japan, a sewage emission standard is stipulated by the Sewerage Law, which includes BOD and SS as items of control. In the standard, 300 mg/L is the limitation on BOD and SS concentrations, respectively, for manufacturers who have effluent volumes of 50m³/day or more. However, since municipalities can set rules making this standard the lower limit, in actuality there are cases which permit COD_{Mn} and BOD levels up to 600mg/L and which BOD and SS levels are each 300mg/L. Therefore, naturally it is a precondition that there are controls on BOD and SS in the thinking on the calculation of usage fees mentioned above. Note that, as a rule, there are no restrictions on COD when the effluent of sewage-treatment plants is discharged into rivers.

3.3 Removal of Nitrogen and Phosphor

The standard for the discharge into rivers of factory effluent T-P is generally 2mg/L and, in the case of the textile industry, an extremely severe 1mg/L. Of the factories subjected to this survey, there were many whose effluent exceeded this standard. However, most exceeded the standard by single digit figures and only a small number exceeded it by double digits. The phosphor concentration of the entire wastewater of Maribor City is believed to be even lower than that.

Conceptual designs for discharge into rivers were prepared for the installation of pretreatment facilities for the removal of phosphor in each of the model factories that exceeded the emission standard. It is clear from the results that such installations will be extremely expensive. Therefore, it will more advisable for the treatment to be carried out collectively by the WWTP (the current WWTP plan includes a process for removing phosphor).

For the method of treatment, please refer to "1. Nitrogen-Phosphorus-Removal Technology," a supplement attached to Relative Information.

V. Recommendations

V. Recommendations

In this Chapter, we submit our proposals to the Government and to the factories based on the results of the preceding chapters. The contents of our proposals are divided into (1) industrial wastewater and pretreatment, (2) water conservation, (3) the WWTP, and (4) measures that should be taken by government.

In industrial wastewater and pretreatment, first we advise the factories to grasp the actual state of their industrial wastewater. To do so, each factory we recommend the appointment of person exclusively for that purpose, the installation of flowmeters in the factory facilities, the simplification of wastewater sampling procedures, and the regular measurement of water quality and volume. We also point out a few technical issues that should be tackled by the factories in the future. In addition, we give advice on injurious substances that the WWTP should be careful about when in operation.

In water conservation, first we mention that water conservation not only reduces the amount of water consumed but also indirectly reduces the amount of pollution flowing into rivers, lowers the volume of pollution to be treated by the WWTP, and improves the operational situation of the factory. Next, as suggestions to the Government, we take up (1) technical and financial assistance to enterprises, and (2) the setting up of a WWTP fee structure that will not hinder improvements and upgrading by enterprises. In addition, as recommendations to enterprises, we advise that they should (1) accurately grasp their water consumption and wastewater volume to work towards a perfect water balance, (2) grasp the minimum volume and quality required for each purpose, (3) review the water balance to cope with any changes in the operating state of their factories, (4) study specific improvement methods, and, after checking the economic efficiency of those methods, start carrying out those that can be implemented.

With regard to the WWTP, we make recommendations on the establishment of a fee structure for industrial wastewater. As the basic policy for establishing WWTP fee structure, we lay down the following principles: (1) WWTP's cost shall be covered by the fees paid by users, (2) the average treatment cost shall be 160 SIT/m³, and this shall be raised or lowered depending on the degree of pollution of the industrial wastewater, (3) the index for expressing the degree of pollution shall be COD, BOD, and SS. Based on the above principles, the fee calculation formula was made a primary function of the pollution index. Based on this calculation formula, we propose the following three recommendable cases and describe their characteristics, whereby: (1) industrial wastewater is handled under a separate fee structure from household effluent, (2) the minimum fee for industrial wastewater is made the household effluent fee, and (3) pollutant load limits are set on industrial wastewater. Also, we describe what should be done by the administrative authorities based on the comments. In addition, we state that consideration should be given to high COD concentrations when the WWTP is in operation.

Finally, we give the measures that should be taken by the Government. First, we emphasize the need for a special agency for fostering human resources. We also give the position the special agency should hold, its main functions, and its operating method. In addition, we propose the establishment of a specialist qualification system, and the institution of a tax reduction and exemption system and low interest financial loans for environmental equipment investments as incentives for the implementation of environmental protection measures. We further mention the need for environmental engineering companies, and describe ways to foster them.

1. Treatment of Industrial Wastewater and Pretreatment

1.1 Necessity of Studying the Actual Condition of Industrial Wastewater

Through this survey, we learned that, with the exception of a few enterprises, general factories are not aware of the actual condition of the effluents they discharge. Nor are they aware of the volumes of water they consume other than tap water; i.e. water from their own wells and rivers. Even in large-sized factories, they do not measure water consumption by the building, much less by the process.

Following are our recommendations regarding the treatment of industrial wastewater in each factory:

(1) Establish in each factory an environmental-preservation section exclusively devoted to the management of industrial wastewater, and appoint a full-time person in charge.

- a. Have the Chief Executive appoint the person directly, and invest the person with authority.
- b. Benchmark model enterprises (like Henkel-Zlatrog).

(2) Install flowmeters.

- c. Install flowmeters in each factory to measure the quantity of water taken from rivers and the factory's own wells.
- d. Install flowmeters to measure the water consumption of each major process.

(Water consumption management like rationalization of water use starts with the installation of the flowmeters.)

(3) Secure the capability to collect proper effluent samples.

- e. Install effluent pits if possible.
- f. Prepare effluent ports of circular sections so that flowmeters can be installed on drainage canals.

(When flow proportional composite samples are collected, average water quality of a day can be obtained.)

(4) Regular measurement of water quantity and water quality

- g. Enterprises and the Government must jointly determine a set of analysis items for voluntary management.

(Analysis of all items is not necessary every time.)

- h. The WWTP will bear the cost of water quality analysis required for the assessment of sewage rates, and the cost of checking for observing the standards.

(Spot inspection by an inspector or NIGRAD must in principle be conducted.)

- i. Accelerate the integration of discharge ports.

(With the integration, total drainage volume and water quality can be checked economically. Make the integration obligatory by providing subsidies.)

(5) Notify relevant agencies of changes made in major processes which affect effluent greatly, changes in product items, and the raw material.

- j. Items regarding hazardous substances and those which affect the calculation of sewage rates must be notified in advance.

1.2 Continuous Study of Technology

This survey has shown that even factories in the same industry are affected by different types of problems. The report given here covers only general surveys and conceptual study and design.

For the actual planning of the installation of wastewater-treatment facilities and pretreatment facilities, We advise you to refer to this report in detail when checking the circumstances of the plan, and to continuously confirm the effects obtained through small-scale experiments as the plan is carried forward.

We also suggest that you conduct ongoing research on potentially fruitful subjects whose results many factories can hold in common. If foreign countries offer technical assistance, make use of it.

Following are several research subjects which we deem highly recommendable: (Not listed in any particular order)

(1) The effect of the charcoal-filtration equipment installed in S-2 TABOR was confirmed even under a low-concentration condition by the fourth on-site survey. Observe the performance of the equipment over a long period.

(2) It seems that S-2 TABOR uses more water than standard in order to lower the pollutant concentration of effluent. With the introduction of proper wastewater treatment, the volume of water used can be decreased sharply. Based on the result, the economy of direct discharge to rivers and discharge to the sewer must be compared minutely.

(3) The design of M-1 SVILA's model wastewater-treatment system, a design based on the information obtained from the second on-site survey, places too much of an emphasis on the removal of color. Judging from the result of the fourth on-site survey (coagulation tests etc.), when biological treatment is employed after coagulating-sedimentation treatment, the size of the biological treatment facilities can be reduced greatly, and ozonization and activated-carbon treatment introduced as a measure against coloring will possibly become unnecessary. Wastewater treatment facilities which discharge directly to rivers need to be reexamined.

(4) pH of the total effluent of S-3 MTT is very high and the pollutant concentration is higher than that of dyeing effluent. Bleaching and scouring may have a great influence. Check the matter and take necessary measures.

(5) The wastewater of A-5 Henkel-Zlatrog has high concentrations of COD, BOD, and oil, but these pollutants can be treated biologically. Aerobic biological treatment will cause foaming, but anaerobic biological treatment may be applicable. Small-sized experiments of anaerobic biological treatment must be conducted. This technology can be applied to the treatment of other high-concentration wastewater.

1.3 Education on Substances Hazardous to the WWTP

We recommend that the factories which send effluent for treatment at the WWTP be educated on the substances that hinder its operation. Refer to "Relative Information", Item 4 for a list of substances which hinder WWTP operations and the volumes required to cause hindrance; and "Relative Information", Item 3 for a description of the technologies used to remove these substances.