STUDY ON WASTE TREATMENT AND RECYCLING PLAN OF SELECTED INDUSTRIES IN THE REGION OF SFAX IN THE REPUBLIC OF TUNISIA

FINAL REPORT

(SUMMARY)

SEPTEMBER 1993

JAPAN INTERNATIONAL COOPERATION AGENCY

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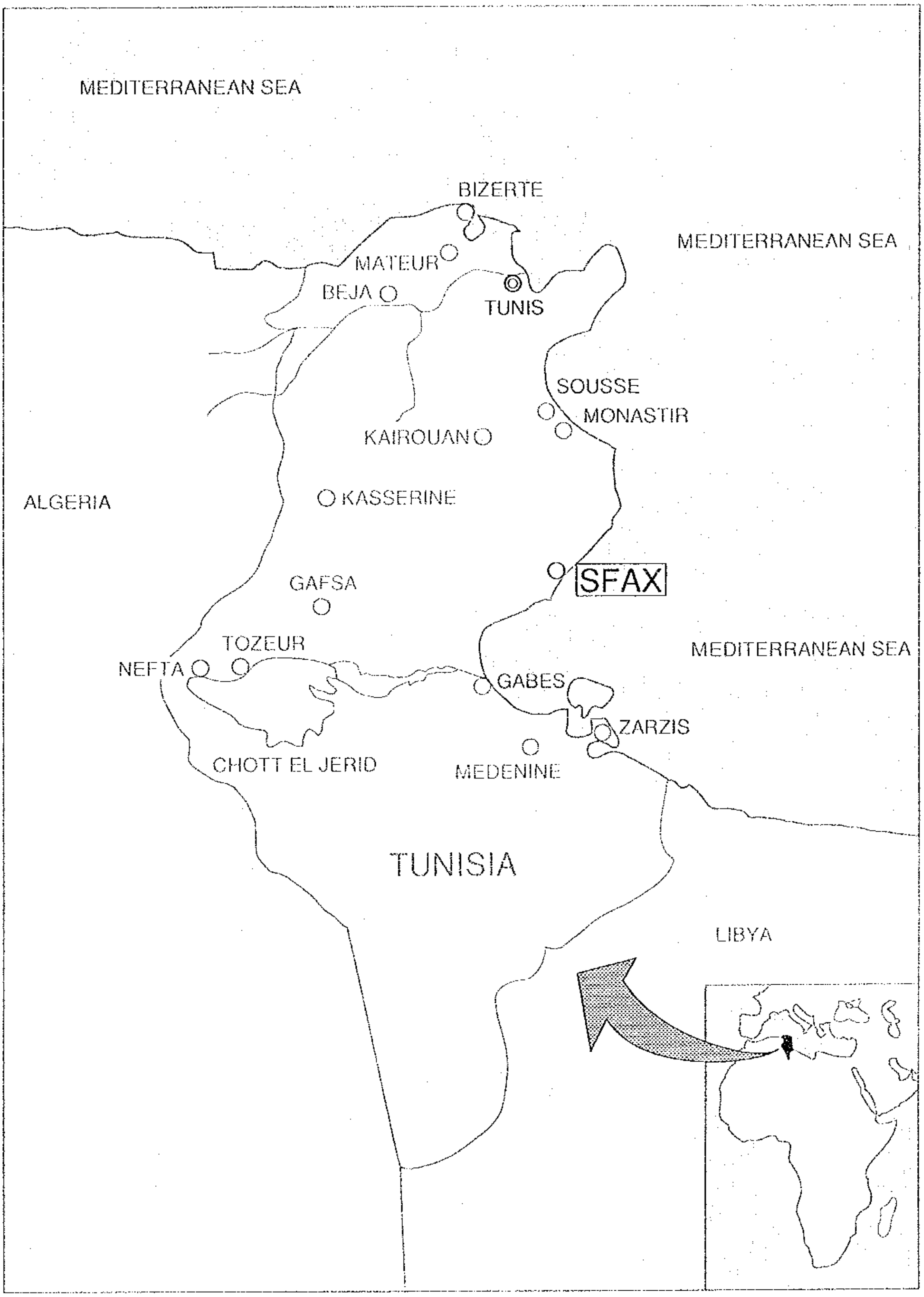
LOCATION MAP

(SFAX CITY IN TUNISIA)



Abstract

1. Objective of the Study

The objective of this study is to contribute to regional environment protection and sound industrial development by formulating industrial pollution prevention plans in selected factories.

2. Period of the Study

From May 1991 till September 1993

3. Selected Factories of the Study: Sfax city and surrounding area in the Republic of Tunisia

(1) National phosphatic fertilizer factory (1 factory: SIAPE A)

(2) Sfax plant of national oil company (1 factory: SNDP)

(3) Olive oil factory (1 factory: UPOTS)

(4) Soap factory (2 factories: SIOS-ZITEX and SATHOP)

(5) Tanning factory (2 factories: SMCP and TMC)

(6) Dyeing factory (1 factory: STS)

(7) Sewage treatment plant (1 plant: ONAS)

4. Outline of Countermeasures

(1) Establishment of emission standard

① Waste water treatment

In Tunisia, there is a INNORPI standard specifying the discharged waste water. However, a tentative standard has been proposed, since a stepwise achievement of the standard is considered to be more realistic.

② Exhaust gas treatment

Since there is no exhaust gas emission standard in Tunisia, the Japanese emission standard has been referenced.

(2) Outline of antipollution facilities

Total discharge

Total waste water volume: 4,968 m^3/day

Total exhaust gas volume: 568,600 Nm^3/hr

Number of discharge points: 15 points

Method of treatment

① Case 1 (For waste water, tentative standard proposed by Japanese side)

Waste water: The waste water is to be pre-treated to be discharged to the ONAS sewage treatment plant except SIAPE. At SIAPE, the waste water is discharged to the sea after being treated.

Exhaust gas: At the sulfuric acid plant of SIAPE, the existing method has been modified to DCDA method. At the phosphoric acid plant and TSP plant, a wet scrubber type has been adopted and multi-cyclone has adopted for the boiler of these plants. Multi-cyclone has also be adopted at SIOS-ZITEX, SATHOP, and STS.

② Case 2 (for waste water, tentative standard proposed by Tunisian side)

Waste water: Waste water is treated up to the higher grade to be discharged to ONAS sewage treatment plant, except SIAPE. At SIAPE, the waste water is discharged to the sea after being treated.

Exhaust gas: Same as in Case 1.

③ Case 3 (for waste water, INNORPI standard)

Waste water: Waste water is treated up to the higher grade to be discharged to ONAS sewage treatment plant, except SIAPE. At SIAPE, the waste water is discharged to the sea after being treated.

Exhaust gas: Same as in Case 1.

(3) Total capital requirement

① Case 1 (for waste water, tentative standard proposed by Japanese side)

Waste water treatment: 15,782,600 TD

(construction cost: 14,550,000 TD)

Exhaust gas treatement:	17,386,400 TD
	(construction cost: 15,931,700 TD)
Total:	33,169,000 TD
	(construction cost: 30,481,700 TD)

② Case 2 (for waste water, tentative standard proposed by Tunisian side)

Waste water treatment:	24,329,600 TD
	(construciton cost: 22,537,100 TD)
Exhaust gas treatment:	17,386,400 TD
	(construciotn cost: 15,931,700 TD)
Total:	41,716,000 TD
	(construction cost: 38,468,800 TD)

③ Case 3 (for waste water, INNORPI standard)

Waste water treatment:	25,450,900 TD
	(construction cost: 23,581,000 TD)
Exhaust gas treatment:	17,386,400 TD
	(construction cost: 15,931,700 TD)
Total:	42,837,300 TD
	(construction cost: 39,512,700 TD)

(4) Construction period

Two years are required for the construction.

5. Financial and Economic Studies

Generally, investment on industrial antipollution countermeasures will not generate an output increase, so that it will not directly lead to a profit increase for the enterprises. Therefore, such investment does not fit in an ordinary financial or economic analysis. In the study, however, consideration has been given to the recent trend and the possible future reinforcement in Tunisia of the regulations and to the fact that some factories in Tunisia have been actually suspended from the operation because of the industrial pollution they caused. Thus, the influence by the number of suspended operation days has been evaluated, based on a concept of evasion of the suspension and evasion of output loss through the execution of the antipollution countermeasures. Along with the result of such evasions, an economic benefit has been taken into account such as reduction of the cost for exceeding the waste water quality standard and sewage treatment cost, value of the by-products, reduction of raw-material cost, and effect of tax exemption by special depreciation. These factors are included in the calculation of financial internal rate of return (F.IRR) and economic internal rate of return (E.IRR). The concept of economic benefit including the evasion of output loss is hardly considered to meet the essential objective of antipollution measures and industrial development, even though the IRR indicates a positive figure. Since the present study is intended for environmental countermeasures, the IRR cannot be used to determine the profitability of the investment. Instead, an even wider viewpoint should be taken to determine the appropriateness of the investment.

As a result of the financial and economic studies, the following conclusions can be reached:

(1) Prevention of pollution is significant to the community, by encouraging the industrial development and helping the enhancement of the residents' standard of living. Moreover, utilization of the useful material recovered from the treatment process will not only bring about an economic effect, but also offer the opportunity to acquire the techniques to improve the various production processes.

(2) At the stage of actual implementation, efforts should be made to reduce the cost of construction and operation to lighten the burden on each enterprise.

(3) By the introduction of the planned facilities, and opportunity for new employment will be offered not only to the direct personnel but also to the construction personnel.

6. Conclusions

The present study has been conducted for a regional conservation of environment through industrial antipollution countermeasures at the selected factories. Therefore, this study should be used as a model to be widespread to all Tunisian areas to establish the execution plans.

(1) Present state of selected factories

Except some factories, no countermeasures are taken for the industrial pollution at any factory. For the waster water, there is an established standard of INNORPI, but it has not been attained. For the exhaust gas, no emission standard has been provided.

(2) Conclusion of study

To protect the environment and enhance the economic efficiency of each enterprise, the cost of construction and operation for the antipollution facilities should be reduces. For this purpose, the following points should be examined as the key factors:

① Each factory discharges a large amount of polluting substances. By promoting a rationalisation within each factory, the valuable materials should be recoverd to reduce the polluted content in the waste water.

② Installation of the waste water treatment facilities should be studied according to the tentative standard proposed by Japanese side. While it is tentative, the standard satisfies the INNORPI standard, except SO4 which is discharged to the sea at SIAPE.

③ INNORPI standard also regulates the salts such as C1 and SO4.
Therefore a reexamination is required.

④ Treatment of the margin is a worldwide problem. In Tunisia, this report should be referenced to further study this problem.

⑤ SIAPE should increase the yield of sulfuric acid at the sulfuric acid plant, and at the same time endeavor to apply the DCDA method for the antipollution measures. Moreover, the scrubber should be improved to remove F for treating the exhaust gas from the phosphoric acid plant and TSP plant.

⑥ For the soap factory and dyeing factory, installation of cyclone is recommended for preventing the particles of soot. As a preparatory step, the method of controlling the combustion techniques should be improved.

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VOLUME I INTRODUCTION

1. Introduction

This report was compiled as a final report for "Study on Waste Treatment and Recycling Plan of Selected Industries in the Region of Sfax in the Republic of Tunisia", implemented by Japan International Cooperation Agency and scheduled from May 1991 to August 1993.

This report is based on, and revising the interim report prepared in Feburuary 1993, by incorporating the result of discussion at the fifth field survey and the result of the study in Japan continued thereafter.

2. Background of the Study

Key industries in the Republic of Tunisia are phosphate fertilizer and olive oil industries whose raw materials are produced abundantly in the country. Sfax, the second largest city (with a population of about 600,000), is one of the most industrialized in Tunisia, and environmental pollution, particularly caused by big projects like phosphate fertilizer factories, has been a serious problem for a long time.

Since Sfax is adjacent to the fishery industrial zone along the Gulf of Gabes and close to the tourist resorts of the Mediterranean Sea, the Tunisian government regarded the matter serious and set up Agence Nationale de Protection de l'Environnement (ANPE) in the Prime Minister's Office in 1988 to take countermeasures against environmental pollution, with priority given to industrial waste water treatment and exhaust fume removal. Under these circumstances, the Tunisian government requested Japan to cooperate in solving these problems.

In response to the request, Japan International Cooperation Agency (JICA) concluded the S/W Agreement concerning this study after confirming the subject matter of the request by the Tunisian government and conducting a general survey on selected factories.

The Study team started the study in May 1991.

3. Objective of the Study

The objective of this study is to contribute to regional environmental protection and sound industrial development by formulating industrial pollution prevention plans in selected factories.

Concretely, the followings will be carried out for selected eight factories.

① Planning of waste water treatment, recycling, and exhaust fume (particles of soot) removal

② Diagnosis of oil storage facilities (Measures against the leakage of petroleum)

Also the study team conducts this survey in cooperation with the Tunisian partner and implements the technical transfer of survey method to the counter-partner during the survey.

4. Selected Areas of the Study

(1) Selected areas: Sfax City in the Republic of Tunisia

(2) Selected factories: The locations of the following factories are indicated in Fig. -1.

① National phosphatic fertilizer factory (1 factory: SIAPE A)

② Sfax plant of national oil company (1 factory: SNDP)

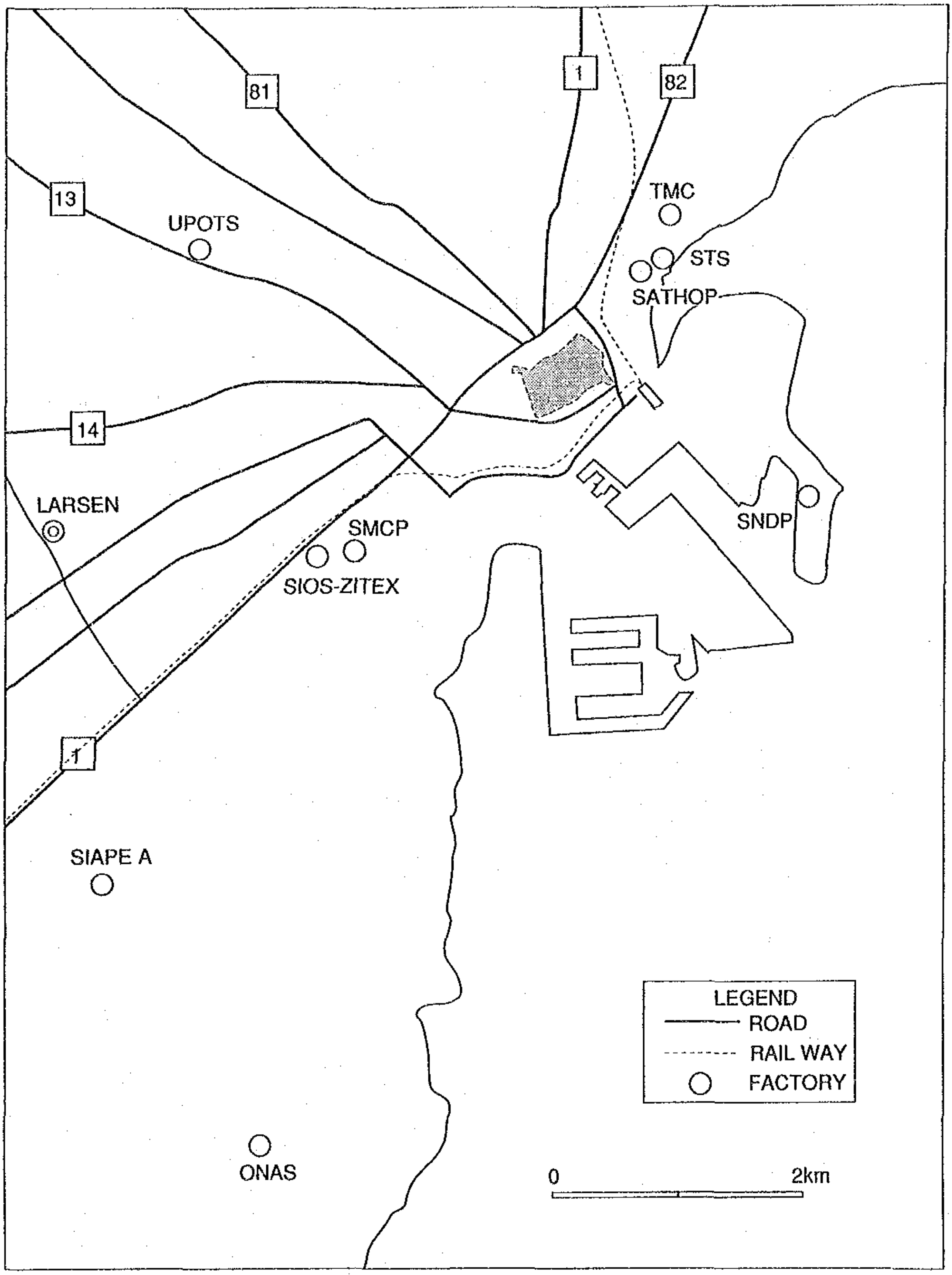
③ Olive oil factory (1 factory: UPOTS)

④ Soap factory (2 factories: SATHOP and SIOS-ZITEX)

⑤ Tanning factory (2 factories: SMCP and TMC)

⑥ Dyeing factory (1 factory: STS)

Fig. I-1 Location of Selected Factories



5. Scope of the Study

The following eight items were selected as major subjects for investigation related to this study, and the correlation of each item is shown in Fig. -2: Flowchart of the study methods and procedures.

① Diagnosis of the present condition of production process

② Diagnosis of the present condition of supply water and waste water

③ Diagnosis of the present condition of exhaust fume

④ Setting of proper environmental standard and water quality standard

⑤ Making plans for improvement in production process and evaluation of economical efficiency

⑥ Making plans for waste water treatment and recycling, and evaluation of economical efficiency

⑦ Making plans for exhaust fume removal and evaluation of economical efficiency

⑧ Evaluation of entire economical efficiency and conclusion

6. Implementation Methods of the Study

6.1 Schedule of the Study

The working schedule of this study began in May, 1991 and will end in September, 1993 by submitting the final report. The working schedule is shown in Fig. -3.

Fig. -2 Flowchart of the Study Methods and Procedures

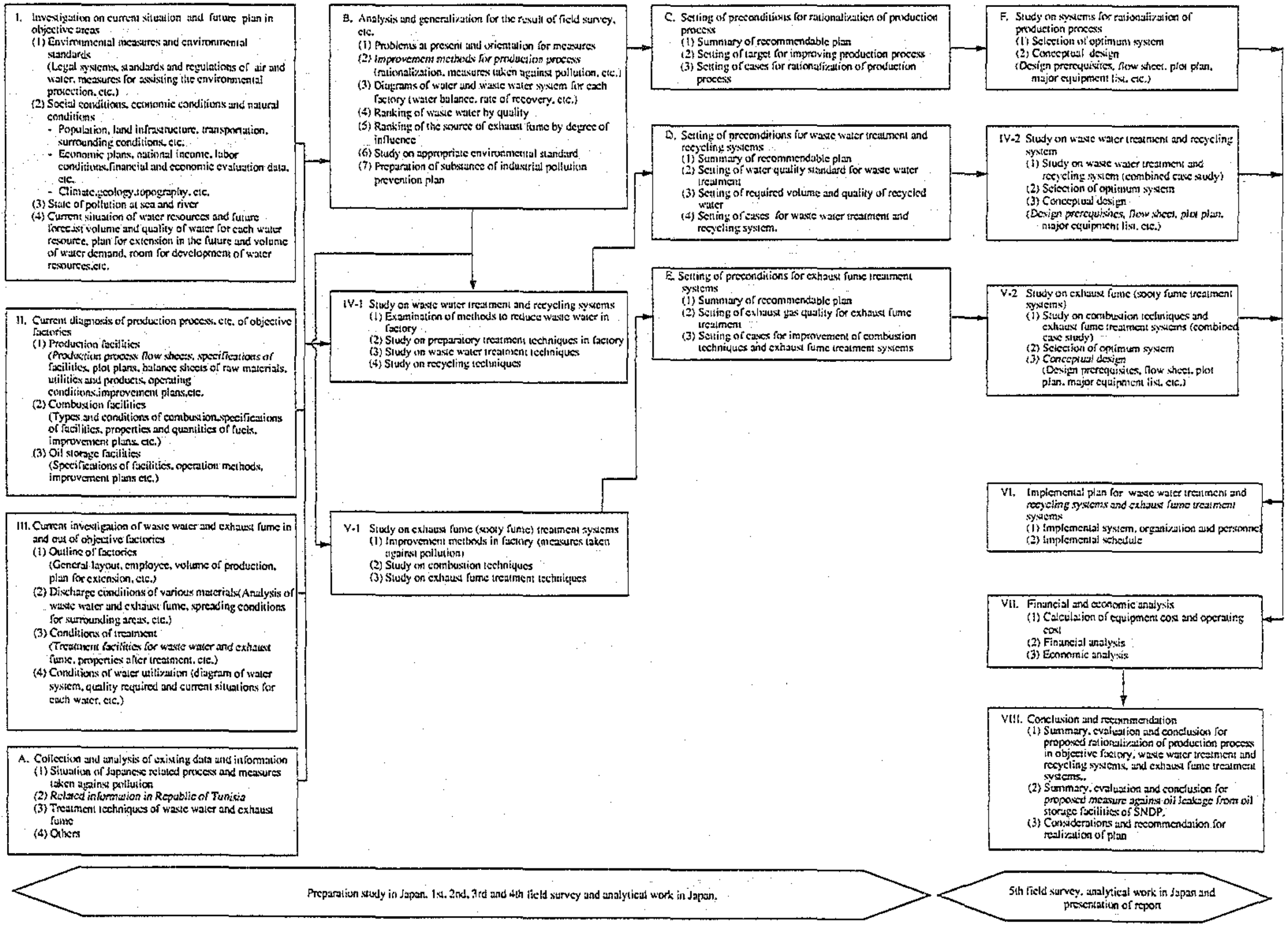
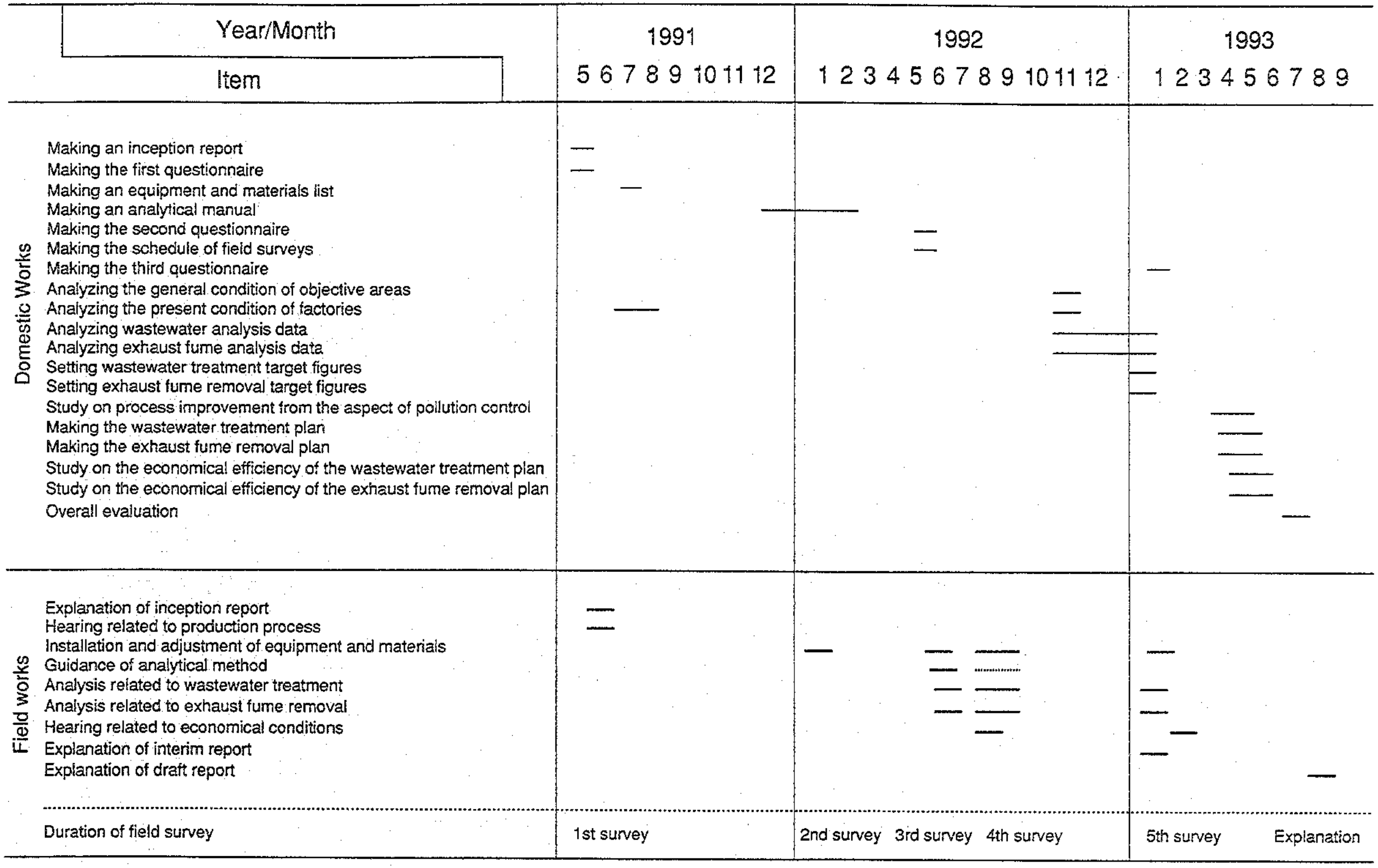


Fig. -3 Working Schedule



6.2 Outline of the Study

(1) The First Field Survey (From June 7, 1991 through June 21, 1991)

① Explanation of entire study based on the inception report (Plan for the third field survey is included.)

② Survey of the present condition of selected factories from the aspect of production process

③ Survey of the points for waste water and exhaust gas analysis to be made in the third survey

④ Confirmation of the method of waste water and exhaust gas analysis to be made in the third survey

⑤ *Holding a seminar related to processes in the selected factories*

(2) The Second Field Survey (from January 18, 1992 through February 1, 1992)

① Explanation of supplied equipment and materials

② Confirmation of exhaust gas sampling points

③ Explanation of the methods and schedule of the third and fourth field surveys

(3) The Third Field Survey (from June 12, 1992 through July 29, 1992)

① Unpacking, installation and adjustment of supplied equipment and materials

② *Guidance of exhaust gas and waste water analysis methods by using the analytical* manual

③ Confirmation of construction works for exhaust gas sampling point

④ Making the flowchart of waste water of selected factories

⑤ Execution of sampling of waste water and simplified analysis

⑥ Execution of sampling and analysis of exhaust gas

(4) The Fourth Field Survey (September 5, 1992 through October 19, 1992)

① Collection of data for financial and economical analysis

② Investigation of the processes related to phosphoric acid factory and tanning factory

③ Execution of sampling of waste water and analysis of detailed daily variation analysis

④ Execution of sampling and analysis of exhaust gas

(5) The Fifth Field Survey (February 5, 1993 through March 6, 1993)

① Explanation and discussion of interim report

② Supplementary survey on selected factories

③ Unpacking, checking of quantity and adjustment of supplied equipment and materials

④ Guidance and discussion of analysis methods

(6) The Sixth Field survey (July 27, 1993 through August 9, 1993)

① Explanation and discussion of draft final report

VOLUME II PRESENT CONDITIONS OF SELECTED AREAS

1. Environmental Control Policy

(1) History in Environmental Policy

1) With the advance of economic development, ONAS was established in 1974 as an institute in charge of industrial and domestic waste water treatment.

2) Each institute concerned had individually taken a measure on the different level against the problem of environmental pollution aggravating with the progress of economic development. Under these conditions, the law (88-91) enacted in 1988 provided the following points.

   - Establishment of ANPE as a unified organization to cope with the problem of environmental pollution
   - Measures to foster environmental protection
   - Establishment of 'polluter pays principle' and penal regulations for the violators of the law.

3) In 1989, the Tunisia Standard (INNORPI) was settled. The following items were included in the standard.

   ① Objects under the application of waste water quality standard

   ② Analysis of water quality and method of analysis

   ③ *Waste water quality standard for the sea area, river and sewerage*

4) In 1991, ANPE enacted the law of "Environmental Assessment" which assigns a duty of executing environment survey before a project is started.

5) In 1991, MOE was established to strengthen the environmental protection activities conducted by ANPE.

(2) Related Regulations

1) The Tunisia Standard (INNORPI) enacted in 1989 defines waste water discharged into the sea area, river and sewerage, The standard covers more than 50 materials.

2) Emission standard to control exhaust gas emitted into the atmosphere have not yet been provided, and they are now under investigation.

3) The Tunisia Standard provides that the violator of the regulation is punished with a fine from 100 to 50,000 TD. As it does not provide the method to calculate the amount of penalty, the court of justice decide it.

4) The basic principle is 'polluter pays principle.' However, if the facilities for environmental pollution control planned by factories are approved by the Government, following special favors are granted.

   ① The tax to be imposed on the import of equipment for environmental pollution control is exempted.

   ② The sales tax to be imposed on the purchase of equipment for environmental pollution control produced in Tunisia is exempted.

   ③ Factories are furnished with a loan at an interest of 8% by the Central Bank of Tunisia.

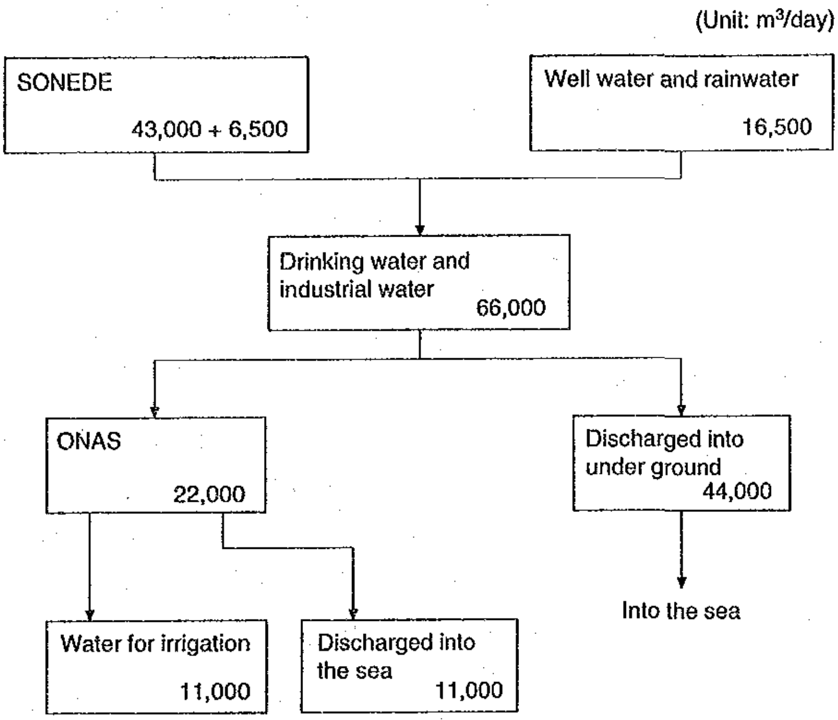
   ④ The rate of depreciation on investment related with environmental pollution control is 25% per year.

2. Present Condition of Water Supply in Sfax

(1) About 90% of city water in the Sfax area is supplied by SONEDE as tap water and it is used as drinking water and industrial water. The remaining 10% includes underground water and rainwater.

(2) The flow of supply water and waste water in the Sfax area is given in the Fig. -4.

Fig. -4 Flow of Supply Water and Waste Water in Sfax



(3) There is no problem in water supply, because object factories have no planning to increase production sharply.

(4) However, in keeping with growing population and the economic development in Sfax, a critical problem of water resources may possibly arise in the near future.

3. Conditions of Air Pollution

(1) There exists no regulation on air pollution now, but it is now under investigation by institutions concerned.

(2) People living in the neighborhood brought forward a claim for the emission of sooty smoke resulting from the growing industrial development.

(3) Sfax is the second largest city in Tunisia, and air pollution by transportation is becoming an important social problem.

(4) Sampling of polluted air was conducted along the streets in Sfax city.

VOLUME III PRESENT CONDITIONS OF SELECTED FACTORIES

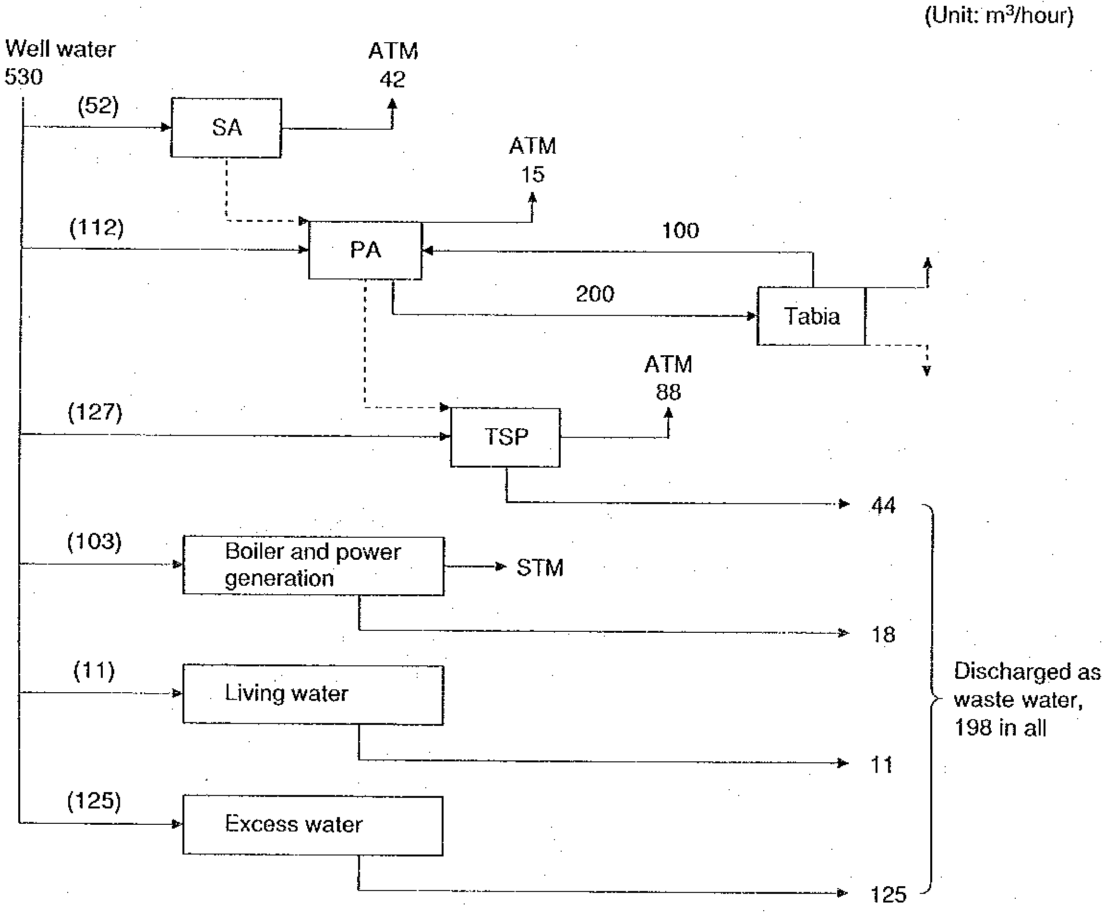
The selected factories of this study vary in the line of business and scale of factory, and we could not obtain desired information from some factories. We summarize the present condition of environmental pollution in Sfax based on information we acquired through hearing in the field survey and actual data analysis.

1. SIAPE

Sulfuric acid, phosphoric acid and TSP are produced at SIAPE. With the production of these products, waste water is discharged, exhaust gas is emitted, and refuse are produced.

The general flow of supply water and waste water in the factory is illustrated in Fig. -5 Supply water of 530m^3 is used hourly, and waste water of 198m^3 is discharged hourly. For exhaust air, soot and dust are removed by the scrubber in each plant. However, the function of removing soot and dust is not so efficient, and harmful substances are discharged. Waste gypsum is also drained as refuse into Tabia, but a part of water contained in gypsum is recycled for use in process.

Fig. -5 General Flow of Supply Water and Waste Water (SIAPE)



We measured supply water, waste water and exhaust gas in the field survey. The results of measurement are given in Tables -1 and -2 together with the results of measurement in other factories. However, we will evaluate these values after set up standards later. From the property of a fertilizer factory, F is contained in waste water discharged and exhaust gas emitted from SIAPE.

2. SNDP

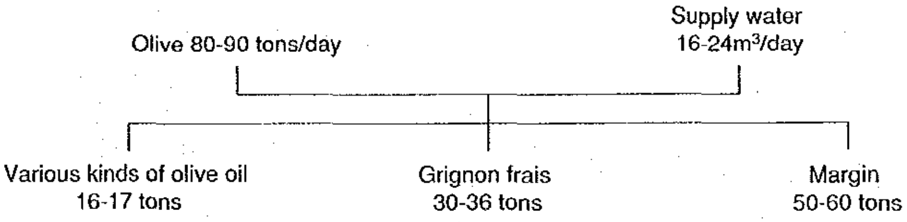
SNDP is an oil storage facility with 17 tanks having a total capacity of 26,699 k*l*.

The most serious problem is that SNDP receives different kinds of oil through a single pipeline and uses sea water to clean inside the pipeline when receiving different kinds of oil. This was a possible cause of oil outflow into the sea. At the time of field survey in February 1993, however, dedicated pipelines were under construction for individual oil to improve the state of things at SNDP. Therefore, the problem of oil leakage will almost be dissolved.

3. UPOTS

In and around Sfax city, there are more than 200 factories of olive oil which is one of the main export items of Tunisia. These olive oil factories are in operation for approximately 100 days a year (from November till February). The output of UPOTS in the fiscal year 1991 is given in Fig. -6.

Fig. -6 Material Balance of Production (UPOTS)



Of the above oil products, grignon frais is used as a raw material for soap factories.

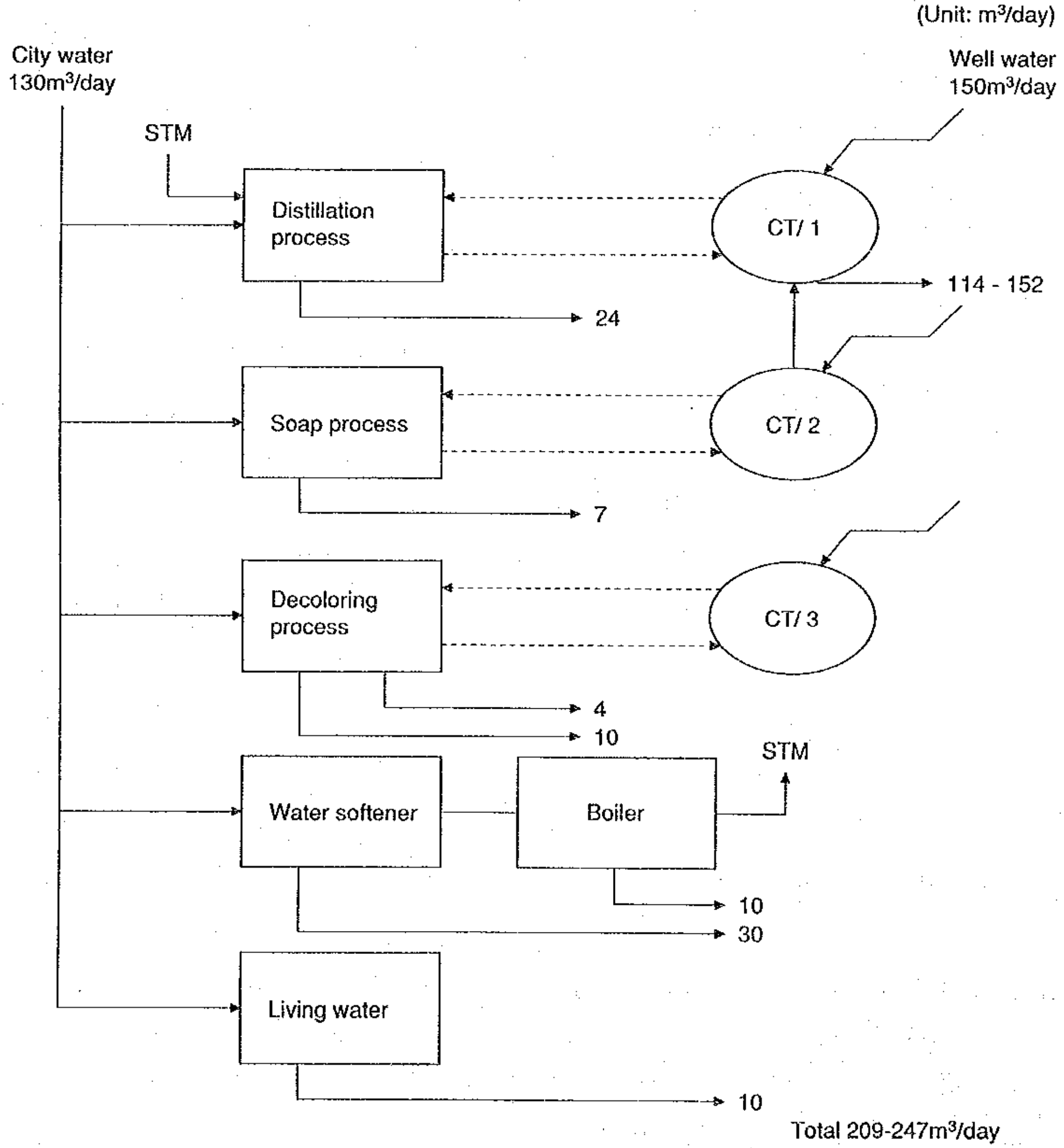
The serious pollution source in olive oil factories is margin, which is carried to the neighboring estate of ONAS waste water treatment facilities. It is dried in the open air and treated economically. It is required to adopt a more efficient treatment method because the land is limited for storing all margin discharged from more than 200 olive oil factories in the region of Sfax as mentioned above.

4. SIOS-ZITEX

SIOS-ZITEX is producing soap from oil contained in grignon frais discharged from olive oil factories and soya bean oil as raw materials. Grignon frais with its oil content extracted is used as fuel for drying furnace and boilers.

Particles of soot which generate when grignon is burnt and high-density organic substances contained in waste water are pollution sources from SIOS-ZITEX. The outline of water balance at SIOS-ZITEX is given in Fig. -7.

Fig. -7 Water Balance (SIOS-ZITEX)

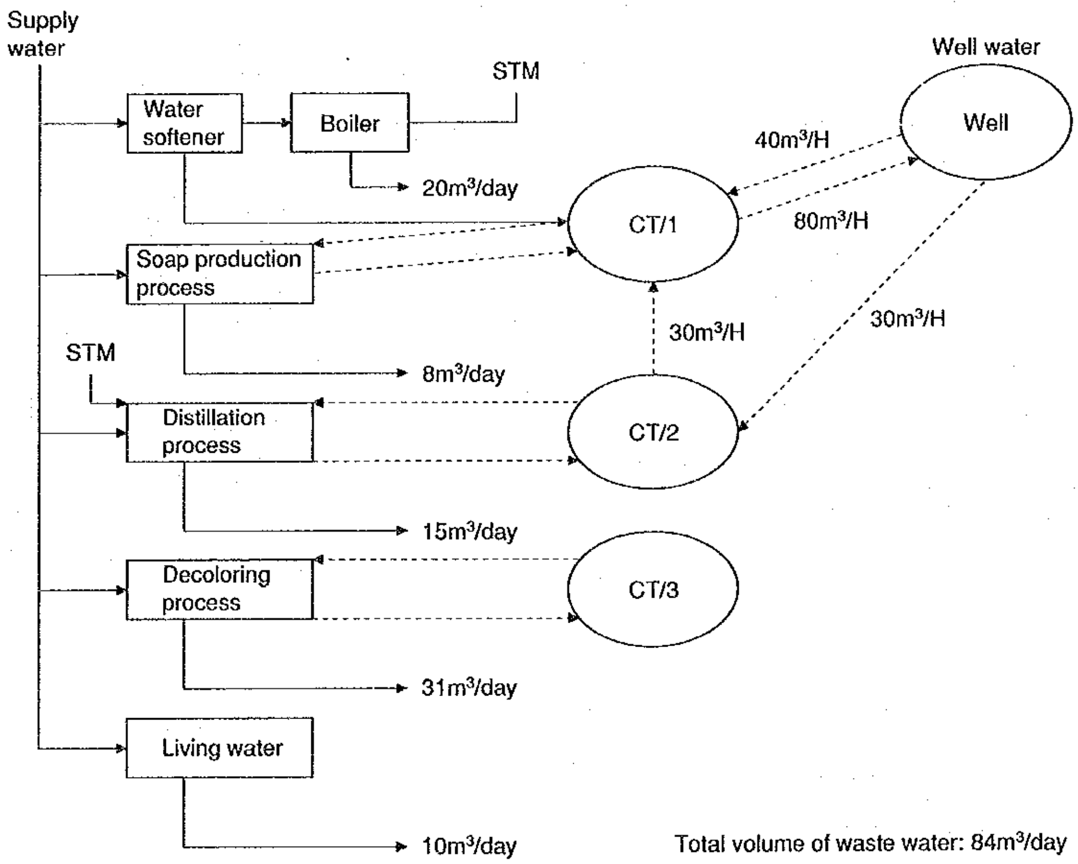


5. SATHOP

SATHOP is a soap factory using more outdated facilities than SIOS-ZITEX, and has the same kind of problem for pollution source.

The water balance at SATHOP is given in Fig. -8.

Fig. -8 Water Balance (SATHOP)



The circuits of supply water and waste water are not clear as the results of extension of the plant facilities. Waste water containing contaminants are discharged into wells as illustrated above.

However, SATHOP is executing installation work of a coagulator at the final discharge outlet to treat high-density waste water.

6. SMCP/TMC

SMCP is the only tanning factory which has a definite plan to increase production in the future. SMCP built a new factory (TMC) according to this plan, and started production partially. The old factory (SMCP) will be used as a warehouse, while all production will be assigned to the new factory.

The pollution source in the factory is waste water. The flow of production and waste water in old and new factories is given in Fig. -9.

In the new factory, waste water is discharged in the way as shown in the figure, and facilities to treat waste water are under construction now.

7. STS

STS is the only textile factory with a dyeing process in the region of Sfax.

Colored waste water containing high-density COD and BOD is drained intermittently from the dyeing process of the textile manufacturing process. The flow of supply water and waste water is given in Fig. -10.

A boiler is used to generate steam to be used in the drying process, and heavy oil is used as fuel. Particles of soot contained in exhaust gas from the boiler show rather high values.

Fig. -9 Block Flow of SMCP

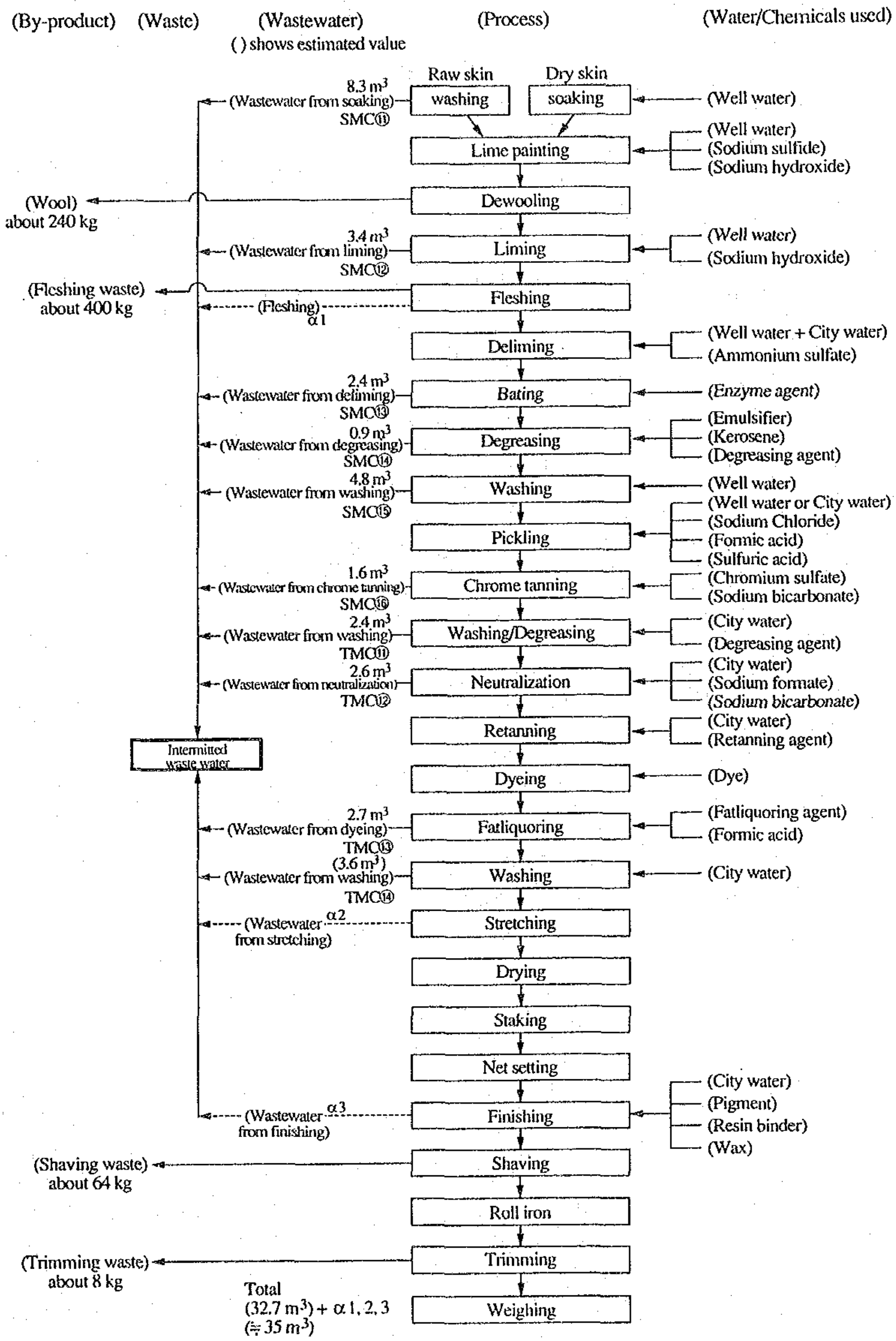
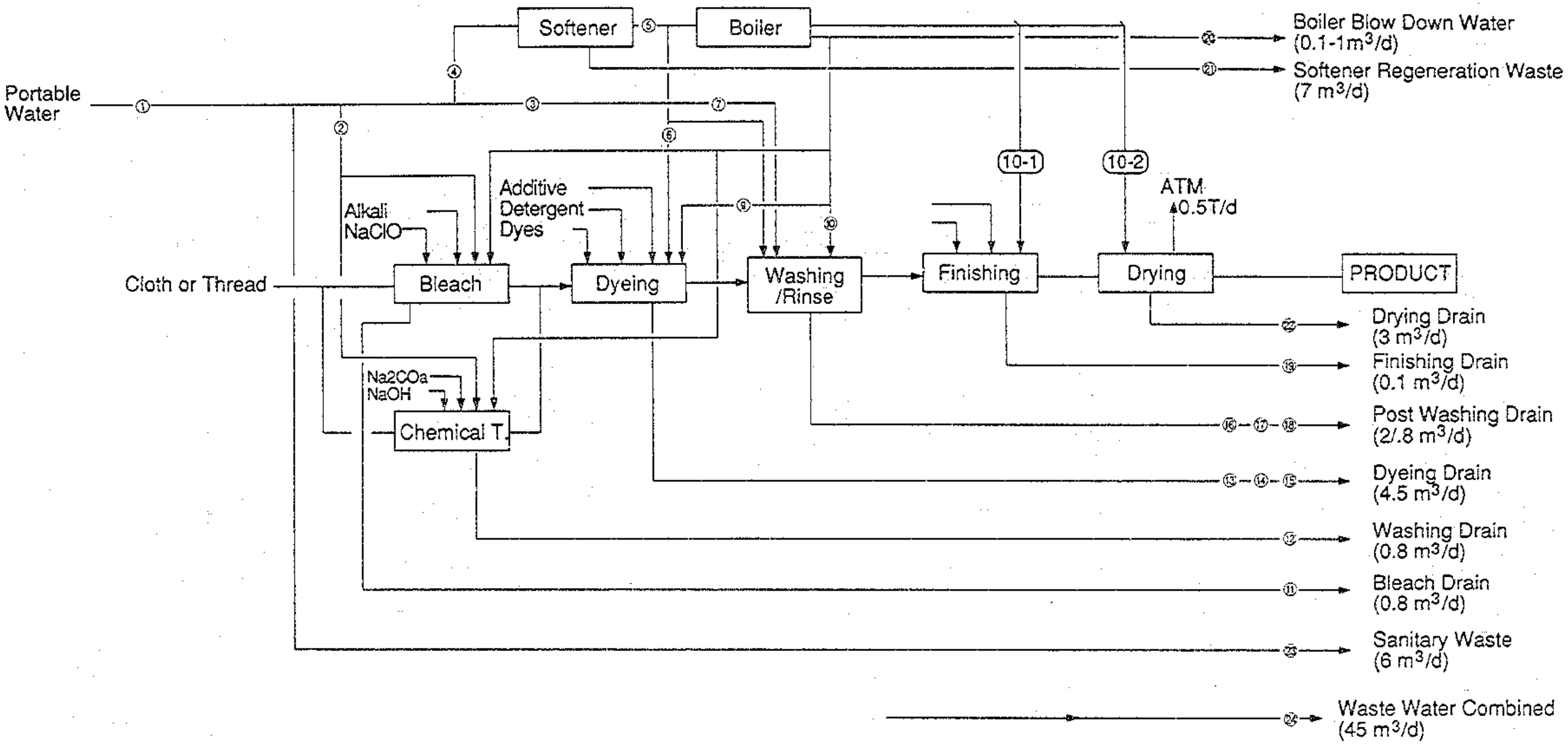


Fig. -10 Water Flow of STS

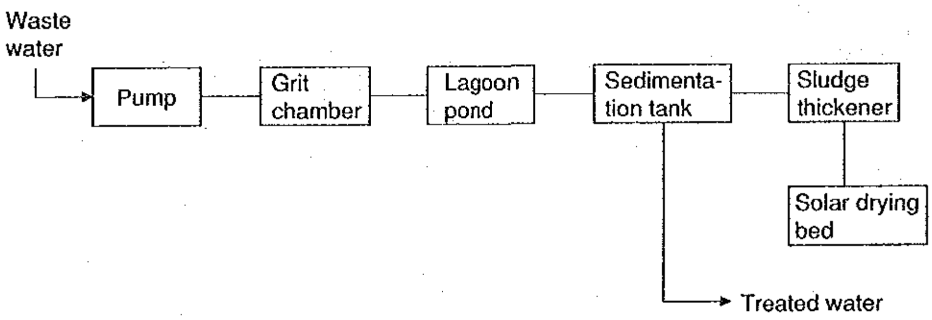


8. ONAS

ONAS is a national sewage treatment plant located in the south of Sfax city. The object factories of this survey are different in the line of business and scale, and it is less possible to install waste water treatment facilities corresponding to the Tunisia Standard in each factory. This study was carried out to make judgment whether the treatment of general waste water conforming to the Tunisia Standard can be executed at ONAS or not, while only waste water of inferior quality is treated in small-scale factories.

The flow of treatment at ONAS sewage treatment plant is given in Fig. -11.

Fig. - 11 Block Flow of ONAS Sewage Treatment Plant



ONAS treatment plant can treat waste water of 20,300m^3 daily (a mean daily waste water treatment). According to the record of discharged water quality, the measured values of some items exceed the limit of the Tunisia Standard. Under the present conditions, it is impossible to treat entire waste water of object factories. The partial modification of facilities is required.

Table-1(1) Result of Water Analysis

A. PRIMARY ANALYSIS (44 POINTS)

SAMPLING POINT	SAMPLING DATE	ANALYSIS ITEMS(8)							
		TURBIDITY	p H	CONDUCT'TY	S. SOLID	C O Dcr	B O D	n-HEX	D O
		deg.		ms/cm	mg/L	mg/L	mg/L	mg/L	mg/L
SPE-01	10/07/92	2	7.2	5.7	4	<6		5	1
SPE-01	15/07/92	13	7.2	5.5	5		1		1.4
SPE-11	10/07/92	130	2.0	22.0	82	190	--	3	4.5
SPE-11	15/07/92	51	2.0	19.9	29	120	--	4	3.7
SPE-13	10/07/92	30	1.2	48.0	10	240	--	16	3.5
SPE-13	15/07/92	6	1.3	38.7	2	240	--	4	3.5
SPE-14	10/07/92	2	1.1	59.0	3	350	9	3	6.8
SPE-14	15/07/92	6	1.2	57.7	4	270	--	9	2.8
SPE-17	10/07/92	>999	2.1	18.0	31000	8700	--	4	5.7
SPE-17	15/07/92	>999	2.0	19.5	210000	5400	2200	39	1.5
SPE-18	10/07/92	110	7.3	8.9	160	190	--	3	4.6
SPE-18	15/07/92	50	9.0	6.7	66	210	130	3	3.6
SPE-19	10/07/92	25	1.6	24.0	60	220	--	10	4.2
SPE-19	15/07/92	10	1.7	20.1	11	220	--	5	3.8
SPE-20	10/07/92	14	1.8	19.0	27	260	400	6	3.9
SPE-20	15/07/92	6	1.9	14.7	7	470	--	11	3.8
SND-11	10/07/92	79	7.9	62.0	60	240	290	60	0.4
SND-12	10/07/92	72	7.3	51.0	20	550	140	34	0.5
SND-13	10/07/92	63	7.4	57.0	10	510	150	57	0.3
SZT-01	11/07/92	10	7.5	2.4	<1	6	5	3	4.8
SZT-01	14/07/92	0	7.7	2.1	<1	2	5	-	4.2
SZT-09	11/07/92	10	6.7	21.9	1	24	3	3	2.4
SZT-09	14/07/92	1	6.9	14.0	18	170	33	-	2.3
SZT-11	11/07/92	6	7.7	16.9	8	230		2	3.3
SZT-11	14/07/92	1	7.8	17.9	5	530	30	4	3.5
SZT-12	11/07/92	1	4.3	14.2	36	2000	700	23	3.3
SZT-12	14/07/92	20	4.6	15.6	57	2000	12	39	
SZT-13	12/07/92	>999	8.9	14.0	220000	170000	27000	18000	0.3
SZT-13	14/07/92								
SZT-14	11/07/92	695	6.3	2.5	20000	65000	23000	1800	1.8
SZT-14	14/07/92								
SZT-15	11/07/92	31	7.5	30.6	28	1600	160	14	0.7
SZT-15	14/07/92	27	7.8	24.5	26	1600	13	5	0.3
SZT-16	11/07/92	>999	12.3	91.7	740	44000	16000	9800	0.5
SZT-16	14/07/92	>999	12.6	>100	2600	29000	13000	5500	0
SZT-17	11/07/92	715	11.7	35.0	590	620	140	34	2.3
SZT-17	14/07/92	980	12.0	58.3	1300	550	450	20	1.5
SZT-18	11/07/92	10	8.5	2.6	1	130	26	4	4.9
SZT-18	14/07/92	2	8.0	2.5	1	32	170	4	3.9
SZT-19	11/07/92	110	5.7	14.0	70	940	530	4	3
SZT-19	14/07/92	700	6.1	14	2900	6400	2300	33	0.2
SZT-20	11/07/92	10	6.8	2.4	4	64	6	6	5
SZT-20	14/07/92	165	7.8	2.3	3	330	250	27	

Table-1(2) Result of Water Analysis

A. PRIMARY ANALYSIS (44 POINTS)

SAMPLING POINT	SAMPLING DATE	ANALYSIS ITEMS(8)							
		TURBIDITY	p H	CONDUCT'TY	S.SOLID	C O Dcr	B O D	n-HEX	D O
		deg.		ms/cm	mg/L	mg/L	mg/L	mg/L	mg/L
SMC-01	09/07/92	94	7.4	12.5	1	15	1	<1	
SMC-01	14/07/92	0	7.1	12.0	<1	27	16	--	3.5
SMC-11	09/07/92	>999	6.8	18.4	2700	50000	5200	270	
SMC-11	14/07/92	500	7.1	15.0	99	4600	13000	210	1.9
SMC-12	09/07/92	>999	>12	25.3	7200	740000	170000	260	
SMC-12	14/07/92	>999	12.0	18.0	9700	8800	6000	310	0.1
SMC-13	09/07/92	>999	8.7	31.1	1700	550000	59000	490	
SMC-13	14/07/92	>999	8.4	25.7	820	6000	112000	510	1.9
SMC-14	09/07/92	>999	8.7	16.5	3200	640000	170000	42000	
SMC-14	14/07/92	>999	8.4	12.5	1300	190000	140000	41000	6.4
SMC-15	09/07/92	>999	8.4	15.6	420	48000	8000	330	
SMC-15	14/07/92	>999	7.8	13.0	440	4100	2700	230	1.5
SMC-16	09/07/92	288	3.0	77.6	360	11000	2400	260	
SMC-16	14/07/92	440	3.6	76.0	180	720	1900	330	1.4
TMC-01	09/07/92	3	7.7	2.0	2	8	0.4	2	
TMC-01	14/07/92	0	6.6	2.3	0.8	4			5.4
TMC-11	09/07/92	>999	3.2	36.0	690	9700	7	990	
TMC-11	14/07/92	>999	3.4	27.0	260	7200	2300	1200	4.3
TMC-12	09/07/92	>999	4.9	36.0	690	5300	1200	810	
TMC-12	14/07/92	>999	5.0	31.0	280	10000	1800	1600	4.3
TMC-13	09/07/92	63	3.6	25.0	54	6400	2900	21	
TMC-13	15/07/92	125	3.2	19.3	37	10000	6500	19	3.9
STS-01	10/07/92				<1	<6	0.1	3	
STS-01	15/07/92	0	8.0	2.3	<1	<6	<6	--	4.8
STS-13	10/07/92	>999	10.3	17.0	770	19000	--	760	
STS-13	15/07/92	>999	11.3	22.0	110	2.1	48000	400	0
STS-16	10/07/92	0	8.8	2.6	12	160	--	3	
STS-16	15/07/92	20	9.8	2.9	6	410	130	4	4.2
STS-19	10/07/92	>999	5.4	2.6	30000	130000	1	230	
STS-19	15/07/92	>999	7.8	2.8	37000	160000	100000	7	0.7
STS-20	10/07/92	28	11.3	12.0	36	510	--	7	
STS-20	15/07/92	10	11.1	5.2	13	54	47	200	4.2
STS-21	09/07/92	10	7.3	34.0	<1	2000	--	4	
STS-21	15/07/92	0	7.3	35.0	2	15	7	--	4.6
ONS-11	10/07/92	220	7.3	6.2	100	240	45	9	1.4
ONS-11	13/07/92	180	7.6	5.0	200	360	230	73	0.5
ONS-11	14/07/92	650	7.3	4.6	770			140	0
ONS-11	16/07/92	160	7.6	6.0	150	340	280	--	0.6
ONS-12	10/07/92	220	7.8	5.5	140	210	39	7	0.5
ONS-12	13/07/92	200	7.8	5.3	110	190	71	12	2.3
ONS-12	14/07/92	230	7.7	5.2	130			9	1.8
ONS-12	16/07/92	280	7.8	5.3	130	280	160	--	4.6
ONS-13	10/07/92	120	7.9	5.5	13	410	74	4	2.3
ONS-13	13/07/92	150	7.8	5.2	42	230	43	8	3.8
ONS-13	14/07/92	180	7.8	5.2	50			4	3.7
ONS-13	16/07/92	200	7.9	5.5	24	210	86	--	4.5
MRG	10/07/92	>999	4.8	32.0	3200	180000	27000	320	0.2
MRG	14/07/92	>999	4.6	--	6000		74000	290	0

Table-2 Result of Exhaust Gas Analysis

EXHAUST GAS ANALYSIS (1)

FACTORY	S T S		S I O S - Z I T E X							
SAMPLING POINT	STS-51	STS-52	SZT-51	SZT-52	SZT-53	SZT-54	SZT-54	SZT-55	SZT-56	SZT-57
SAMPLING DATE	JUL/7/92	JUL/7/92	JUL/13/92	JUL/13/92	JUL/13/92	JUL/14/92	OCT/1/92	JUL/15/92	JUL/14/92	JUL/15/92
FACILITY	BOILER	BOILER	R. KILN	R. KILN	R. KILN	BOILER	BOILER	BOILER	BOILER	BOILER
FUEL	H. OIL	H. OIL	GRIGNON	GRIGNON	GRIGNON	GRIGNON	GRIGNON	GRIGNON	GRIGNON	H.OIL
GAS VOLUME										
ACTUAL m3/h	2870	720	13100	11500	12000	12400	16100	2020	6250	1860
WET GAS Nm3/h	1370	380	11000	9830	10200	8280	10100	1670	3850	1370
DRY GAS Nm3/h	1230	350	10000	9130	9400	7830	9500	1540	3570	1240
H2O %	10.5	7.9	8.8	7.1	8.2	5.5	5.6	7.7	7.2	9.4
GAS TEMP. ℃	298	248	52	46	48	137	163	58	170	99
CO2 %	7.8	11.6	0.3	0.3	0.9	4.9	4.8	1.8	2.6	10.0
O2 %	11.0	8.2	19.9	20.3	19.9	15.7	15.2	18.7	17.8	8.0
DUST mg/Nm3	1200	1000	43	160	100	2800	3100	1900	720	1300
SOx ppm	560	900	<11	<11	<11	<11	21	<11	<11	1000
NOx ppm	170	180	<12	<12	22	46	63	22	55	290

EXHAUST GAS ANALYSIS (2)

FACTORY	S A T H O P				SIAPE(H2SO4)				SIAPE(H3PO4)	
SAMPLING POINT	STP-51	STP-52	STP-53	STP-53	SPE-51	SPE-52	SPE-53	SPE-53	SPE-54	SPE-55
SAMPLING DATE	SEP/11/92		SEP/11/92	OCT/1/92	SEP/24/92	SEP/23/92	SEP/24/92	SEP/30/92	SEP/29/92	SEP/29/92
FACILITY	R. KILN	R. KILN	BOILER	BOILER	750-ABSORB	CIRC. TANK	300-ABSORB	300-ABSORB	SCRUB. IN	SCRUB. OUT
FUEL	GRIGNON	GRIGNON	GRI./OIL	GRIGNON	---	---	---	---	---	---
GAS VOLUME										
ACTUAL m3/h	4410		43800	42100	135000	300	41600	45600	75100	75200
WET GAS Nm3/h	3770		28500	25000	107000	240	31100	34000	58800	58600
DRY GAS Nm3/h	3100		26900	23300	107000	240	31000	34000	34800	34800
H2O %	17.9		5.6	6.7	0.1	0.5	0.1	0.2	40.8	40.5
GAS TEMP. ℃	46		147	186	73	73	92	92	77	77
CO2 %	5.6		5.6	4.2	0	0	0	0	6.4	6.3
O2 %	15.4		15.4	14.8	9.2	18.1	11.7	12.6	19.8	20.0
DUST mg/Nm3	1360		360	610	770	700	230	110	30	60
SOx ppm	7		110	38	4100	3300	2100	1620		
NOx ppm	19		16	30	11	<10	<10	<10		
TOTAL MIST mg/Nm3									47700	7000
H2SO4 MIST mg/Nm3					250	630		140	700	170
H3PO4 MIST mg/Nm3									40	22
F COMPOUND mg/Nm3									3900	1510
F MIST mg/Nm3									330	62

EXHAUST GAS ANALYSIS (3)

FACTORY	S I A P E (TSP)										(BOILER)
SAMPLING POINT	SPE-56	SPE-57	SPE-58	SPE-59	SPE-60	SPE-61	SPE-62	SPE-63	SPE-64	SPE-65	SPE-66
SAMPLING DATE		SEP/17/92	SEP/18/92	SEP/18/92	SEP/16/92	SEP/14/92	SEP/14/92	SEP/15/92	SEP/15/92	OCT/21/92	OCT/28/92
FACILITY	TSP500-IN	TSP500-OUT	TSP500-IN	TSP500-OUT	TSP-MAIN	TSP600-IN	TSP600-OUT	TSP600-IN	TSP600-OUT	TSP-SUB	E.G/BOILER
FUEL	H.OIL	H.OIL	H.OIL	H.OIL		H.OIL	H.OIL	H.OIL	H.OIL	---	H.OIL
GAS VOLUME											
ACTUAL m3/h		76800	93100	64200	6300	119000	115000	121000	108000	3540	16700
WET GAS Nm3/h		62200	63700	52900	5100	79900	84700	79800	85400	2960	10300
DRY GAS Nm3/h		50300	50300	43400	4200	57900	61200	60900	64100	2610	9500
H2O %		19.1	21.0	17.9	18.3	27.5	27.8	23.7	24.9	11.9	7.7
GAS TEMP. ℃		64	130	58	66	138	98	145	73	53	169
CO2 %		2.0	2.4	2.3	46.0	3.0	2.5	2.3	2.2	2.0	4.2
O2 %		18.6	17.6	17.7	12.0	15.9	16.5	18.5	18.3	19.4	14.6
DUST mg/Nm3		290	580	310	890	1220	1110	580	1000	30	140
SOx ppm		220	400	260	1100	560	550	400	520	135	800
NOx ppm											108
TOTAL MIST mg/Nm3		---		1500			---		---		
H2SO4 MIST mg/Nm3											
H3PO4 MIST mg/Nm3				91							
F COMPOUND mg/Nm3		154	1850	130	33	1780	1250	1540	400	33	
F MIST mg/Nm3				64							

VOLUME IV PROPOSAL ON PRODUCTION PROCESS

We conducted hearing and interview to acquire various kinds of data in this study to make a proposal on improving the production process from the viewpoint of environmental pollution control, but data is not well pigeonholed in all factories.

Before we discuss the proper subjects of each factory, we summarize the importance of data as follows.

① Method of numerical analysis in production process

- Importance of data in production process
- Method of data arrangement
- Utilization of data

② Introduction of Japanese production control

- Features of Japanese production control
- Basic concept of quality control
- Cycle of control
- Application of QC method to improve the conditions of job site

1. SIAPE

We made the following proposal to SIAPE on sulfuric acid, phosphoric acid and TSP plants.

(1) Sulfuric Acid Plant

① Modification from SCSA method to DCDA method

This allows to take a measure to collect efficiently SO_2 emitted from the plant for environmental pollution control.

(2) Phosphoric Acid Plant/TSP Plant

① Switching to more efficient scrubber

The present scrubber is inferior in gas-liquid contact performance. Improving the present scrubber to a more efficient one which decrease the volume of F emitted into the atmosphere.

② Application of recycled water to the filters used in the phosphoric acid plant.

About 100m^3 of well water is used hourly as supply water to the filters. Waste water from the TSP scrubber is treated and used as supply water to the filters.

(3) Others

Since the following methods require a change in production process or huge expenses for facilities, we will only give informations.

1) Recovery of F

- Recovery of F from the phosphoric acid concentrator

2) Utilization of gypsum from Tabia

- Filler for NPK fertilizer
- Production of sulfuric acid
- Production of ammonium sulfate

2. SNDP

We have pointed out the following items as the causes of oil leakage.

- Leakage from tanks and pipelines
- Drain from oil separator tank

However, SNDP initiated the examination of corrective actions against oil leakage and construction work for improvement. Therefore, we introduced the "Safety Standards of Storage Tanks for Dangerous Materials" in order to maintain and control storage tanks to be used for a large volume of dangerous materials.

3. UPOTS

Margin produced in olive oil factories is a source of serious problem common to all oil manufacturing countries. Accordingly, we have summarized various kinds of oil production methods and margin treatment methods which are prevailing in each country.

We have proposed the following points as the basic conception of treating margin. Since the treatment of margin at small factories may affect the basis of their business operation, it is recommended to carry out the integrated treatment of margin.

4. SIOS-ZITEX/(SATHOP)

The two soap factories we investigated were discharging waste water containing a large volume of organic substances. We investigated the facilities to recover glycerin with an intention to collect valuables. The scales of recovering facilities in both factories are almost similar, and their features are as follows.

• Original waste water to be treated:	7,000 kg/day
• Recovered glycerin:	320 kg/day (recovery rate: 91%)
• Annual recovery volume:	105.6 tons/year (0.32 × 330 days)
• Expenses for facilities:	¥203 million
• Selling price:	¥270/kg

As a result, the production cost exceeds the selling cost, investment on these facilities and equipment seems doubtful. Therefore, it is important not to install facilities to recover valuables from waste water but to examine the operation method to decrease the discharge of waste water containing valuables.

5. SMCP/TMC

SMCP/TMC are constructing waste water treatment facilities and making efforts to cope with environmental pollution control intensively. The measure to be taken now is the recovery of chromate.

Therefore, we have introduced the trend of recovering chromate in the world. It is not profitable to recover chromate if the scale of enterprise is not large. It is always required to examine carefully profitability in recovering chromate.

6. STS

For the STS or a dyeing factory, we introduced several examples of corrective actions for energy saving and improvement of waste water quality in Japanese dyeing factories.

VOLUME V PRECONDITIONS OF WASTE WATER TREATMENT PLAN

1. Setting of Waste Water Quality Standard

In Tunisia INNORPI was settled as the standard for waste water. The standard contains very severe numerical values, and we felt in our field survey that all factories were in operation without observing the INNORPI standard. We concluded in this study that it would be difficult to aim at the standard at once under these circumstances.

For this reason, the Japanese side proposed a system to adopt a loose standard temporarily and then achieve the final target by stages, meanwhile a tentative plan was also proposed from the Tunisian side. Therefore, the standards to be examined include two tentative standards (Japanese proposal and Tunisian proposal) and the INNORPI standard, and these standards are given in Table-3. The three standards include six cases, because values vary depending on the discharge destinations, i.e. sea area and sewage treatment plant. However, since the tentative standard proposed by the Tunisian side includes the same values of the INNORPI standard with regard to waste water discharged into the sea area, thus the cases are five in total.

Table-3 Waste Water Quality Standard

		TENTATIVE STANDARD (JAPAN PROPOSAL)		TENTATIVE STANDARD (TUNISIA PROPOSAL)	TUNISIA EMISSION STANDARD (INNORPI)	
		EMISSION TO PUBLIC SEA	EMISSION TO SEWAGE TREAT. PLANT	EMISSION TO SEWAGE TREAT. PLANT	EMISSION TO PUBLIC SEA	EMISSION TO SEWAGE TREAT. PLANT
Cd	mg/l	0.005	0.1	0.1	0.005	0.1
CN	mg/l	0.05	1	0.5	0.05	0.5
ORGANIC P	mg/l	-	1	-	-	-
Pb	mg/l	0.5	1	1	0.5	1
Cr+6	mg/l	0.5	0.5	0.5	0.5	0.5
Cr+3	mg/l	2	2	2	2	2
As	mg/l	0.1	0.5	0.1	0.1	0.1
Hg Total	mg/l	0.001	0.01	0.01	0.001	0.01
pH		6.5-8.5	5.0-9.0	5.0-9.0	6.5-8.5	6.5-9
SS	mg/l	30	800	500	30	400
BOD	mg/l	30	800	800	30	400
COD Cr	mg/l	90	2000	2000	90	1000
OIL	mg/l	20	50	50	20	30
MINERAL	mg/l	10	-	-	10	10
NON MINERAL	mg/l	-	-	-	-	-
PHENOL	mg/l	*0.05*	5	5	*0.05*	1
Cu	mg/l	1.5	3	3	1.5	1
Zn	mg/l	10	10	10	10	5
Fe	mg/l	1	10	10	1	5
Mn	mg/l	1	10	3	1	1
F	mg/l	5	15	15	5	3
S	mg/l	2	-	-	2	3
COLON BACILLUS		2,000 /100ml	-	-	2.000 /100ml	
STREPTOCOCCUS		1.000 /100ml	-	-	1.000 /100ml	
SALMONELLA		ABSENCE	-	-	ABSENCE	
TEMP.	°C	35	-	-	35	35
Cl	mg/l	-	-	*2000*	-	*700*
Cl2	mg/l	0.05	-	-	0.05	1
ClO2	mg/l	0.05	-	-	0.05	0.5
SO4	mg/l	-	-	1000	1000	400
PO4	mg/l	0.1	-	-	0.1	10
Mg	mg/l	2000	-	-	2000	300
K	mg/l	1000	-	-	1000	50
Na	mg/l	-	-	-	-	1000
Ca	mg/l	-	-	-	-	-
Al	mg/l	5	-	-	5	*10*
COLOR		100	-	-	100	-
NO3	mg/l	90	-	-	90	90
NO2	mg/l	5	-	-	5	10
NH4-N	mg/l	*30*	-	-	*30*	*100*
T-N	mg/l		-	-		
				-		

The difference in the three standards is summarized as follows.

- INNORPI standard prescribes more than 50 items.

  Sea area: Salt (SO_4) is specified.

  Sewage treatment plant: Severe as a whole

- Tentative standard proposed by Tunisia

  Sea area: Same with INNORPI

  Sewage treatment standard: Similar to tentative standard proposed by Japan, and salt (Cl and SO_4) are specified.

- Tentative standard proposed by Japan

  Sea area: Salt (Cl and SO_4) are excluded. As to others, the INNORPI standard applied.

  Sewage treatment standard: Specified items were reduced and are about two times as loose standard as INNORPI.

In order to proceed the examination of waste water treatment, we divided the above-mentioned standards as follows.

Standard	Discharge	Case No.
• Tentative standard proposed by Japan	Sewage treatment plant	1A
• Tentative standard proposed by Japan	Sea area	1B
• Tentative standard proposed by Tunisia	Sewage treatment plant	2A
• Tentative standard proposed by Tunisia	Sea area	2B
• INNORPI standard	Sewage treatment plant	3A
• INNORPI standard	Sea area	3B

In the long run, the final target is case 3B, the severest of all. However, the examination of facility specifications is directed to both tentative standards, and all cases are examined only for financial and economic analyses.

2. Classification by Quality of Waste Water

Based on the measured values indicated in Table-1 in Volume III, the quality of waste water is classified by the density of organic matter, salt and solid material. The result of classification is given in Table-4.

The judgment of superior or inferior quality waste water is defined by referring to the drainage diagram from this table.

Table-4 Classification of Waste Water by Quality

Organic substance and salinity	Suspended solid matters (SS: mg/l)		
	A. Less solid matters 100 > SS	B. Medium solid matters 400 > SS ≥ 100	C. Highly solid matters SS ≥ 400
1. High concentration of organic matter and high salinity	SZT-12, SZT-15, TMC-13	SMC-16	SPE-17, SZT-13, SZT-16, SZT-17, SZT-19, SMC-11, SMC-12, SMC-13, SMC-14, SMC-15, TMC-11, TMC-12, STS-13, STS-19, MGR
2. High concentration of organic matter and medium salinity			SZT-14
3. High concentration of organic matter and low salinity	SND-12, SND-13		
4. Medium concentration of organic matter and high salinity	SPE-11, SPE-13, SPE-14, SPE-19, SPE-20, SND-11, SZT-11, SZT-20, STS-16, STS-20, ONS-30	SPE-18, ONS-11, ONS-12	
5. Medium concentration of organic matter and medium salinity			
6. Medium concentration of organic matter and low salinity			
7. Low concentration of organic matter and high salinity	STS-21,		
8. Low concentration of organic matter and medium salinity	SZT-18,		
9. Low concentration of organic matter and low salinity			
Remarks	Waste water with high concentration of organic matter: CODcr ≥ 1,000 mg/*l* Waste water with medium concentration of organic matter: 1,000 mg/*l* > CODcr ≥ 100 mg/*l* Waste water with low concentration of organic matter: 100 mg/*l* > CODcr Waste water with high salinity content: EC ≥ 5 ms/cm Waste water with medium salinity content: 5 ms/cm > EC ≥ 0.5 ms/cm Waste water with low salinity content: 0.5 ms/cm > EC For two or more analysis results, the average was used		

3. Preconditions for Planning Waste Water Treatment by Factory

When mapping out a waste water treatment plan, we decided not to conduct the treatment of entire waste water together but conduct an appropriate treatment by rearranging the drainage system in each factory based on the drainage diagram and the result of waste water analysis.

(1) SIAPE

In the entire factory, critical matters are pH, Cd, F, COD, BOD, Fe, SO_4 and P. To treat these materials, the drainage system should be divided into four.

I. Waste water from TSP scrubber → Treatment equipment

→ Sea

II. Waste water from generator and boiler → Treatment equipment

III. Living waste water → ONAS

IV. Excess and over flow → Restriction of water-intake

(2) SNDP

We excluded SNDP from our study on waste water treatment, because various kinds of construction works are in progress including the betterment of waste water treatment.

(3) UPOTS

Waste water from UPOTS contains margin which is produced 50 m^3 daily (5,000 m^3 yearly). Margin from olive oil factories in the Sfax district totals 100,000 m^3 yearly and are transported to ONAS. Taking a scale merit of treatment into account, we propose to conduct the primary treatment of waste water from the entire Sfax district before it is discharged to ONAS.

(4) SIOS-ZITEX

This factory has such critical matters as pH, SS, COD, N-Hex, Cl and SO_4. When treating them, it is effective to separate waste water containing high-density COD from waste water containing low-density COD.

I. Waste water from extraction, refinery, soap production processes (high-density COD)

II. Cooling water, waste water from boilers and softeners, and living waste water (low-density COD)

We also examine for reference the case where glycerine is recovered from soap production process.

(5) SATHOP

We decided to treat waste water by separating the drainage into two systems as for SIOS-ZITEX, and we also examine for reference the case to recover glycerine from soap production process.

(6) SMCP/TMC

SMCP and its new factory TMC should be integrated in processing waste water. We set the volume of waste water to 300 m^3 daily with due regard to future extension.

(7) STS

COD, Cl and SO_4 are critical matters at STS. To treat them, we propose to divide the drainage into three systems.

I. Waste water from dyeing process (high-density COD)

II. Waste water from softeners (high-density salt)

III. Other kinds of waste water

(8) ONAS

To execute environmental pollution control at the selected factories of this study immediately, we considered it necessary to lighten the burden of each factory and transfer a part of its burden to the public sewage treatment plant, and proposed the Japanese tentative plan. This shows that waste water discharged from each factory conforms to the tentative standard and meets the requirements of the INNORPI standard at the outlet of the ONAS waste water treatment plant.

At this time, the contamination load on ONAS increases, so that facilities at ONAS should be improved to comply with it.

Moreover, the record of waste water treated by the existing ONAS treatment facilities shows that the requirements of the INNORPI standard are not satisfied. For this reason, we propose to examine the draft of environmental pollution control to meet the treatment of COD, BOD and SS.

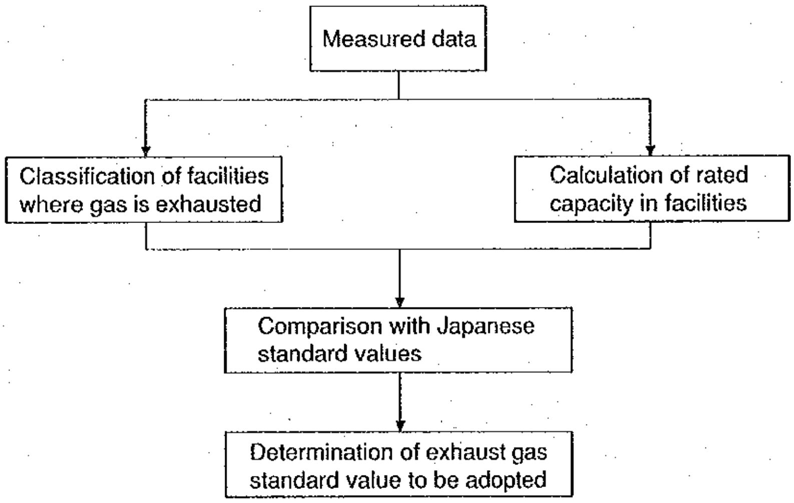
VOLUME VI PRECONDITIONS OF EXHAUST GAS TREATMENT PLAN

1. Setting the Standard for the Emission of Exhaust Gas

In Tunisia the INNORPI standard regulates waste water, but no standard applies to exhaust gas in this study. Only a standard is now under investigation to regulate exhaust gas.

Therefore, we adopted an exhaust gas emission standard in this study conforming to the Japanese Air Pollution Control Law. The standard for emission has been set up in the procedure below.

Fig. -12 Emission Standard Establishing Procedure



Following the above-mentioned procedures, we determined the emission standard for particles of soot, NOx and fluorine. We also determined the K-value to control SOx. The emission standard of exhaust gas varies depending on the type and capacity of facilities in each factory, and the standard values of all facilities we measured are as follows.

- Particles of soot: 0.20-0.40 g/Nm^3 (residual oxygen density considered)
- NOx: 230-650 ppm (residual oxygen density considered)
- F: 10-15 mg/Nm^3
- SOx: K-value regulation, K=17.5

2. Preconditions of Exhaust Gas Treatment Facility Plan

Based on the standard values, we set up the exhaust gas treatment capacity for the facilities whose measured values exceeded the standard with the following preconditions.

① The heavy oil burning boiler and drying furnace is improved by 5% over the present rated capacity.

② The grignon burning boiler is a special incinerator for waste, and a 5% allowance of capacity is provided over the rated capacity.

③ As to the PA and TSP scrubbers at SIAPE, the capacity is improved by 5% over the measured volume of exhaust gas. For the TSP scrubber, the capacities of 500 ton and 600 ton systems are provide for each systems.

④ The capacity of the SZT-56 and SZT-57 are integrated because there are two facilities: the capacity of one facility was measured and capacity of another facility was not measured.

⑤ The STP-52 and STP-51 have the same capacities.

The results are given in Table-5.

Table-5 Capacity of Exhaust Gas Treating Facilities

Factory Name	Sampling Point	Equipment Measured	Treatment Capacity m3/h	Measuring Data				SOx	NOx		Particele of Soot		F
				SOx Nm3/h	NOx ppm	Dust mg/Nm3	F mg/Nm3	Calculated Value(K=17.5) Nm3/h	Standard Value ppm	Residual Oxygen %	Standard Value mg/Nm3	Residual Oxygen %	Standard Value mg/Nm3
S T S	STS-51	H.Oil Boiler	1,500			2.040			250	4.0	300	4.0	
S T S	STS-52	Oil Heater	600			1.328			250	4.0	300	4.0	
SIOS-ZITEX	SZT-54	Grignon Boiler	4.800			7,925			480	6.0	400	6.0	
	SZT-54	Grignon Boiler	6.400			8.017			480	6.0	400	6.0	
	SZT-55	Grignon Boiler	1,800			12.391			480	6.0	400	6.0	
	SZT-56	Grignon Boiler	1,300			3,375			480	6.0	400	6.0	
	SZT-57	H.Oil Boiler	2.000		411	1,700			250	4.0	300	4.0	
SATHOP	STP-51	Grignon dryer	3.600			1,360			250	16.0	400	0s	
	STP-53	Gri. H.Oil Boiler	21.000			964			480	6.0	400	6.0	
	STP-53	Gri. H.Oil Boiler	21.000			1,476			480	6.0	400	6.0	
S I A P E	SPE-51	750 SA Absorber	190,000	439		770		98	250	14.0	300	0s	
	SPE-53	300 SA Absorber		65				32	250	14.0	400	0s	
		300 SA Absorber	43,000	55				33	250	14.0	400	0s	
	SPE-55	PA Scrubber Out	37.000				1,510		650	15.0	– – –		10
	SPE-57	500TSP Scrubber Out	98.000			290	154		250	16.0	200	0s	15
	SPE-59	500TSP Scrubber Out				310	130		250	16.0	200	0s	15
	SPE-62	600TSP Scrubber Out	130,000			1,110	1,250		250	16.0	200	0s	15
	SPE-64	600TSP Scrubber Out				1,000	400		250	16.0	200	0s	15
	SPE-66	H.Oil Boiler	25,000		262	372			190	4.0	200	4.0	

VOLUME VII FACILITIES AND IMPLEMENTATION PLAN

1. Selection of Waste Water Treatment Facilities

When selecting waste water treatment facilities, we compared them according to the selected items of water quality.

(1) Suspended Solids

The selected items of waste water quality generally are SS, suspended BOD, COD and oil. The treatment method includes coagulating sedimentation, pressure flotation and sand filtration. Among them, we selected coagulating sedimentation because treated water is stable and easy to maintain.

(2) Organic Matter Treatment

The selected items of water are organic matters represented by COD and BOD. The biological treatment is appropriate for the treatment of waste water. Biological treatment is divided into aerobic treatment (activated sludge process and lagoon process) and anaerobic method. In order to apply biological treatment to the after-treatment of coagulating sedimentation, we selected activated sludge process in this study because treated water is stabler. Additionally, margin is treated in a combination of anaerobic process and activated sludge process because organic matter is significantly high in density.

(3) Salt Treatment

This is a method to eliminate salt (Cl and SO_4 in this study) contained in water. The removal of salt is usually adopted in producing water to drink from seawater. It is very rare to eliminate salt from waste water to be discharged.

The salt removing method includes reverse osmosis filtration, ion exchange, evaporation process. In spite of variation in the density of salt contained in raw water, we selected reverse osmosis filtration which stabilizes the density of salt in treated water.

2. Selection of Exhaust Gas Treatment Facilities

We selected exhaust gas treatment facilities by dividing them into two categories: (a) exhaust gas from production equipment and (b) exhaust gas of combustion equipment.

(1) Treatment Facilities of Exhausted Gas Emitted from Production Equipment

1) Sulfuric Acid Plant

Changing from the SCSA method to the DCDA method increases the conversion rate of SO_3 and improves the production unit figure of sulfuric acid. As a matter of fact, this will restrain currently discharged SOx.

2) Phosphoric Acid and TSP Plants

Scrubbers are installed in both plants, but the discharge of F exceeds the standard. Therefore, existing scrubbers should be changed by new scrubbers which feature a function of liquid and gas contact.

(2) Treatment Facilities of Exhaust Gas Emitted from Combustion Equipment

Critical matters contained in exhaust gas emitted from combustion equipment are particles of soot, and NOx. In the point of oil burning boilers of SZT-57 and SPE-66, NOx exceeds the standard. These can be complied with by using low NOx burners, but if existing facilities are operated properly or existing burners are well adjusted, NOx can be maintained below the standard value. Therefore, we propose to examine a facility for removing particles of soot. Electric dust collectors, bag filters and cyclone separators are available as equipment to remove particles of soot.

From the characteristics of particles of soot, we selected a cyclone.

3. Facility Plan

3.1 *Waste Water Treatment Facility Plan*

The list of facilities planned for waste water treatment is given in Table-6.

3.2 Exhaust Gas Treatment Facility Plan

(1) Facility to treat exhaust gas emitted from the production process.

1) Sulfuric acid plant: DCDA method is adopted.

2) Phosphoric acid plant: Washing scrubber (TCA tower)

3) TSP plant: Washing scrubber (TCA tower)

(2) Facility to Treat Exhaust Gas Emitted from the Combustion Equipment

1) SIAPE: Multicyclone 1 unit

2) SIOS-ZITEX: Multicyclone 4 units

3) SATHOP: Multicyclone 3 units

4) STS: Multicyclone 2 units

Table-6 (1) Block Flow of Waste Water Treatment by Factory and by Case

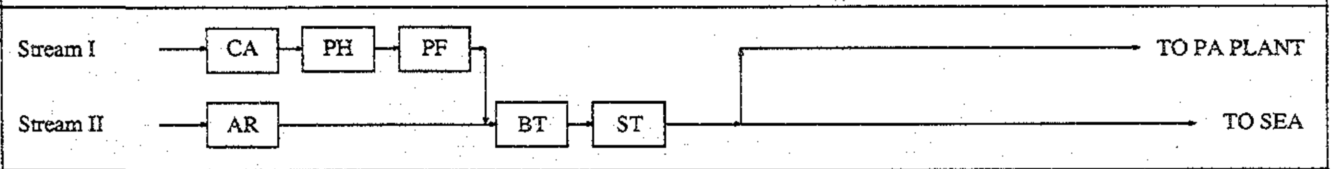
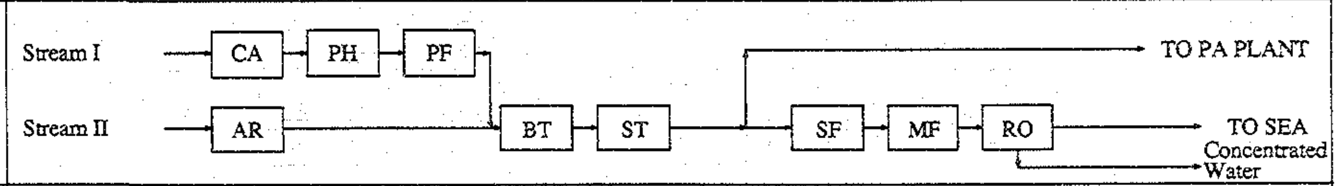
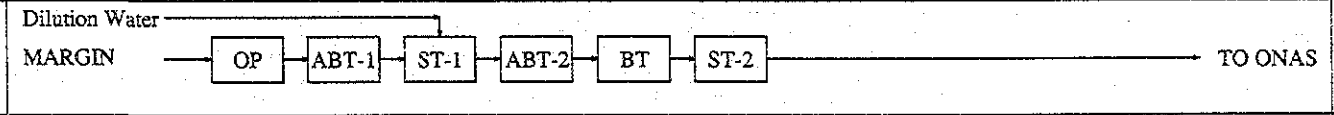
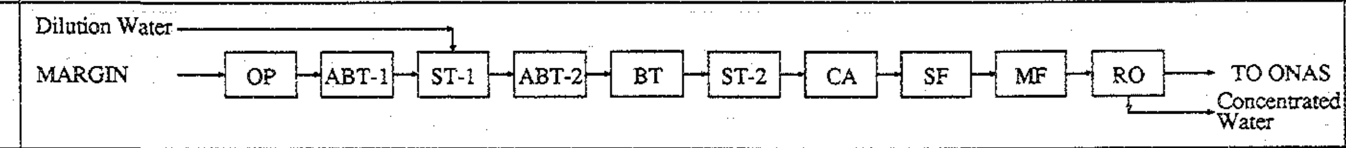
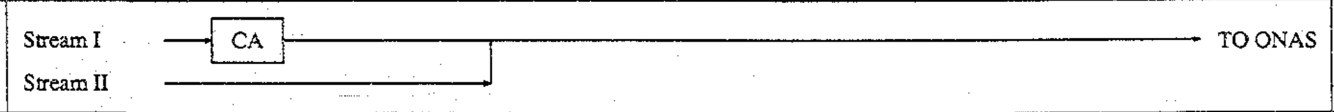
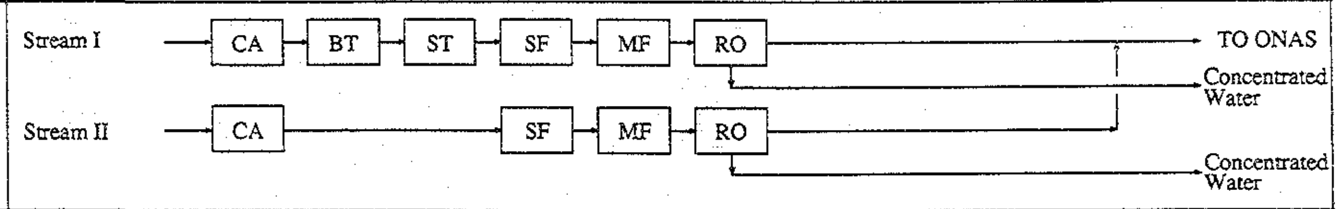
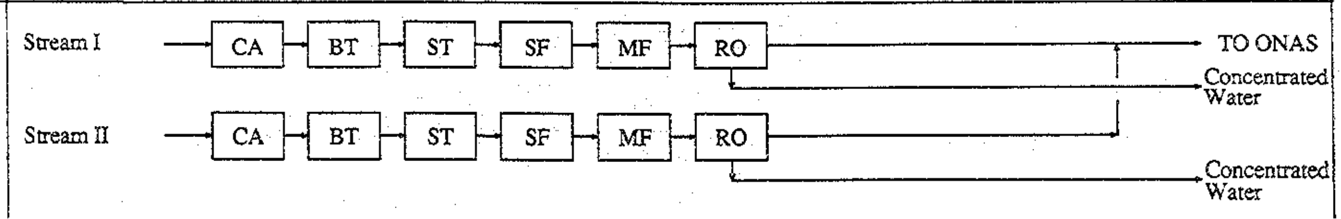
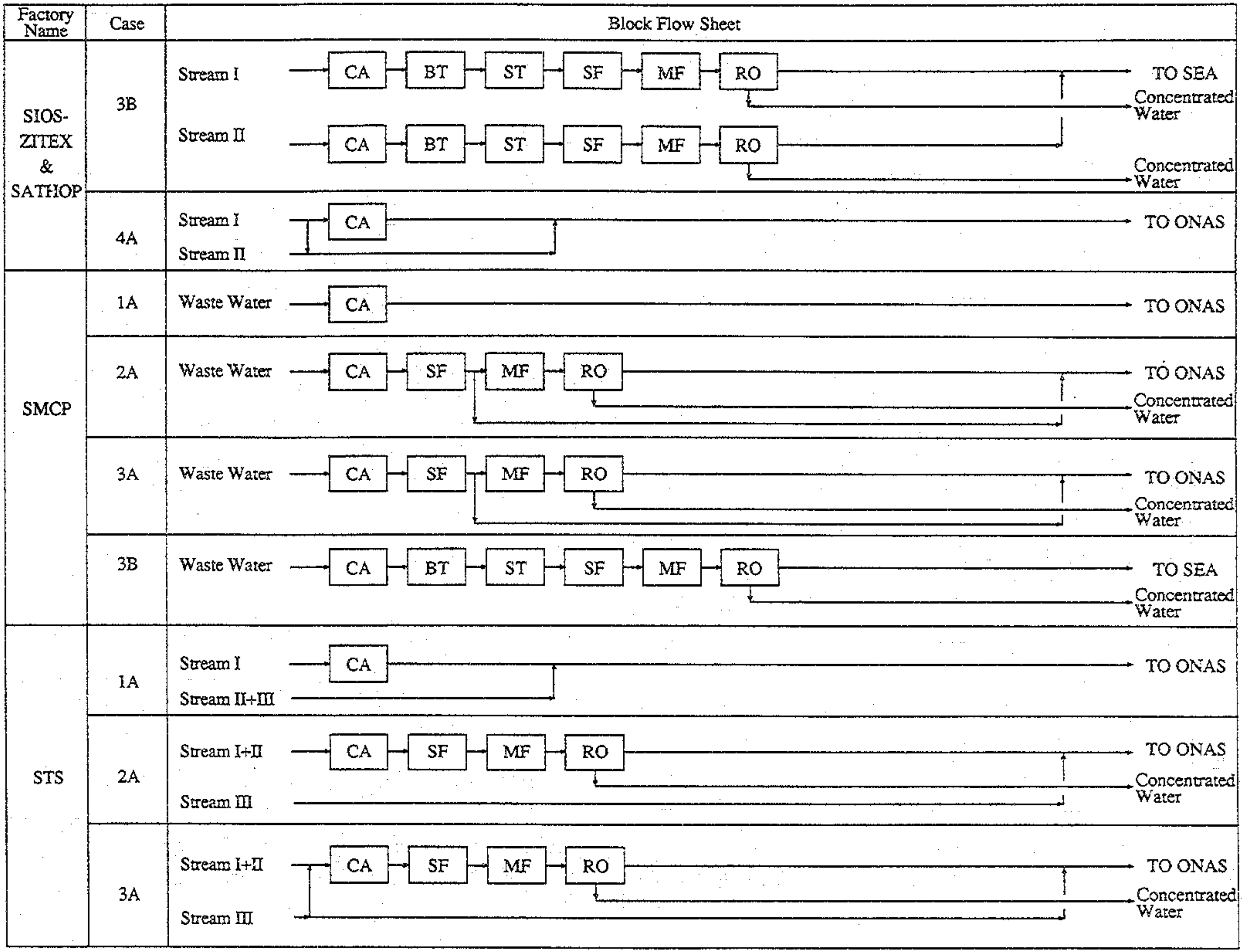
Factory Name	Case	Block Flow Sheet
SIAPE	1B	
	2B 3B	
UPOTS	1A	
	2A 3A	
SIOS- ZITEX & SATHOP	1A	
	2A	
	3A	

Table-6 (2) Block Flow of Waste Water Treatment by Factory and by Case



4. Implementation Plan

4.1 Implementation System and Organization

This study narrowed down to selected factories to prevent environmental pollution in Sfax city and mapped out plan to take measures against it. Therefore, we propose to organize "Sfax Industrial Pollution Prevention Committee" to carry out this project.

(1) Members of Committee

Chairman: Governor of Sfax city or equivalent person

Members: General manager of environment department of Sfax city or equivalent person

Staff of MOE

President of LARSEN – *Mr.* K. MEDHIOUB

Factory manager of each factory or equivalent person

Fishing industry related responsible person

Finance related responsible person

Representative of residents in Sfax city

(2) Period to Organize the Committee

September 1993 - December 1996

(3) Contents of Implementation

① Study on the present condition of environmental pollution in Sfax

② Preparation of written implementation plan

③ Governmental subsidy step and promotion of financing

④ Promotion of implementation plan and schedule control

⑤ Technical guidance for each factory

4.2 Personnel Plan

A personnel plan was made for each factory and case about the operation of facilities.

Assumptions for the personnel plan and the outline are as follows.

(1) Operating personnel of the existing sulfuric acid plant which will be changed to a DCDA method, and the scrubbers of the phosphoric acid and TSP plants which will be also reconstructed will be continuously the operators of the plants reconstructed and therefore new operators were not provided in this plan.

(2) Water quality analysis personnel is necessary for the waste water treatment operation and newly provided.

(3) Current operating personnel of the factories are to take care of the exhaust fume treatment cyclone also and personnel for this purpose was not provided.

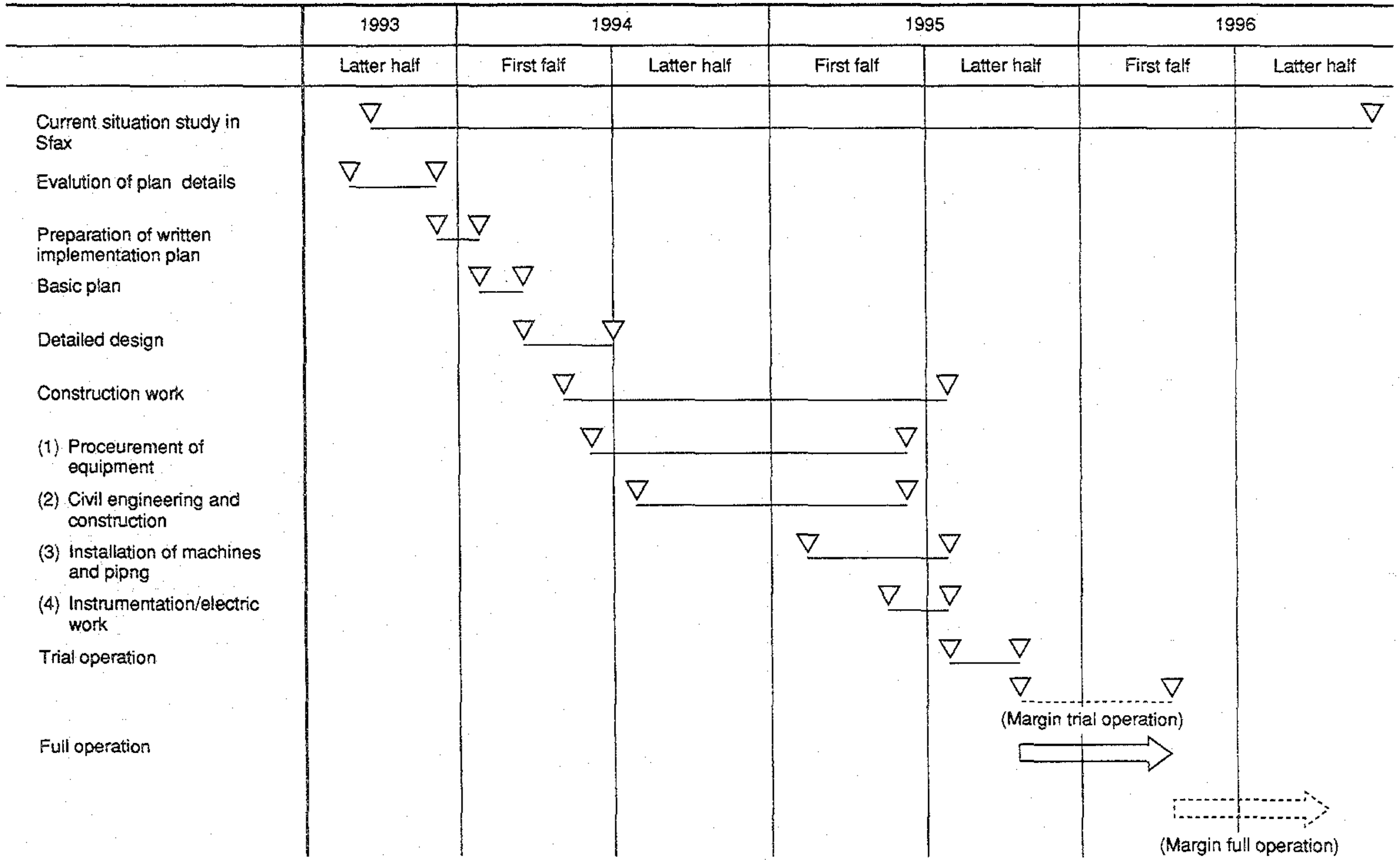
(4) Operating personnel of existing facilities are to take care of ONAS also and any personnel for this purpose was not provided.

4.3 Implementation Schedule

Implementation schedule for this plan is as follows, which is shown in Table -7.

(1) Sfax current situation study:	Oct. '93 - Dec. '96
(2) Evaluation of plan details:	Sept. '93 - Nov. '93
(3) Preparation of written implementation plan:	Nov. '93 - Jan. '94
(4) Basic plan:	Feb. '94 - Mar. '94
(5) Detailed design:	Apr. '94 - June '94
(6) Construction work:	May '94 - July '95
(7) Trial operation:	Aug. '95 - Sept. '95
(Margin:	Oct. '95 - Mar. '96)
(8) Full operation:	Oct. '95 -
(Margin:	April '96 -)

Table-7 Schedule for Industrial Pollution Prevention Plan in Sfax



VOLUME VIII TRIAL CALCULATION OF FINANCIAL AND ECONOMIC PROFIT AND LOSS

As the last of the present study, we made a trial calculation of financial and economic effect of profit and loss on enterprises.

As the investment does not apply to new production facilities, the result of trial calculation should not be used for seeking after the possibility of investment.

The effect of financial and economic profit and loss on each enterprise was calculated by standard as a internal rate of return (IRR) by setting some preconditions.

In the trial calculation of this volume, continuation of each enterprise and observance of the minimum environmental standard were set as preconditions.

Therefore, in trial calculation, we only indicate the effect of financial profit and loss on each enterprise, the necessity of managerial efforts and the importance of governmental subsidiary measures as indices.

1. Total Capital Requirement

1.1 Outline

The total capital requirement consists of the construction cost, pre-operation cost (cost of personnel training, test operation, and office work plus interest during the construction period). The grand total capital requirement of the waste water treatment facilities and exhaust gas treatment facilities is summarized below by application standard.

CASE1: 33,169,000 TD (tentative standard proposed by Japan)

CASE2: 41,716,000 TD (tentative standard proposed by Tunisia)

(Discharge to ONAS, except SIAPE)

CASE3: 42,837,300 TD (INNORPI)

(Discharge to ONAS, except SIAPE)

Table-8 lists the total capital requirement broken down by factory and by case.

1.2 Preconditions

(1) Facility construction cost

Calculated by the following procedure based on result of a conceptual design:

1) By cumulative calculation as of April 1993 in Japanese price

2) Conversion into Tunisian price

  - The ratio between the domestic equipment and machinery of Tunisia and the imports was set to 30% and 70%.
  - Price of the imports was set to 90% of the Japanese price, assuming that they come from the neighboring countries of Tunisia.
  - Price of Tunisian domestic products was set to 70% of the Japanese price.
  - Cost of local work

    75% of the Japanese domestic level
  - Exemption from import tax and sales tax (application of Article 7, Law No.88-91)
  - Exchange rate: 1 TD = ¥125 (as of April 1993)

    (1 TD = 0.8085 SDR, 1 SDR = US$1.375, US$ 1= ¥112)

Table-9 summarizes the construction cost of the waste water treatment facilities and exhaust gas treatment facilities.

The indicated scale of margin treatment covers the whole Sfax area. However, the present study is based on the information of UPOTS because information from other enterprises is not available.

(2) Cost of personnel training

- For two months before starting test run (except the margin treatment)
- For three months before starting test run (margin treatment)
- Utility expense, chemicals expense, labor expense, and factory overhead during the training period have been calculated.

(3) Test run cost

1) Period

  - Margin treatment: 6 months
  - Other facilities: 2 months

Table-8 Total Capital Requirement

(Unit:1000 TD)

		Case	Training Expense	Test Operation Expense	Office work cost, etc.	Interest During Constr.	Pre-operating Expense	Con-struction cost	Capital Require-ment
Waste Water Treatment Facilities	SIAPE	1B	3.6	49.8	18.0	206.4	277.7	3,449.4	3,727.1
		2B&3B	3.6	50.9	31.2	366.0	451.7	6,101.2	6,552.9
	UPOTS	1A	13.4	18.4	44.3	692.9	769.0	8,456.0	9,225.0
		2A	13.4	23.9	51.2	806.9	895.4	9,847.6	10,743.0
		3A	13.4	25.2	52.9	834.8	926.3	10,183.2	11,109.5
	STOS-ZITEX	1A	1.6	0.5	2.1	21.0	25.1	354.0	379.1
		2A	2.4	0.9	9.6	108.6	121.4	1,817.7	1,939.1
		3A	2.4	1.1	10.7	122.4	136.6	2,043.0	2,179.6
		3B	2.4	1.1	10.0	113.4	126.8	1,899.0	2,025.8
		4A	3.2	1.5	9.6	108.0	122.3	1,803.0	1,925.3
	SATHOP	1A	2.4	0.6	2.4	22.8	28.1	382.3	410.4
		2A	2.4	1.1	9.8	111.0	124.3	1,856.0	1,980.3
		3A	2.4	1.2	11.0	126.6	141.2	2,114.1	2,255.3
		3B	2.4	1.2	10.7	123.0	137.3	2,054.7	2,192.0
		4A	3.2	0.9	10.0	111.6	125.6	1,868.8	1,994.4
	SMCP	1A	1.6	0.4	4.3	48.0	54.2	800.2	854.4
		2A	2.4	0.7	8.8	100.2	112.1	1,670.2	1,782.3
		3A	2.4	0.7	9.4	106.8	119.3	1,781.6	1,900.9
		3B	2.4	1.0	10.3	118.2	131.9	1,971.3	2,103.2
	STS	1A	0.5	0.1	0.9	9.6	11.1	167.1	178.2
		2A	0.5	0.1	1.6	18.0	20.2	303.4	323.6
		3A	0.5	0.1	2.2	24.6	27.4	416.9	444.3
	ONAS		2.4	3.4	5.2	56.4	67.4	941.0	1,008.4
Exhaust Gas Treatment Facilities	SIAPE		2.4	10.6	77.9	1315.0	1405.8	15,479.9	16,885.7
	SIOS-ZITEX		2.4	0.3	1.4	15.3	19.4	188.5	207.9
	SATHOP		2.4	0.3	1.5	17.9	22.1	210.8	232.9
	STS		2.4	0.0	0.7	4.3	7.4	52.5	59.9

Table-9 Construction Cost

(Unit : 1000 TD)

Facili-ties	Factory	Case	Machine & Equip.	Inciden-tal Equip.	Sub Total	Field Work	Total
Waste Water Treatment Facilities	SAIPE	1B	1735.4	304.6	2040.0	1409.4	3449.4
		2B&3B	4005.2	455.6	4460.8	1640.4	6101.2
	UPOTS	1A	4148.0	408.0	4556.0	3900.0	8456.0
		2A	5134.0	489.6	5623.6	4224.0	9847.6
		3A	5385.6	489.6	5875.2	4308.0	10183.2
	SIOS-ZITEX	1A	129.2	54.4	183.6	170.4	354.0
		2A	1046.2	159.8	1206.0	611.7	1817.7
		3A	1176.4	180.2	1356.6	686.4	2043.0
		3B	1094.8	159.8	1254.6	644.4	1899.0
		4A	513.4	53.0	566.4	1236.6	1803.0
	SATHOP	1A	135.3	64.6	199.9	182.3	382.2
		2A	1023.4	176.8	1200.2	655.8	1856.0
		3A	1175.0	204.0	1379.0	735.4	2114.4
		3B	1102.3	231.2	1333.5	721.3	2054.8
		4A	542.6	64.6	607.2	1261.6	1868.8
	SMCP	1A	349.9	142.8	492.7	307.5	800.2
		2A	1012.9	193.8	1206.7	463.5	1670.2
		3A	1123.7	193.8	1317.5	464.1	1781.6
		3B	1165.5	219.3	1384.8	586.5	1971.3
	STS	1A	52.5	26.4	78.9	88.2	167.1
		2A	155.0	37.4	192.4	111.0	303.4
		3A	230.5	44.2	274.7	142.2	416.9
	ONAS		112.2	414.8	527.0	414.0	941.0
Exhaust Gas Treatment Facilities	SIAPE		11198.4		11198.4	4281.5	15479.9
	SIOS-ZITEX		149.9		149.9	38.6	188.5
	SATHOP		167.3		167.3	43.5	210.7
	STS		40.8		40.8	11.7	52.5

2) Cost

- 60% of the running cost after the operation start has been added.

(4) Factory overhead

0.5% of the construction cost has been appropriated as the factory overhead for the period from early construction period till the personnel training start time. Further, 10% of the personnel training cost and test run cost has been added.

(5) Interest during construction period

1) Division of construction period

Two years' period after the construction start has been divided into four quarters for each year.

2) Criteria for payment: Table-10 lists the criteria

Table-10 Payment Criteria

(Unit: %)

		1st year				2nd year			
		1Q	2Q	3Q	4Q	1Q	2Q	3Q	4Q
Machines & equipment	24 months	30		25			25		20
	18 months	30		20	20		30		
Construction Work	24 months			10	20	20	20	20	10
	18 months		20	20	20	20	20		

3) Fund raising

① Own funds: None

② Public subsidy: Subject to Article 7 of Law No.88-91

③ Loans payable: Interest during the construction period — short-term loans from commercial banks

Other — long-term loans from central bank

4) Interest

① Interest rate: 8% per annum for long- and short-term borrowing

② Repayment condition: After the operation start taking account of corresponding depreciation

2. Operation Cost

The operation cost consists of variable cost and fixed cost. Variable cost includes chemicals expense and utilities expense. Fixed cost includes labor expense, maintenance expense, depreciation, catalyst depreciation, and factory overhead.

For the depreciation, a special depreciation is approved as a subsidiary step by Article 7 of Law No.88-91. Therefore, both ordinary and special depreciation expenses have been financially treated within each fiscal year as the precondition.

Table-11 lists the operation costs.

3. Financial Analysis

(1) Present state analysis of each enterprise

The industrial antipollution countermeasures are a basically non-profit making investment. For the calculation of the economic benefit, all governmental subsidies for the antipollution countermeasures must be expected as the precondition.

Moreover, to determine whether each enterprise is capable of investing for the antipollution measures, the financial state has been analyzed by simulation based on the field survey data, with the following results:

1) The enterprises are managed on a fundamental environment that hardly ensures a long-term and stable production activities.

2) The enterprises are in need of a financial improvement of the organizations, lacking a inner reserve to enable a reinvestment.

3) For the non-profit making investment, a public subsidy is essentially needed both for the funds and running cost.

4) SIAPE has an extremely low gross profit rate of production so that a full simulation is impossible. However, since it is under a governmental management, we assumed some efforts for improvement or subsidies are being made there.

5) Other enterprises have a room for improving the profit level to enable the planned investment.

(2) Major preconditions of financial analysis

1) Objective period: 15 years

2) Basic price level: Fixed price as of 1993 is assumed, expecting no increase

Table-11 Operation Cost

(Unit:1000 TD/Year)

		Case	Utility Expense	Chemical Expense	Labor Expense	Mainte. Expense	Depreci. Expense	Factory Overhead	Catalyst Depreci.	Total
Waste Water Treatment Facilities	SIAPE	1B	66.2	2898.1	21.4	111.8	372.7	50.6		3520.8
		2B&3B	98.1	2933.6	21.4	196.6	655.3	87.3		3992.3
	UPOTS	1A	68.7	23.1	26.8	276.7	922.5	122.6		1440.4
		2A	74.6	54.0	26.8	322.3	1074.3	142.3		1694.2
		3A	76.5	60.8	26.8	333.3	1110.9	147.1		1755.4
	SIOS-ZITEX	1A	5.4	11.0	9.4	11.4	37.9	5.9		80.9
		2A	9.3	28.1	14.2	58.2	193.9	26.6		330.3
		3A	22.6	29.2	14.2	65.4	218.0	29.8		379.1
		3B	21.1	29.4	14.2	60.8	202.6	27.8		355.8
		4A	55.1	11.7	19.0	57.8	192.5	26.9		363.0
	SATHOP	1A	4.9	13.3	9.4	12.3	41.0	6.8		87.6
		2A	20.1	32.1	14.2	59.4	198.0	27.2		351.0
		3A	21.1	33.8	14.2	67.7	225.5	30.7		393.0
		3B	21.1	34.2	14.2	65.8	219.2	29.9		384.3
		4A	13.2	18.4	19.0	59.8	199.4	27.8		337.7
	SMCP	1A	3.4	7.3	9.4	25.6	85.4	12.0		143.2
		2A	10.3	14.7	14.2	53.5	178.2	24.6		295.4
		3A	10.3	16.1	14.2	57.0	190.1	26.1		313.8
		3B	16.2	25.8	14.2	63.1	210.3	28.8		358.4
	STS	1A	1.5	0.1	3.0	5.3	17.8	2.6		30.4
		2A	2.0	0.7	3.0	9.7	32.4	4.5		52.2
		3A	2.5	1.5	3.0	13.3	44.4	6.1		70.8
	ONAS		40.2	165.5	0.0	30.3	100.8	13.1		349.9
Exhaust Gas Treatment Facilities	SIAPE		282.2	0.0	0.0	506.6	1640.7	214.7	95.7	2644.3
	SIOS-ZITEX		8.5	0.0	0.0	6.2	20.8	2.7		38.2
	SATHOP		9.3	0.0	0.0	7.0	23.3	3.0		42.6
	STS		1.2	0.0	0.0	1.8	6.0	0.8		9.8

3) Tax rate: 35% as proportionate tax rate (A corporate tax is composed of a proportionate tax based on the criteria of the sale amount and net profit.)

(3) Economic benefit

1) Evasion of loss from output reduction by operation suspension

For the future, the regulations on pollution will be applied more severely, so that suspension of operation will be enforced by Articles 8 and 11 of Law No.88-91. Actually in Sfax, some factories seem to have had an order for the suspension because of a pollution occurrence.

For the present study, therefore, an evasion has been assumed from 15 to 90 days' suspension of operation.

2) Reduction of cost exceeding the waste water quality standard

Amount of the penalty was assumed at 50,000 TD per factory.

3) Reduction of sewage treatment cost

By installing facilities for discharge to the sea, the sewage treatment cost of ONAS can be avoided.

4) Production profit and loss from by-products

① Methane generation by treatment of margin:	310,000 TD/Y
② Glycerol collection at soap factory:	170,000 TD/Y
③ Reduction of raw material (sulfur) cost at SIAPE:	236,000 TD/Y

5) Tax exemption effect by execution of special depreciation

By executing a special additional depreciation, a tax exemption effect is expected corresponding to the amount of the depreciation expenses. Profit improvement measures for such special depreciation are assumed in the present study.

(4) Method of financial analysis

To analyze the profitability against the investment, a financial internal rate of return (F.IRR) has been adopted.

The F.IRR is a method to obtain the rate of return on the invested amount for a collected fund by deducting the depreciation expenses, catalyst depreciation, and the interest from the financial profit and loss. It indicates the essential profitability of the present project, excluding the influence by the financing conditions of the loans payable and the owned capital ratio.

Table-12 lists the F.IRR of each factory by case.

Table-12 F.IRR of Each Factory by Case

(Unit: %)

	SIAPE			SIOS-ZITEX			SATHOP			SMCP			STS			UPOTS		
Number of output reduction days	15	60	90	15	60	90	15	60	90	15	60	90	15	60	90	15	60	90
CASE 1A				22	105	H	0.3	30	49	-7	17	30	52	167	329	×	×	×
CASE 1B	×	44	176															
CASE 2A				×	5	16	×	×	-9	×	-5	5	22	66	104	×	×	×
CASE 2B	×	18	70															
CASE 3A				×	0.4	12	×	×	-14	×	-6	3	12	43	66	×	×	×
CASE 3B	×	18	70	×	5	16	×	-23	-7	×	-7	3						
CASE 4A				7	22	32	6	12	17									
Exhaust gas treatment	-13	24	44	25	241	H	31	85	136				H	H	H			

Note ×: No profitability
H: IRR - 200% or more

(5) Financial analysis results

1) According to the financial analysis result taking account of various conditions, CASE 1 should be selected.

2) In the implementation stage, the construction cost and operation cost should be reduced.

3) Table-13 lists the additional expenses generated when the present plan is implemented. It is assumed that such additional costs would be covered by the net profit of each enterprise.

Table-13 Additional Expenses

(Unit: 1,000 TD)

	SIAPE	SIOS-ZITEX	SATHOP	SMCP	STS	UPOTS
CASE 1A		79	92	87	24	826
CASE 1B	4,950					

4. Economic Analysis

The financial analysis was made on the economic efficiency of the enterprises, whereas the economic analysis studies the influences over the regional economy of the community. Therefore, calculation has been made on the economic internal rate of return (E.IRR) based on the economic benefits and expenses that could be represented into numeric figures. The result has shown a trend similar to that of the F.IRR. The economic benefits used for the calculation of E.IRR is described below.

(1) Economic benefits

1) Direct benefits

As for the benefit in economic analysis, the following items which do not make any profit and loss for the entire region changed their contents from those of financial analysis.

① Reduction of cost exceeding the waste water standard

The balance of income and outgo is assumed to be zero.

② Tax exemption effect by execution of special depreciation

The balance of income and outgo is assumed to be zero.

③ Reduction of sewage treatment cost

Evaluation by 50% is assumed because this means a consumption of the variable cost only.

2) Indirect benefits

① Increasing employment opportunities

By introducing the present facilities, opportunities for new employment will cover the personnel for the construction and maintenance work as well, further to the direct personnel.

Therefore, a nationwide and stepwise promotion of the present plan will have large far-reaching effects in increasing the employment opportunities, and shifting to a higher income of people.

② Resource utilization and better environment

Removal of the effects of waste water and exhaust gas is a highly significant activity for the society.

Moreover, utilization of the useful substances that are collected during the treatment process will not only improve the economic efficiency, but will offer the chances to acquire the techniques of improving the production processes.

③ Development of regional economy

To eliminate the pollution and develop the industries to help enhance the standard of living of the residents are highly important objectives.

(2) Economic influence

The study has resulted in a similar trend shown by the F.IRR and E.IRR.

During the field survey, it was informed that suspension of operation had been ordered to some factories that were continuously discharging a pollution source.

Based on such information, calculation has been tried on the possible differences that might be caused between the case of introducing the present plan and the case where the present state were continued. For the calculation, the cases of SIAPE and UPOTS have been taken for the examples, where a large initial investment is required.

1) SIAPE

In Tunisia, TSP is produced also by manufacturers other than SIAPE. On the assumption that all factories were suspended from operation because they did not undertake the present plan, there will be a loss in the price difference between TSP and phosphate rock. Calculation of such lose has been tried as follows:

① Preconditions

• Price:	Phosphate rock	US$31/T
	TSP	US$140/T

- Output: TSP 1,000,000 T/Y (Tunisia)

  TSP 363,000 T/Y (SIAPE)

  Use of raw material (phosphate rock) 681,000 T/Y (SIAPE)
- TSP yield: 53.3% (SIAPE)
- Equivalent energy consumption: 1/2 of raw material cost

② Calculation result

- Added value in TSP production at SIAPE: US$19,148,000/Y
- Nationwide conversion: US$52,749,000/Y

  (= 47,263,000 TD/Y)

Cancellation of economic effect is estimated below in case where all TSP plants across the country have been suspended from production because of non-execution of the present plan.

Annual amount: 47,000,000 TD/Y

During the facility life (15 years): 708,000,000 TD

③ Cost of industrial antipollution countermeasures

	SIAPE	Nationwide
• TSP output (tons)	363,000	1,000,000
• Facility cost (TD)	20,613,000	58,083,000
(Waste water)	(3,727,000)	(10,262,000)
(Exhaust gas)	(16,886,000)	(47,821,000)
• Annual depreciation (TD)	2,013,000	5,545,000
• Annual running cost (TD)	6,165,000	18,264,000

④ Conclusion

- Assuming that the above estimation stands up, it will affect the achievement of the target growth rate 8.7% for the manufacturing industry by the eighth five-year plan.

- While the antipollution measures will become a large investment scale, a stepwise gradual implementation is desired in view of the high economic effects and the secondary influence over other industries as well.
- As shown in ② and ③ above, the calculation has proved a loss that is larger if the operation were suspended, than the annual running cost by introducing the planned facilities.

2) Margin

Margin is discharged to an unoccupied land, so that more site is required for continuing the discharge. Comparison has been made on a nationwide basis between the land acquisition cost and the cost of constructing the planned facilities as follows:

① Margin volume: UPOTS: 5,000 m^3/Y

Sfax: 100,000 m^3/Y

Nationwide: 225,000 m^3/Y

② Land acquisition cost

- Reservation of margin discharge site (depth: 1.5 m) including green buffer zone
- One discharge site will be left for ten years. Then from the eleventh year onward, it will be utilized for recycling.
- Land requirement per year

  225,000 m^3/Y ÷ 1.5 m = 150,000 m^2, or

  200,000 m^2 including green buffer zone
- Land cost (assumed to be adjoining to industrial site)

  200,000 m^2 × 20 TD/m^2 = 4,000,000 TD
- Land cost for 10 years: 40,000,000 TD

③ Estimated construction cost of nationwide margin treatment facilities

	Sfax	Nationwide
Volume to be treated m^3/Y	100,000	225,000
Construction cost (TD)	9,225,000	20,756,000
Annual depreciation (TD)	921,000	2,076,000
Annual running cost (TD)	1,622,000	3,650,000

A simple comparison proves that the annual running cost of the invested facilities is smaller than the land acquisition cost.

④ Influence on other industries

For the coming ten years, an area of 2 square kilometers is needed for discharging the margin. Considering the growth rate of manufacturing and tourist industries, a shortage of land supply may possibly occur to cause the following problems:

- Difficulty in increasing olive oil output
  - → Difficulty in attaining a goal of 2% increase in agriculture
  - → Difficulty in increasing the raw material of low-prices soap
  - → Export promotion and acquisition of foreign currency are affected
- Influence by site reservation for margin discharge
  - → Reservation of new industrial site is affected
  - → Resources for tourism is affected
  - → Acquisition of foreign currency is affected

⑤ Conclusion

The present plan must be implemented also from the following advantages:

- Effective promotion of the olive industry is expected.
- Achievement of the eighth five-year plan and the source of tax revenue are ensured.

5. Evaluation by Financial and Economic Analysis

By financial and economic analysis, the industrial antipollution countermeasures for the region of Sfax in Tunisia have been evaluated as follows:

(1) SIAPE is a governmentally managed enterprise, so that failure in undertaking the antipollution countermeasures will cause suspension of the factory operation, thus seriously affecting the economy. An immediate step should be taken to prevent such occurrence.

(2) UPOTS has been examined as the countermeasures of the margin discharge problem for the entire Sfax area. Considering the cost of land acquisition for the margin discharge, this project should be pushed forward positively.

(3) For other factories (SIOS-ZITEX, SATHOP, SMCP, and STS), the plan can be implemented by further reinforcing the managerial fundamentals of each enterprise.

VOLUME IX CONCLUSION AND RECOMMENDATION

To complete the present study, we describe a conclusion and recommendation in this volume. The object of the study is to assure the environmental protection in the region through the countermeasures for the industrial pollution.

Therefore, it is necessary to make the result of the present study be a model and spread it all over the Tunisia to make a working plan.

1. Outline of the Present State of Selected Factories

It is concluded that, except some factories, no antipollution measures are undertaken. Some factories are studying the possibility, while some others in the process of constructing the equipment. In fact, however, full-scale countermeasures for the waste water or exhaust gas are not taken at the moment.

On the waste water, there is the INNORPI emission standard specifying the standard for the discharge to rivers, sea area, and sewage treatment plant. However, such standard goals have not yet been attained.

For the exhaust gas, no standard exists, and no countermeasure is taken.

2. Conclusion of the Study

To protect the environment and enhance the economic efficiency of each enterprise, the cost of constructing and operating the antipollution facilities must be reduced. For this purpose, the following points must be examined:

(1) Every factory produces polluted substances at a high density. Polluted substances are originally valuable substances such as raw materials. The valuable substnaces must be collected as much as possible through rationalization of the factory, so as to reduce the polluted content in the drainage. To that end, the numerical data in each section at the factory must be grasped first. The present study has been made temporarily, and further data must be collected continuously on a long-term basis.

(2) Waste water treatment facilities must be examined based on the tentative standard proposed by Japan. While the standard is tentative, the drainage from all factories except those from the SIAPE factory is accepted by ONAS, and its quality becomes to fulfill the sea area emission standard of INNORPI by ONAS. In the tentative standard proposed by Japan to be applied for SIAPE, SO_4 exceeds the standard value for sea area of INNORPI standard. However, since removal of SO_4 requires an expensive device, it will have to be studied in the next stage.

(3) For the INNORPI standard of the inflow into ONAS, Cl and SO_4 are subject to regulations. However, the tentative standard proposed by Japan does not satisfy these regulations. Therefore, if a part of the ONAS treated waste water is used for irrigation, the salt content will be increased. However, in view of the high investment cost required for the removal of salt, reservation of the irrigation water must be studied from an overall point of view.

(4) By the INNORPI standard of discharge to sea area, SO_4 is subject to regulation. SO_4 also exists in the sea water, so we raised the question about the reason of the SO_4 regulation, without a clear response being received so far. In our opinion, the SO_4 regulation has to be reexamined.

(5) Treatment of margin at UPOTS is a problem not only for Tunisia, but also for the entire world. In the present study, study was mainly concentrated on a treatment by anaerobic bacteria as treatment methods.

Although the method of anaerobic treatment is being researched in various countries of the world, there is no record of the actual plant. It is desired that the research will be further promoted in Tunisia.

(6) At the sulfuric acid plant in SIAPE, the DCDA method should be adopted to cope with the soaring sulfur price. At the same time, countermeasures for the pollution should be taken along with the efforts to improve the rate of collecting the sulfuric acid.

Furthermore, the modification of scrubber in phosphoric acid plant and TSP plant should be implemented to remove fluorine and to be a countermeasure for pollution.

(7) As the countermeasures for the particles of soot dust from soap factories and STS, installation of cyclone is proposed. As a preparatory step, training of the operating engineers should be projected in order to improve the method of controlling the combustion technique.

3. Recommendation and Considerations

3.1 Recommendation

As a conclusion of the present study on waste treatment and recycling plan, the following items are recommended:

(1) The construction cost indicated for each case in the present study was first calculated on the cost level in Japan then converted into Tunisian base by taking account of the field survey results. Therefore, the indicated values do not fully reflect the conditions unique to Tunisia. Hence, before executing the plan, the construction cost has to be reexamined from an overall standpoint.

(2) Efforts should be made to reduce the polluted substance at the discharge outlet of each factory. Generally, there is a high density of the polluted substance at the discharge outlet of factory. The problems are that a large expense will be required to treat such polluted substance, and that some useful substances are discharged and wasted. It is recommended that the complete numerical data at the production processes be grasped so as to reduce the quantity of the polluted substance.

(3) Establishment of reasonable emission standard

It is important to enforce a strict emission standard to protect the healthy environment. However, it is also important to set a standard to be harmonized with the industrial development. Especially, removal of salt requires a high cost of investment and operation. Preparation of the irrigation water standard and re-examination of salt regulation in the sea area are recommended.

3.2 Considerations on Plan Execution

After examining the items in the foregoing sections, the following notes must be taken into consideration in executing the plan:

(1) Organizing of the committee

As the countermeasures for the industrial pollution in the region of Sfax, it is desirable to organize a committee consisting of the governmental and civil personnel and men of learning and experience, to execute the countermeasures for the entire community.

(2) The present study has been made on some selected local factories. For the next study, it is desirable to cover the whole area, and execute the project step by step by assigning the priority.

(3) Reconfirmation of quality of waste water

Quality of waste water from each factory should be analyzed again to reconfirm the preconditions for design.

(4) Treatment test by actual drain

To obtain the basic numerical data for design, a simple test should be conducted on the actual drain sample. For example, the following data should be confirmed with the actual drain sample:

- Preparation of neutralization curve
- Preparation of coagulating sedimentation curve

(5) Confirmation by pilot plant or demonstrative facility

It is desirable to test the following items through a pilot plant to implement the research and development as they are big problems in Tunisia:

- Anaerobic treatment of margin
- Removal of salt by reverse osmosis

(6) Overseas technical survey

It is desirable that the technical contents of the following items be grasped by inspecting the overseas technology:

- Anaerobic treatment equipment
- Reverse osmosis equipment

(7) It is recommended that LARSEN be expanded into an environmental technology center (or an environmental training center) to serve as a core organization for training the environmental engineers in Tunisia.

JICA