SECTOR C

INDUSTRIAL AND PIGGERY WASTEWATER TREATMENT

THE STUDY ON THE ENVIRONMENTAL IMPROVEMENT PROGRAM OF THE UPPER AND MIDDLE STREAM OF THE TUY RIVER BASIN

SECTOR C : INDUSTRIAL AND PIGGERY WASTEWATER TREATMENT

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SECTOR C INDUSTRIAL AND PIGGERY WASTEWATER TREATMENT

1. PRESENT TREATMENT CODITION OF WASTEWATER BY FACTORIES AND PIGGERIES

1.1 Pollution Source Inventory

1.1.1 Factories

(1) List of Factories

In the basin there is a large number of industries from small scale to large scale amounts to about 290 according to the information. However, the factories which possibly cause the water pollution can be limited to a certain number. In this study, the following factories are selected for the inventory survey:

- Large scale factories with more than ten employees based on the 1990 OCEI (Central Office of Statistical Information) census and
- Factories not included in the census, but considered to be significant polluters based on past study results.

Table 1.1-1 shows factory categories or type of industry as well as the number of employees by administrative unit of city and town in the study area. The total number of factories and employees in the study area are 103 and 13,028, respectively.

(2) Location of Factories

Factories are concentrated in the major cities on the basin, such as Las

Tejerías, Cúa, Charallave, and San Francisco de Yare. Particularly in Las Tejerías and Charallave there are many factories with the highest number of employees: There are 3,192 employees in 22 factories in Las Tejerías and 3,830 employees in 21 factories in Charallave. The number of factories and employees are compared by sub-basin as follows (see Fig. 1.1-1).

Location of Factories

Sub Basin	Tributary	Name of City	No. of Factories	No. of Employees
Upper Basin	Tuy River	Colonia Tovar	1	54
	Can. Tiquirito	El Consejo	2	653
	Tuy River	Las Tejerías	22	3,192
	Qda. Guayas	Guayas	2	439
	Qda. Maitana	Paracotos	7	365
	Sub-total		34	4,703
Middle Basin	Tuy River	Cúa	16	1,065
	Qda. Maitana	San Diego de los Altos	1	212
	Qda. Maitana	San Jose de los Altos	1	49
	Qda. Charallave	Charallave	21	3,830
	Qda.Charallave	Pitahaya	4	943
	Tuy River	Ocumare del Tuy	6	679
	Tuy River	San Francisco de Yare	11	1,714
	Sub-total		60	8,492
Total			103	13,028

(3) Production Pollution Load

(a) Food Related Industries

Food related industries, which will cause organic pollution, is dominant in both total number of factories and employees; It has 23% of the total number of factories and 31% of employees. Alcohol manufacturers of chiefly rum, have the largest employees among them; One factory in El Consejo employs 573 and another in Ocumare del Tuy, does 440. In Charallave, one food and snack manufacturer has 691 employees.

(b) Non-Food Related Industries

The textile, foundry, and car parts industries, which possibly discharge heavy metals, are the second to the food related industries in the numbers of factories and employees. One manufacturer of ceramic floor tiles in San Francisco de Yare has an exceptionally large number of employees, 1,039.

Other possible polluters include: Tanneries which will discharge large quantities of organic substances and probably also cyanide, chromium and lead; Paint factories; Plastics and synthetic fiber manufactures; Soap and cleaning chemical factories; Other chemical manufactures; Glass and fiberglass factories. These, however, are small in number compared with other industries mentioned above.

The table next is the list of industries whose factories probably discharge inorganic chemicals, mainly heavy metals in their wastewater

Factories probably discharge inorganic chemicals

CIIU	Industrial Category	Inorganic Chemicals	No. of factories (employees)
32311	Tannery and finishing of leather	CN, Pb, Cr^{6+}	1(14)
32321	Industry to prepare tanning leather	CN, Pb, Cr^{6+}	1(59)
35211	Manufacture of paint and varnishes	Cd, CN, Cr^{6+}, Hg	6(914)
35231	Manufacture of soaps and cleaning products	CN, Pb, Cr^{6+}	7(821)
36201	Production of fiberglass	CN, Pb, Cr^{6+}, As	2(87)
37201	Production of non-ferrous metals and alloys	CN, Pb, Cr^{6+}	6(524)
38191	Manufacture of metallic products, excl. machinery	CN, Pb, Cr^{6+}	3(183)
38193	Metal plating	Cd, CN, Pb, Cr^{6+}, As, Hg	7(833)
38431	Car parts factory	Cd, CN, Pb, Cr^{6+}, As, Hg	1(296)
38433	Automobile spare parts factory	CN, Pb, Cr^{6+}, As,	5(722)

(4) Treatment Condition

During this study period 41 factories that were considered to be significant polluters according to past studies and were decided to conduct interview on them for basic information on their establishment including treatment facilities (see Table 1.1-2).

Whatever their industries, many factories were founded over 25 years ago and, in particular, two famous rum factories were founded nearly a half century ago; Ron Santa Teresa started its operation 40 years ago and Industrial Pampero 58 years ago.

Considering the large scale of the 41 factories selected, a problem is that a significant number of them are without a wastewater treatment system (refer to Table 1.1-2). Four of twelve food related factories surveyed have no treatment facilities. In other 29 factories, 14 which may discharge inorganic chemicals do not give any treatment.

Such 41 factories were interviewed including one plant at a sand quarry in Paracotos which is a possible polluter of high turbidity in the Tuy River. This plant of fine aggregate was also listed in the table of the factories.

1.1.2 Piggeries

(1) List of Piggeries

The possible polluters in livestock farms in the study area are piggeries and chicken farms, however, all the waste from chicken farms is recycled as agricultural fertilizer. Therefore, the piggery is the main polluter among them on the upper and middle basin. The list of piggeries in the Study Area is shown in Table 1.1-3.

(2) Location of Piggeries

Piggeries are mostly concentrated around a few areas (see Fig. 1.1-2): Qda. Morocopo and Qda. Guayas in the upper basin, and Ocumare del Tuy and Charallave in the middle basin. The 20 upper basin piggeries with a total of 48,413 pigs and are generally larger than those in the middle basin, where there are 13 piggeries with 23,068 pigs. The area around Qda. Morocopo has the greatest concentration, having 11 piggeries with the effluent from 33,500 pigs being discharged into the creek (see Table 1.1-4).

Compared to the condition in 1988, the number of piggeries in the upper basin decreased from 28 to 20, while stock numbers increased from 38,000 to 48,413 (Table 1.1-5). In the middle basin the numbers of piggeries and pigs decreased from 18 to 13 and 32,000 to 23,068 respectively. Meaning that over the whole Study Area the number of piggeries fell, while the number of pigs is increasing.

(3) Treatment Condition

Most of treatment systems are lagoons, though it is not clear yet how efficiently these are working. However, according to the information several piggeries do not discharge wastes directly into a water course, but use it for irrigation or discharge it on to an open field. Thirty percent (30%) of the piggeries in the upper basin do not discharge waste, while the figure is 23% in the middle basin (refer to Table 1.1-3).

1.2 Water Quality Analysis

(1) Condition of Water Quality Analysis

According to the previous study results, the water pollution in the Tuy River is chiefly due to (1) wastewater from factories, piggeries, residences and (2) sediment transport on the river basin. The pollutants are broadly classified into four; namely, organic substances, toxicants, solid particles (cause of high turbidity), and others.

To confirm the pollution condition from the factories and piggeries, a series of water quality analysis was conducted in the following manner:

(a) Parameter Analysis

The specific parameters were selected for this study from those commonly applied in examining pollutants (see Table 1.2-1).

(b) Sampling Sites and Sampling Times

Sampling sites were selected to confirm the serious sources of factories and piggeries.

The number of sampling sites is listed in Table 1.2-1 and each site location is shown in Fig. 1.2-1.

The sampling and observation with the discharge measurement at each site were conducted once in the first study period.

(2) Results of Water Quality Analysis

(a) Water Quality from Factories

The factories on the basin are classified into two categories by their products: Non-food and food related factories. The wastewater released from these factories has the following qualities:

(i) Non-food Related Factories

Among the non-food related factories on the basin, the main pollutant sources of the Tuy River are textiles, metal works, sand quarries, and tanneries.

The qualities of wastewater from these factories are shown in Fig. 1.2-2 and are explained as follows:

- Organic pollutants released from some factories are over the standard limit, which is 350 mg/ℓ for factories discharging into the sewer system and 60 mg/ℓ for the factories directly discharging into the river. Among the samples from 17 factories, those from 5 factories, discharging directly into the river, were higher than 60 mg/ℓ, and from two factories discharging into sewers were higher than 350 mg/ℓ. For COD, samples from 9 factories had a higher value than the standard limit of 350 mg/ℓ for direct river discharge while two others discharging into the sewers were higher than 900mg/l, the limit.
- Levels of heavy metals in the effluent from factories discharging into the Tuy River are high according to the results; three cases, two for T-Cr and one for T-Hg, were higher than the standard limit.
- In general, the turbidity is not high except the samples nearby the sand quarries. In contrast, SS values from 11 factories among 17 factories are above the standard limit of 80 mg/ℓ for direct discharge to the river and samples from two other factories were above the standard of 400 mg/ℓ for the discharge to the sewer system.
- The pH values from the samples from five factories are out of the allowable range of the standard, while the nitrogen levels of the samples from seven factories were above the standard.

(ii) Food Related Factories

Among the food related factories, the main pollutant of the Tuy

River are from an alcohol distillery, meat processing, and soft drink factories.

The figures for the quality of wastewater from these factories are in Fig. 1.2-3. The following remarks are derived from the results:

- Organic pollutants are dominant in the wastewater. BOD ranges from 5 mg/ℓ to 7,000 mg/ℓ. Six in ten factories released more highly polluted wastewater than the standard (60 mg/ℓ) limit for the factories directly discharging into the river, and five factories also violated the standard limit(350 mg/ℓ) for those discharging into the sewage system. A similar condition can be observed for COD.
- The turbid condition, in general, is not high, judging from the observed values, although SS values of the samples from eight of ten factories were above the standard limit (80 mg/ℓ) while the values of the other samples were higher than the standard limit (400 mg/ℓ).
- The pH values were within the allowable range of the standard. And values above the standard for nitrogen (T-N: 40 mg/ℓ, NO_2 and NO_3: 10 mg/ℓ) were detected from the samples of three factories.

(b) Water Quality from Piggeries

As in the case of the factories producing food related products, the quality of wastewater from piggeries is characterized by organic pollutants as summarized below (also see Fig. 1.2-4):

- Organic pollutants are dominant in the wastewater from the fact that the samples from seven of eight piggeries releasing wastewater into the river were above the standard limit for BOD (60 mg/ℓ) and the samples from five piggeries releasing into sewers were above 350 mg/ℓ. For COD values, all samples from piggeries were higher than 350 mg/ℓ.
- Turbidity and SS were also high in the analyzed data. The samples from seven of eight piggeries releasing waste into the river were above the standard limit (80 mg/ℓ), and for and the samples from five piggeries releasing into sewers were above the limit of 400 mg/ℓ.
- The pH values are within the standard limit. Besides them, the condition of T-N pollution is severe because all factories are releasing more polluted wastewater, above the standard limit of 40 mg/ℓ.

1.3 Influence of Wastewater Discharged from Factories and Piggeries

In the wastewater discharged from factories and piggeries, major pollutants relating to the organic pollution , toxicants and turbidity are included. The influence of the pollution condition of the Tuy River caused by the wastewater discharged from factories and piggeries are summarized as follows:

1.3.1 Organic Pollution

Factory

An alcohol distillery located in the upper basin is the factory having the greatest impact on the water of the Tuy River. A biological treatment plant has been introduced and the present BOD treatment rate is around 95%; COD and SS are 89% and 83%, respectively (see Table 1.3-1). Attention should be paid to the fact that even after treatment the concentration of BOD exceeds 2,000 mg/ℓ, even with the high treatment rate. This level is still well above acceptable limits for effluent being discharged into the river.

The fact that the concentration of the wastewater even after the treatment is at such a high level implies the necessity of overall measures for pollution load reduction including those in the production process, total volume of material used and recycling of water. The introduction of an oxidation pond by the year 1997 has been agreed upon between the factory and the Tuy River Basin Agency. Considering the fact that the effect of the factory on the Tuy River is very large, continued reduction of the pollution load is essential.

Although the treatment rate of BOD by factories with biological treatment plants is generally high, at above 95% for food factories e.g. chicken meet processing, flour milling, dairy produce processing. Furthermore the treatment rates of other parameters range widely, from 60-90% for COD, and 10-90% for SS. With regard to the installation of treatment plants, one third of the total number of the factories remain without any form of treatment. Improvement of the food factories is thus important for the reduction of the pollution load.

The percentage of non-food factories without treatment plants is one half. Improvement in BOD is not good in these factories as is easily imagined from the treatment method. Some of non-food factories, e.g. chemicals and textile producers, discharge high concentrations of organic pollution. Biological treatment is basically preferable for these factories. If biological treatment is not applicable as in the case of some chemical producers, the most appropriate method should be selected.

Piggeries

The effect of the piggeries on the river water pollution is significantly different for those piggeries with oxidation ponds and without any treatment. For example in the case of a piggery located along Qda. Morocopo, pre-treatment is conducted to remove and compost solid wastes, and water is treated with three oxidation ponds. Another example is to utilize water from the oxidation ponds for irrigation of adjacent upland

crop fields. In these cases, more than 90% of pollution could be removed. However in the case of no treatment as in the case of a piggeries located along the Tuy River, 100% of wastes are discharged into the river. The Tuy River Agency is going to order close those not yet facilitated with treatment plants to stop operations.

Table 1.3-1 compares the water quality before and after the treatment. As shown in the table, more than 90% of BOD and SS and 80-90% of COD are removed. Attention should be paid, however, to the fact that the wastewater from piggeries even after treatment contains a high BOD load, 1,000 mg/ℓ. Table 1.3-2 shows the effect of the removal of solid wastes in the value of BOD. Utilization of solid wastes for fertilizer should be promoted for application of biological recycling system in environmental improvement.

1.3.2 Toxicants

In accordance with interview survey results, 54% of non-food factories have treatment plants. Of the factories with treatment plant, 53% are equipped with physical-chemical treatments, 13% are with separators (including those of removal of solid particles), 7% are with biological treatment, and the remaining 27% have other treatment that includes tank storage.

The results of water quality tests for before and after the treatment of heavy metals is discussed below (see Table 1.3-3):

With regard to Pb, one factory achieved a 47% treatment rate. Other factories are below the measurable limit. The discharge from the factory with the treatment rate of 47% still exceeds the discharge standard to the river, and implies that there is a problem in the plant itself or in maintenance. The wastewater from this factory is discharged to a tributary of the Tuy River, and the concentrations of Cr and Cu also exceed the standard.

The treatment rates of Cr vary widely between 28 and 80%. At two factories, the concentration after the treatment is higher than that before, indicating a possibility of inadequate operation and maintenance.

Also for Zn, the treatment rate varies from 5 to 80%. At three factories, high concentrations were found in water after treatment. The treatment rates for Hg and Ni also have a wide range and high concentrations were found even from the sample after treatment.

1.3.3 Turbid Water

As discussed before, turbid water originates, chiefly, from erosion over the entire basin and sand quarries. Of these, sand quarries are considered as industrial wastewater and the other is natural condition (though the destruction of the basin is due to human activities).

Wastewater from sand quarries is from flushing water. In the case of sand quarries along the Qda. Maitana, 20 to 25 ℓ/sec of water is used. One site is equipped with two sand settling ponds and these are used alternatively. Overflow water from the

settling ponds flows to the river. In the other case, there are no sand settling ponds and high concentrations of suspended solids flow into the Tuy River.

1.3.4 Confirmation of the Influence by Simulation Model

The influence of wastewater from factories and piggeries is examined by the simulation model under the following conditions:

- The RIOS model is applied as the simulation model
- As the water quality index for simulation of organic pollution, BOD is used

According to the calculation results, the influence is identified as follows:

As shown in the table below, the BOD production load in the upper and middle basin of the Tuy River is 73 ton/day and 25 ton/day, respectively. The share of the production in the upper basin is as high as 74%. The discharged load from the basin is almost the same at 20.9 ton/day in the upper basin and 20.6 ton/day in the middle basin. This is because the production load at an alcohol distillery in the upper basin shares a large amount and the treatment at the same factory greatly reduces the discharged load, although the discharge load to the river remains high.) Discharge load in the middle basin is relatively high because of the high share in the mid basin and the low treatment rate of the domestic wastewater.

Pollution Load	Pollution source	Upper Basin		Middle Basin		Total	
		(kg/day)	(%)	(kg/day)	(%)	(kg/day)	(%)
Production Load	Factory	58,812	80.2	7,859	30.9	66,672	67.5
	Piggery	8,554	11.7	3,758	14.8	12,312	12.5
	Domestic	5,958	8.1	13,799	54.3	19,756	20
	Total	73,324	100	25,417	100	98,740	100
Effluent Load	Factory	11,817	56.6	5,046	24.5	16,864	40.7
	Piggery	3,222	15.4	1,878	9.1	5,100	12.3
	Domestic	5,840	28.0	13,670	66.4	19,510	47.0
	Total	20,880	100	20,594	100	41,474	100

In the upper basin, the share of wastewater from factories is high. The discharge load from the alcohol distillery at El Consejo is considerably high. An industrial area in Las Tejerías also discharges a large amount of pollution load in the upper basin. The share of the wastewater from the factories is 80% in production load and 56% in

discharged load. Wastewater from piggeries is 12% in production and 15% in discharge load. The domestic wastewater is only 8% in production load but it increases up to 28% in discharged load because the treatment rate is low.

In the middle basin, the share of the domestic wastewater is as high as 54% in production load and 66% in discharge load. Factories are located in the cities of Cúa, Charallave, Ocumare del Tuy, and share 31% of production load and 25% of discharged load. Piggeries share only 9% of discharge load in the middle basin.

As a whole in the upper and middle basins, the production load of factories is as high as 68%. It decreases to 41% in the discharged load and lower than that of domestic wastewater of 47%. The ratio of wastewater from factories and piggeries in the upper and middle basin is 2:1, the ratio for domestic wastewater is 1:2 in contrast.

The rate of the load that flows into the Tuy River is compared: Many towns are not far from the Tuy River and most discharge load flows into the Tuy River. In contrast, in two tributaries, Qda. Maitana and Qda. Charallave, polluters are relatively far from the Tuy River and the delivery rate to the Tuy River is low.

Self-purification of the river is high in some stretches. The stretch from Qda. Guayas to Tácata, receiving the water of Qda. Maitana, especially presents a high rate of self-purification. In this stretch, BOD concentration is reduced to one tenth. It should be noted that the self-purification is resolution and/or decomposition of organic substances and their deposition on the riverbed, which is not an absolute improvement of the pollution. Such self-purification in the middle stream is also remarkable.

On the whole basin, the total production pollution load is 99 ton/day, discharge load is 41 ton/day, the effluent load flows into the Tuy River is 29 ton/day and the effluent load in the Tuy River at Toma de Agua is 3 ton/day.

2. MASTER PLAN STUDY

2.1 Consideration of Applicable Structure Measures

For the treatment of wastewater from the factories and piggeries, the applicable structure measures in principle is to install treatment plants so as to comply with the water quality standard.

2.2 Measures to Reduce Pollution from Factories and Piggeries

2.2.1 Study Procedure for Factories and Piggeries

To cope with organic pollution problem from factories and piggeries, the applicable structure measure is installation of treatment plant in the factories and piggeries. In principle, the selection of suitable treatment plant and its installation to fulfill the water quality standard are the responsibility of factory and piggery owners. In this Master Plan study, the suitable treatment plant and the necessary cost to install the treatment plants are examined in the following procedure:

- Preparation of an inventory of factories and piggeries
- Identification of installation and treatment conditions of the plant
- Study on the unit cost to treat wastewater from the factories and piggeries
- Blocking the study area to estimate the treatment cost for factories and piggeries
- Cost estimation of the treatment plant to treat the wastewater for existing factories and piggeries
- Cost estimation to install treatment plant for newly built factories.

2.2.2 Investigation of the Installation and Treatment Conditions of Plants

As the inventory of the existing factories and piggeries, factories of 103 and piggeries of 33 are arranged in the list as mentioned in Section 1.1 "Pollution Source Inventory".

From the inventory, 40 factories and 10 piggeries were selected to investigate the installation and treatment condition and examined the untit cost to treat the wastewater from the factories and piggeries so as to fulfill the water quality standard. Fig.2.2-1 shows an example of treatment plant flowchart of factory and piggery. Among them surveyed, 18 factories and 2 piggeries fulfill the water quality standard as shown below:

Group	Number of Factories (Nos.)	Number of Piggeries (Nos.)
(1) Factories and piggeries which fulfill the water quality standard	18	2
(2) Factories and piggeries which do not fulfill the water quality standard though they have installed a plant	9	5
(3) Factories and piggeries which have not installed a plant	13	3
Total	40	10

As the investigation results for the said group (1), the suitable treatment plants are identified. Also, the cost of the suitable treatment plants are examined. The cost of the suitable treatment plants are shown in Fig.2.2-1.

2.2.3 Unit Cost to treat the wastewater from factories and piggeries

For the groups of factories and piggeries which fulfill the standard, the unit cost to remove the effluent pollution load up to the level fulfilling the standard is examined. As a result, the unit cost is obtained as shown below:

Category (Factory/Piggery)	Average Discharge Wastewater Volume (ton/day)	Average Construction Cost of Treatment Plant (US$)	Unit Cost (US$/ton/day)
Food Related	317	404,924	1,277
Non-Food Related	106	208,724	1,963
Piggery	11.5	20,000	1,739

2.2.4 Blocking the study area to estimate the treatment cost for factories and piggeries

In connection with the study on the sewage treatment plant, the study area is divided into several blocks and the treatment cost for factories and piggeries is calculated for each blocked area. The treatment cost for existing factories and piggeries is US$ 14,055,000 in total as shown in Table 2.2-1.

2.2.5 Cost to Install Treatment Plants to the Factories Built by 2003

In the future, it is expected that factories will be newly built as discussed in the baseline projection. The number of the factories newly built by 2003 is 44. The cost to install treatment plant to these factories will be US$ 10,791,000 as shown in Table 2.2-2.

2.2.6 Cost to Install Treatment Plants to the Factories Built by 2010

Furthermore, the necessary cost for the factories newly constructed in the future after 2003 by 2010 is estimated. The number of the factories newly built from 2003 to

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2.2.6 Cost to Install Treatment Plants to the Factories Built by 2010

Furthermore, the necessary cost for the factories newly constructed in the future after 2003 by 2010 is estimated. The number of the factories newly built from 2003 to

2010 is 120. The cost to install treatment plant to these factories will be US$ 18,606,000 as shown in Table 2.2.3

2.2.7 Cost to Install Treatment Plants to Reduce Odor and Color

As discussed in the key issues, water intake suspension at water intake point occur due to odor and color. The suspension days due to odor and color are 7 days and 6 days (13 days in total), respectively, and suspension hours are 8 hours a day on average. As the target, it is proposed to secure water quantity by reducing the suspension times of water intake through water quality improvement of odor and color, and the reduction volumes are roughly estimated at 403,200 m^3 for odor and 345,600 m^3 for color assuming that river discharge at the time of suspension is 2 m^3/s, namely 2×7×8/24×86,400 = 403,200 and 2×6×8/24×86,400 = 345,600). In short, the effectiveness of water quality improvement by reducing the suspension period of 13 days is the securement of the water quantity of 748,800 m^3/year (0.024 m^3/s), i.e., 403,200 m^3/year (0.013 m^3/s) for odor and 345,600m^3/year (0.011 m^3/s) for color.

Therefore, it may be possible to reduce the water intake suspension through installation of treatment plant for such the factories discharging the elements of odor and color in an early stage. In this connection, the cost to install treatment plants to those factories is calculated. It is considered that the factories which discharge the elements of odor and color seems to be the industrial category of drink and plastic products according to the interview survey results. The number of these factories are 6 at present. The cost of treatment plant is US$1,692,000 as shown in Table 2.2.4

2.3 Identification of the Priority Area

In this section, the priority area in which the treatment plants of factories and piggeries be introduce in early stage:

(1) Study Cases to Select Priority for Institutional Measures

(a) Blocking of the Study Areas

To select the priority area to apply the institutional measures, alternative study cases are examined by comparing areas in terms of effectiveness to reduce pollution to the target point. For this purpose, the industrial area is divided into several blocks as mentioned in 2.2.4.

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(Year: 1995)

Tuy River	Name of Block	Major Urban Center	No. of Factories	No. of Piggeries
Upper Stream	El Consejo	El Consejo	2	0
	Las Tejerías	Las Tejerías (Morocopo)	22	11
	Qda. Guayas	Qda. Guayas (Boca de Cagua)	2	9
	Paracotos	Paracotos	9	0
	Río Guare	Tácata	0	1
Middle Stream	Cúa	Cúa	4	1
	Charallave	Charallave	6	3
	Ocumare del Tuy	Ocumare del Tuy	6	3
	S. F. de Yare	S. F. de Yare	11	3

(b) Study Cases to Decide Priority Based on Size of Factory and Piggery

In line with the selection of priority areas, it is necessary to examine the economic advantages based on the size of factory and piggery, i.e., whether (1) priority is given to large sized factories and piggeries, or (2) priority is given to middle and small sized factories and piggeries.

In this study, the level of advantage is confirmed by comparing the unit water treatment cost by factory size.

(2) Study on Effectiveness of Each Block to Reduce Organic Pollution

The effectiveness of each blocked area to reduce organic pollution is calculated by using the RIOS model. On the other hand, the cost of treatment plant to reduce the pollution is calculated based on the interview survey results. The effectiveness and cost including economic priority are summarized in Table 2.3-1. As noted from the table, the area of highest priority regarding the installation of a treatment plant is Ocumare del Tuy, followed by El Consejo. The relation between the effectiveness and cost based on economic priority is shown in Fig. 2.3-1 and 2.3-2.

(3) Priority of Each Block

Based on the study results, the areas near the target points will effectively contribute to the reduction of organic pollution in general. The priorities according to the blocked areas are as follows:

Priority	Blocked Area
1st	Ocumare del Tuy
2nd	El Consejo
3rd	S. F. de Yare
4th	Cúa

Priority	Blocked Area
5th	Charallave
6th	Qda. Guayas
7th	Las Tejerías
8th	Paracotos

To reduce odor and color which cause suspension of water intake, high priority is given to factories discharging pollution that is likely to affect the color and odor in the whole Study Area.

(4) Study on Effectiveness of Size of Factory and Piggery to Reduce Organic Pollution

To examine the effectiveness of size of factories and piggeries to the reduction of organic pollution, the unit water treatment cost is calculated based on the observed data.

Fig. 2.3-3 shows the unit water treatment cost for treatment plants and the water treatment volume. As noted, the decrease in the initial cost per unit treated (Bs/m^3) is inversely proportional to the volume treated. Thus, from the economic viewpoint the priority to provide a treatment plant is given to large sized factories and piggeries. Judging from the present sizes of factories and piggeries, factories with more than 300 employees and piggeries with more than 5,000 pigs belong to the large size group. (Refer to Table 2.3-2.)

3. FEASIBILITY STUDY ON INSTALLATION OF TREATMENT PLANTS TO FACTORIES AND PIGGERIES

3.1 General

In the Master Plan study, an inventory of factories and piggeries was prepared based on the following information: (1) OCEI census in 1990, (2) list of factories and piggeries enrolled in the Tuy Agency and (3) other information through field investigation. Eventually, an inventory of 103 factories and 33 piggeries was arranged classifying by industry categories and their locations. The inventory includes number of employees (refer to Table 1.1-1).

In this feasibility study, installation condition of a treatment plant in each factory and piggery is re-examined to identify the following points: (1) percentage of factories and piggeries with a wastewater treatment plant, (2) percentage of factories and piggeries which fulfill the water quality standard for wastewater discharged, (3) basic process of planned treatment plants and (4) cost to install and maintain a treatment plant.

Based on the above information, the factories and piggeries are broadly classified into several groups, to which similar wastewater treatment processes can be applied. For each group, a standard treatment plant to fulfill the water quality standard is examined together with the necessary cost for its installation and maintenance.

Then the cost to install the wastewater treatment plant for each factory and piggery, which does not satisfy the water quality standard at present, is roughly estimated based on that of a standard treatment plant. Also a necessary cost to install wastewater treatment plants for factories built in the future by 2003 is estimated. These costs are required to promote the measures for treatment of wastewater from the factories and piggeries. The costs are shouldered by the factory and piggery owners. Also the costs are used for the formulation of the proposed environmental fund, which is used when the factory and piggery owners face the financial constraint to install the treatment plants.

3.2 Installation Condition of Treatment Plant

To investigate the installation conditions of a treatment plant, 38 factories out of 103 and 10 piggeries out of 13 in the inventory were selected at random, in addition to 27 factories and 3 piggeries investigated in the Master Plan study stage. As a result of the investigation for 65 factories and 13 piggeries, the following conditions were clarified:

(1) The installation condition of factories and piggeries is broadly divided into three cases: (1) those which satisfy the water quality standard, (2) those which do not satisfy the standard though they have installed a treatment plant, and (3) those which have not installed a treatment plant (refer to Table 3.2-1).

The three cases are as follows:

Case	Number of Factories(Nos.)	Percentage (%)
Factories which satisfy the water quality standard	25	38
Factories which do not satisfy the standard though they have installed a plant	5	8
Factories which have not installed a plant	35	54
Piggeries which satisfy the water quality standard	2	15
Piggeries which do not satisfy the standard though they have installed a plant	8	62
Piggeries which have not installed a plant	3	23

(2) The treatment plants in the factories and piggeries at present can be broadly classified in the following processes:

(a) Biological treatment process to reduce high concentration of bio-organic substances which are easily resolved.

(b) Biological followed by physical-chemical treatment process to reduce medium concentration of bio-organic substances.

(c) Physical-chemical treatment process to reduce chemical and organic substances which are difficult to be resolved.

(d) Physical-chemical followed by biological treatment process to reduce metals and organic substances.

(e) Physical-chemical treatment process to reduce metals

(f) Physical-chemical treatment process to reduce non-organic suspended solids (SS)

(g) Biological treatment process to reduce high concentration of bio-organic substances which are easily resolved.

In general, the above treatment processes are applied to the following categories of the industries and the installation cost are as shown in the following table(see Tables 3.2-2, -3 and -4):

Process	Category of industries	Number of * Factories and Piggeries by Categories	Installation Costs (US$ thousand)		
			Large Scale Factories	Middle Scale Factories	Small Scale Factories
(a)	Food Product Industries	6	345 - 1,002	104	64 - 117
(b)	Manufacturing of Textiles	4	390 - 420	no data	132-160
(c)	Chemical Industry	6	267 -465	82 -200	30 -76
(d)	Tannery	3	no data	no data	47
(e)	Metal manufacturing	7	156	40 - 175	31 - 122
(f)	Sand quarries	3	no data	no data	15
(g)	Piggeries	13	no data	1.2-28	no data

*Among factories and piggeries surveyed, only those which satisfy the water quality standard

As for the operation and maintenance cost, the following percentage to installation cost is obtained:

Process	Category of industries	O&M cost (%)
(a)	Food Product Industries	2.85
(b)	Manufacturing of Textiles	4.98
(c)	Chemical Industry	5.87
(d)	Tannery	5.10
(e)	Metal manufacturing	5.50
(f)	Sand quarries	5.20
(g)	Piggeries	5.20

3.3 Study on Standard Treatment Processes

Based on the above present installation condition of treatment plants, standard treatment processes for several cases are examined to estimate cost for installation of treatment plants.

Classification of Industries to examine Standard Treatment Process

As identified through the investigation, treatment processes for the present factories and piggeries are broadly classified into seven (7) cases. In this connection, the standard treatment processes are examined for the same 7 cases based on the specification shown in Table 3.3-1.

(1) Biological treatment which applies to (a) food product industries

Biological treatment is used to reduce the high concentration (BOD2,000 -

4,000mg/l) of bio-organic substances, mainly produced by food factories. A typical biological treatment process is the activated sludge process with extended aeration.

Configuration of treatment process: a screen tank, an aeration tank, a sedimentation tank and a chlorination tank. A primary sedimentation tank is not necessary because of few solid.

The standard treatment process of this type of treatment plant is shown in Table 3.3-2(1/7).

(2) Biological followed by Physical-chemical treatment which applies to (b) manufacturing of texitile

This treatment is used to reduce medium concentration of bio-organic substances, mainly produced by the textile industries. Generally, a standard activated sludge method is adequate. Since BOD load is medium, primary sedimentation is effective. The pH is not neutral and thus, neutralization as pretreatment is required.

Configuration of treatment tanks: a screen, neutralization, primary sedimentation, aeration, final sedimentation and chlorination.

The standard treatment process of this type of treatment plant is shown in Table 3.3-2(2/7).

(3) Physical-chemical treatment which applies to (c) chemical industry

In chemical industry, the substances such as oil based chemical, paints and synthetic resins are mainly produced. Physical-chemical treatment method is appropriate for this sewage due to biodegradable organic compounds; a storage tank is effective for flow equalization and reduction of high SS, followed by flocculation.

Configuration of treatment tanks: a screen, storage, neutralization, flocculation, chemical conditioning, sedimentation. Storage and sedimentation tanks have to enable long time treatment processes of long duration.

The standard treatment process of this type of treatment plant is shown in Table 3.3-2(3/7).

(4) Physical-chemical followed by biological treatment which applies to Tannery

This treatment process is used to reduce metals and organic substances which are mainly produced in the tannery industry. Treatment for both organic substances and chromium is required; A special treatment is to reduce the valency of chromium from 6+ to 3+, followed by neutralization, flocculation and biological process (activated sludge method).

Configuration of treatment tanks: chemical reduction, neutralization, flocculation, sedimentation for chromium treatment. The other combination for organic substances is one for those of aeration, sedimentation and chlorination.

This is the general recommended configuration for tanneries, though, it should be warned that local factors in sewage characteristics may modify this recommendation.

The standard treatment process of this type of treatment plant is shown in Table 3.3-2(4/7).

(5) Physical-chemical treatment process which applies to (e) metal manufacturing

This treatment process is used to remove metals which are mainly produced from metal manufacturing industries. Flocculation treatment by neutralization is appropriate for removal of such heavy metals.

Configuration of treatment tanks: storage, neutralization, flocculation, sedimentation. Two types of sediments are collected; One is suspended type in storage tank and flocculate by neutralization.

The standard treatment process of this type of treatment plant is shown in Table 3.3-2(5/7).

(6) Physical-chemical treatment process which applies to (f) sand quarries

This treatment process is used to remove inorganic suspended solids (SS) which are mainly produced from sand quarry industries. Natural sedimentation cannot achieve the limitation that SS should be below 80 mg/l; Flocculate aid is applied to remove it.

Combination of treatment tanks: flow equalization, chemical conditioning and sedimentation.

The standard treatment process of this type of treatment plant is shown in Table 3.3-2 (6/7).

(7) Biological treatment which applies to piggeries

Biological treatment is in general as same as that for food product industries.used. A typical biological treatment process is the activated sludge process with extended aeration.

Configuration of treatment process: a screen tank, an aeration tank, a sedimentation tank and a chlorination tank. A primary sedimentation tank is not necessary because of few solid.

The standard treatment process of this type of treatment plant is shown in Table 3.3-2 (7/7).

Cost Estimation for Standard Treatment Plant

Based on the standard treatment process, the costs for standard treatment plants for the seven cases are estimated assuming the scale of the factories and piggeries in three cases : (1) large scale factory and piggery, (2) medium scale factory and piggery and (3) small scale factory and piggery. The scale of the factories and piggeries are expressed by the discharge volume of factories and piggeries.

Table 3.3-3 shows the unit cost of standard treatment plants.

Fig. 3.3-1 shows the relation between cost and discharge volume of waste water according to interviews and the cost estimation for standard treatment plants. As noticed from these figures, the cost of standard treatment plant approximately coincides with average value of actual costs of treatment plants obtained from interviews.

3.4 Cost Estimate for Installation of Treatment Plant for Existing Factories

Based on the costs of standard treatment plants, the cost for installation of treatment plants for existing factories and piggeries can be estimated multiplying the cost of a standard treatment plant by the number of the existing factories. Since the factories meeting the water quality standard do not need to install a new treatment plants, the cost estimation is made only for the factories which do not fulfill the water quality standard.

As mentioned earlier, among the existing factories and piggeries with treatment plant, the percentage of which do not fulfill the water quality standard are 8% and 6%, and the percentage of factories and piggeries which do not have treatment plants are 54% and 59%, respectively.

In this connection, the cost for installation of treatment plants for existing factories and piggeries is calculated in the following manner;

- For the factories with treatment plants not fulfilling the water quality standard, 50% of the standard treatment plant cost is adopted considering their scale.
- For the factories with no treatment plant, 100% of the standard treatment plant cost considering the scale of the factories is adopted.
- O&M cost is calculated multiplying the said percentage of O&M cost by the installation cost.

The total costs for installation of treatment plants for existing factories and piggeries are US$ 11,597,900 and US$1,253,900, while annual O&M costs are US$519,000 and US$65,203. Tables 3.4-1 and 3.4-2 show the cost estimation.

3.5 Cost Estimate for Factories newly Constructed by 2003

The number of factories newly constructed in the basin is estimated in the Master Plan Study. Based on the number of factories by industrial categories, the total cost and annual O&M cost necessary for treatment plants for those newly constructed are

estimated at US$ 9,038,000 and US$401,000. The cost estimation is shown in Tables 3.5-1 and 3.5-2.

SECTOR C

TABLES

Table 1.1-1 Factory and Employee Numbers in Cities

CIIU	City / Category	Colonia Tovar / Town	El Consejo / San Felix Ribas	La Victoria / Santos Michelena	Ocumare / Santos Michelena	Cua / Urdaneta	Petare / Sucre	San Diego de los Altos / Sucre	San Jose de los Altos / Sucre	Charallave / Cristobal Rojas	Paracay / Cristobal Rojas	Ocumare del Tuy / Lander	San Francisco de Yare / Simon Bolivar	Total
31100	Food product factory excl. soft drinks						1(203)			1(691)			1(26)	3(920)
31111	Abattoirs for cattle, pigs, sheep, horses and rabbits			1(45)	1(90)					1(33)				3(168)
31112	Farms of chicken and other animals		1(80)		1(328)									2(408)
31113	Preparation and manufacture of meat centerings	1(54)		2(261)						1(56)				4(371)
31121	Milk pasteurization and bottling					1(14)								1(14)
31173	Biscuits,shortcake and noodles									1(590)			1(286)	2(676)
31221	Production of animal food			1(39)	1(39)									2(78)
31311	Distillery		1(575)									1(440)		2(1015)
31341	Production of soft drinks												1(18)	1(18)
31342	Bottling and gasification of natural mineral waters								1(49)					1(49)
Subtotal of food related factories		1(54)	2(653)	4(345)	3(457)	1(14)	1(205)	0	1(49)	4(1170)	0	1(440)	3(330)	21(3715)
32111	Manufacturer of textiles fibers			1(253)		1(23)								2(276)
32112	Spinning, weaving and finishing of wool and mixed fibers					1(11)						1(37)		2(48)
32113	Spinning, weaving and finishing of cotton, artificial, synthetic and mixed fibers			2(859)		2(320)				5(376)	1(160)	1(61)		12(1576)
32511	Tannery, finishing of leather						1(41)							1(41)
32521	Tannery						2(65)							2(65)
35131	Synthetic resins, plastic materials and artificial fibers					1(20)								1(20)
35135	Synthetic resins, plastic materials and artificial fibers			1(117)		1(28)					1(700)	1(37)		4(882)
35211	Manufacturer of paint and varnishes			1(11)		1(66)				3(821)			1(16)	6(914)
35231	Manufacturer of soaps and cleaning products			1(48)	1(236)		1(39)			1(210)			3(288)	7(821)
35234	Manufacturer of perfumes and cosmetics													0
35291	Manufacturer of polishing products, waxes and polish			2(92)										2(92)
35292	Manufacture of adhesive, glue and printing for textile factory									1(45)				1(45)
35295	Manufacture of adhesive materials, glues, gelatin, and pates									1(18)				1(18)
36200	Pottery and porcelain maker												1(80)	1(80)
36201	Production of fiberglass					1(15)	1(72)							2(87)
36991	Manufacturer of floor tiles					1(300)							1(1039)	2(1339)
3699	Manufacture of other non-metallic products										1(42)			1(42)
37102	Manufacture of iron rod, rod, pig iron and other rolling					1(12)	1(24)			1(350)				3(386)
37201	Production of non-ferrous metals and alloys			1(180)		3(218)					1(41)		1(85)	6(524)
38191	Manufacture of metallic products, excl. machinery			1(22)			2(130)						1(53)	4(205)
38193	Metal plating		1(25)	2(346)		1(25)	1(53)			2(321)		2(141)		9(911)
38431	Car parts factory			1(296)										1(296)
38433	Automobile spare parts factory					2(414)		1(212)		1(170)		1(26)		5(822)
	Sand mining			1(7)		2(19)	2(19)					2(16)	1(7)	8(68)
Subtotal of non-food related factories		0	1(25)	14(1978)	1(236)	18(1279)	11(443)	1(212)	0	15(3311)	4(943)	8(318)	9(1568)	82(9566)
Total		1(54)	3(678)	18(2323)	4(693)	19(1293)	13(648)	1(212)	1(49)	19(3481)	4(943)	9(358)	12(1898)	104(13028)

Note: Employee numbers in parentheses

Table 1.1-2 (1/5) Inventory of Representative Factories in the Study Area

code	Name	Category (C11U)	Location	Municipality	Registration	Treatment system	Type of treatment system	Water source	Volume of using water (ton/day)	Volume of wastewater (t/day)	Water body receiving wastewater	Kind of Products	Total production (ton/year)	Employees	Work h/day	Work d/wk.
F-1	Ron Santa Teresa	Alcohol Production (31311)	Had.Santa Teresa El Consejo Edo. Aragua	Jose Felix Ribas	Yes	Yes	UASB	5 wells	243	288	Cano Tiquirito	Rum and alcoholic beverages	$12x10^3$	500	9	5
F-2	La Monser-ratina	Sausagery (31113)	Andres Bello St.No.4 Las Tejerias Industrial Zone	Santos Michelena	Yes	No	-	1 well	25	25	Sewers	Sausage, ham, blood pudding	Sausage: 960, Ham:240 Blood-pudding: 384	69	8	5
F-3	Proagro	Fowl Processing (31112)	Guayas Industrial Zone Curiepe road	Santos Michelena	Yea	Yes	Biological System	8 wells	1800	1800	Tuy River	Poultry	60,000 per day	339	8	6
F-4	Industrias Savoy	Snack Factory P-P7 (31173)	Charallave - Ocumare Road, KM 1, Pitahaya Flache	Cristobal Rojas	Yes	Yes	Biological System	Mains	200	200	Qda. El Dividive	Corn Flour	-	390	8	5
F-5	Beneficiadora Airebi	Slaughter-house (31111)	La Bonanza Sector, Old Road, Charallavo - Caracas	Guaicaipuro	Yes	No	-	Mains Cistern	80	80	Qda. Charallave	Pork Meat	2,200	33	6	5
F-6	Industrias Savoy	Snack Factory P-P7 (31173)	Ocumare - Yare Road, KM 6	Simon Bolivar	Yes	No	-	1 well & mains	167	83	Tuy River	Salad Snacks	200-300	286	20	6
F-7	Pepsi Cola	Soft Drink Plant (31341)	Ocumare - San Francisco de Yare Road	Simon Bolivar	Yes	Yes	Irrigation	Mains	22.5	15	Infiltration	Soft drink	2,100	18	8.8	5
F-8	Ilamaca	Milky Factory (31121)	Ramon Rodriguez Street, Marin J. Industrial Zone, CUA, Miranda ST.	Urdaneta	Yes	Yes	Grease removal Biological reactor-sedimentation	Mains	31.9	32	Tuy River	Butter, Cheese	Butter 0.4ton/d Cheese 0.3ton/d	14	9	5
F-9	Industrias Pampero	Alcoholic Beverages (31311)	Ocumare - Yare Road, Aponte Sector	Lander	Yes	Yes	Biological sedimentat. drying beds	Mains	6,500	320	Tuy River	Alcoholic Drink	14,365	236	8	5

C-T-2

Table 1.1-2 (2/5) Inventory of Representative Factories in the Study Area

code	Name	Category (CIIU)	Location	Municipality	Registration	Treatment system	Type of treatment system	Water source	Volume of using water	Volume of wastewater (t/day)	Water body receiving wastewater	Kind of Products	Total production (ton/year)	Employees	Work h/day	Work d/wk.
F-10	Avicola La Mora	Poultry slaughtering (31112)	Hacienda Tiquire Esperanza	Jose Felix Ribas	Yes	Yes	Activated sludge	1 well	201	201	Qda. Tiquirito	Packed Chicken	Packed chicken 360000/m	80	8.8	5
F-11	Provegran	Meat & bone processing (31152)	Las Tejerias, Canote Sector	Santos Michelena	Yes	Yes	9 Steps - chlorination chamber	1 well	500	202	Qda. Guayas	Processing/ sub products	23,400	85	24	6
F-19	Castelo Blanco Industrias	Ham & Sausage factory (31113)	Charallave, Alvarenga Hillocks	Cristbal Rojas	Yes	No	Septic Tank	Mains	6	6	No	Ham Sausages	2,080	60	8	5
N-10	Grupo Manufact-urero Unidad (Tannery)	Leather coloring factory (32321)	Paracotos	Guaicaipuro	Yes	No	Sediments dried and transported to la Bonaza Landfill	1 well	0.6	0.6	Stored in 3 tanks, treated and discharge into Qua.	Leather Colored	1500-1600 per month	11	9	5
N-11	La Union Concordia Tannery	Leather finishing (32321)	Paracotos KM2, Tacata Road	Guaicaipuro	Yes	Yes	Physical - Chemical	1 well	60	60	Qda. Maitana	Leather for Shoes	300,000 ft^2	42	9	5
N-12	Arenera Paracotos	Sand Production (2901)	Paracotos Main Avenue	Guaicaipuro	Yea	No	Septic Tank for domestic waste	1 well	2000	2000	Sedimentator to Qda. Maitana	Sand	Sand, 600m^3/m	11	8	5
N-13	Alfombras y Fietros Iberia	Carpet factory (32112)	Las Tejerias	Santos Michelena	Yes	Yes	3 Storage tank Treatment tank Sed.tanks, Drying beds	Mains	100	40	Sewer Net, Tuy River	Carpet	Carpet 100,000m^2 /month)	36	9	5
N-14	Pinturas Manpica	Paint factory (35211)	Tejerias Industrial Zone, end of "Elias Rodriguez" Street	Santos Michelena	Yes	No	-	1 well	2	0.25	Sewer Net, Tuy River	Water Paint (90%), Oil Paint	1356	15	8	5
N-15	Textilana	Textile finishing (32113)	Tejerias Industrial Zone, "Andres Bello" Avenue	Santos Michelena	Yes	No	-	1 well	922	748.8	Sewer Net, Tuy River	Textiles	440,000 linear meters	230	16	5.5

Table 1.1-2 (3/5) Inventory of Representative Factories in the Study Area

code	Name	Category (CIIU)	Location	Municipality	Registration	Treatment system	Type of treatment system	Water source	Volume of using water	Volume of wastewater (t/day)	Water body receiving wastewater	Kind of Products	Total production (ton/year)	Employees	Work h/day	Work d/wk.
N-16	Vengrif	Metal mechanics (37201)	Tejerias Industrial Zone, "Andres Bello" Avenue	Santos Michelena	Yes	Yes	Physical - Chemical Treatment	1 well	42	42	Sewer Net, Tuy River	Brass Tubes & Pipes	Brass Tubes & Pipes	180	9	5
N-17	Industrias Vargas	Cosmetics factory (35232)	Las Guayas Industrial Zone, Cadafe Street, Guayas	Santos Michelena	Yes	No	-	2 wells	9	9	Sewers, Tuy River	Shampoo	50,000kg/ week 2600ton/y	100	8	5
N-18	Mack de Venezuela	Truck assembling (38431)	Las Tejerias	Santos Michelena	Yes	Yes	Physical Chemical System	1 well	15	15	Sewers, Tuy River	Trucks	8 per day	-	9	5
N-21	Terminados de Aluminio Alumbra	Metal mechanics (37201)	Alvarenga Industrial Urbanization, Tricentenaria Av.	Cristobal Rojas	Yes	Yes	Physical Chemical System	Mains	29	28.8	Sewers, Tuy River	Aluminum sections	3 ton/day	20	16	5
N-22	Multiprens	Car parts factory (38433)	Charallave - Cua Road, KM 2, Corpoindustria Industrial	Cristobal Rojas	Yes	No	-	Mains	59	34.8	Sewers	Car parts		170	8.8	5
N-23	Aplanc-hados Rey David	Indigo Industrial Pre-Washed (32112)	Tuy River Industrial Urbanization	Cristobal Rojas	Yes	No	-	Mains	15	12	Sewers	Jeans	1200 Jeans/day	13	9	5
N-24	Aiesa	Electric Panels (3699)	Charallave - Ocumare Road, KM6	Cristobal Rojas	Yes	No	Domestic = Septic Tank	Mains	-	-	Qda. Charallave	Electric Panels	-	42	9	5
N-25	Petrosima Quimica	Petro Chemical Industry (35135)	Charallave - Ocumare Road, Pitahaya Sector	Cristobal Rojas	Yes	Yes	Industry = ?, Domestic = Yes	Mains	60	Industry = 10, Domestic = 30 - 50	All wastes recovered	Plastic products	-	700	24	7
N-26	Madosa	Cooker Assembling (37101)	Alvarenga Industrial Urbanization, Charallave	Cristobal Rojas	Yes	Yes	Electrical Chemical Treatment System	Mains	100	100	Qda.El Mamon	Cooker	500 U/m	350	9	5
N-27	Manufactura de Algodon Inca	Medical Cotton & Carpet factory (32113)	Charallave - Ocumare del Tuy Old Road, Pitahaya Sector	Cristobal Rojas	Yes	Yes	Crude Water Reception Tank	Mains	30	30	Qda. Dividiv	Carpets Cotton	-	160	9	5

Table 1.1-2 (4/5) Inventory of Representative Factories in the Study Area

code	Name	Category (CIIU)	Location	Municipality	Registration	Treatment system	Type of treatment system	Water source	Volume of using water (ton/day)	Volume of wastewater (t/day)	Water body receiving wastewater	Kind of Products	Total production (ton/year)	Employees	Work h/day	Work d/wk.
N-28	Hilanderas Hicril	Spinning Mill (35135)	Tuy City Industrial Zone, Shed #56,57	Lander	Yes	No	-	Mains & Cistern	30	30	Sewers - Tuy River	Yarn (Acril 100%)	30000 - 40000Kg/ month	100	16	6
N-29	Quimicas Polyresin	Elastomers & Polyester Production (35135)	Bolivar Avenue, El Cerrito Route	Lander	Yes	No	Domestic Septic Tank	1 well	115	3	Storage tanks	Elast-omers, Polyester	1560	88	24	20
N-31	Industrias Ferrogalvan de Venezuela	Foundry (37201)	Mata Sector, 1st Parcel of Land, #384	Lander	Yes	No	-	Mains	10.5	0	No discharge	Electric & Phone adapters	25ton/m	41	24	5
N-32	Balgres	Ceramic Floor Tile factory (36911)	Yare - Santa Teresa Road	Simon Bolivar	Yes	Yes	Storage Tank	Mains, Lago-ons, Rain-fall	950	300	Recycled	Floor Tiles	15000 m^2/ day	1039	8	6
N-33	Detergentes Yare	Detergent factory (35231)	Santa Teresa - San Fco. de Yare Road, Pararrayos Sector	Simon Bolivar	Yes	Yes	Recycle System	Mains	20	Recycled	Recycled	Detergents	3600 ton/year	50	16	5
N-34	Asea Brown Boveri	Metal mechanics (37201)	Santa Teresa - San Fco. de Yare Road, KM 6	Simon Bolivar	Yes	Yes	Physical Chemical System	Mains	500	300	Tuy River	Transmission, Line Tower Structures	7000-8000 ton/year	85	9	5
N-35	Textiles La Fila	Textile factory (Tannine) (32113)	La Fila Sector, La Laguna Street	Urdaneta	Yes	Yes	Sedimentator & Solids Separator	Mains	200	200	Sewers	Nylon, Cotton, Polyester Cloths	50	109	7	5
N-36	Fabrica de Aires Acondicion-ados	Car Parts Factory (38433)	Cua Perymetral Avenue, Marin J. Industrial Urb.	Urdaneta	Yes	No	-	Mains	70	70	Qda. Aparay, Tuy River	Vehicle, Air Conditioner, Evaporators	100,000	300	9	5
N-37	Dexalum	Aluminium sections finishing factory (37201)	Paracaima Interprise Center, El Canal Avenue, Shed #2, Marin	Urdaneta	Yes	No	Directly to Sewer Net	Mains	2 0`3	2.5	Tuy River	Aluminiun sections	25000-30000 Meters/y	14	8	5

C-T-5

Table 1.1-2 (5/5) Inventory of Representative Factories in the Study Area

code	Name	Category (CIIU)	Location	Municipality	Registration	Treatment system	Type of treatment system	Water source	Volume of using water (ton/day)	Volume of wastewater (t/day)	Water body receiving wastewater	Kind of Products	Total production (ton/year)	Employees	Work h/day	Work d/wk.
N-38	Corporacion Industrial Americer	Ceramic Floor Tile factory (36911)	Marin J. Industrial Zone	Urdaneta	Yes	Yes	Solid Decantation	Mains, Well	90	Clalified water reused	Domestic w/water Qda.	Ceramic Floor Tile	2.5 x 10^6 m^2	300	24	7
N-39	Metal Mecanica Tuy	Foundry (37201)	Marin J. Industrial URB	Urdaneta	Yes	No	-	Mains	from 10 to 12	0.3	Tuy River	Metal casting	5500 pieces/m	44	9	5
N-40	Infra Division Aluminio, S.A. (Industria Nacional Fabrica de Rodradores)	Metal Mechanics (37201)	Marin J. Industrial URB	Urdaneta	Yes	Yes	Biological Treatment System	Mains	50	40	Tuy River	Aluminum Radiators	150000 unit / year	160	8	5
N-41	Estampados Texiles Como, C.A.	Industrial Dyeing (32113)	Charallave - Ocumaredel Tuy Road, Las Juajitos Sector	Cristbal Rojas	Yes	Yes	Physical - Chemical Process	4 wells	200	200	Qda. Charallave	Dye and Finishing Clothes	5000~600	45	16	5.5

Table 1.1-3(1/2) Inventory of Piggeries

Upper Basin

No	Name	Location	Animal numbers	Treatment system	Water source	#Volume of water used (tons/day)	Water body receiving waste water	Working hours (h/day)	Working days (d/week)	Working days (d/year)	Number of workers
1	Funchal	Las Tejerias	4,289	3 ponds	Qda. El Limon	6	Not discharged	8	7	365	6
2	Guayas	Las Tejerias	3,000	2 ponds, poor function	Deep well	20	Qda. Guayas	8	7	365	4
3	Had. San Jorge	Morocopo	3,603	None exist	Deep well	40	Qda. Morocopo	8	7	365	7
4	Graiteca	Morocopo	54	3 ponds, good	Spring water	10	Not discharged	8	7	365	3
5	San Martin de Porres	Morocopo	5,500	3 ponds, poor function	Qda. El Limon	60	Qda. Morocopo	8	7	365	4
6	Ganacer	Morocopo	2,650	4 ponds	Qda. El Rosario	16	Qda. Morocopo	9	7	365	3
7	Dartin	Morocopo	837	2 ponds, poor function	Qda. El Limon	5	Qda. Morocopo	8	7	365	2
8	Valle Alto	Morocopo	900	2 ponds, poor function	Qda. El Limon	6	Qda. Morocopo	12	7	365	4
9	La Milagrosa	Morocopo	1,856	3 ponds	Spring water	10	Qda. Morocopo	8	7	365	1
10	Hnos Rodoriguez, C.A.	Morocopo	7,000	4 ponds, good	Qda. Agua Buena	40	Qda. Morocopo, but not discharged	8	7	365	6
11	Agropecuaria Namarda	Morocopo	4,700	2 ponds	Qda. El Limon and deep well	20	Qda. Morocopo	10	7	365	7
12	Morocopo	Morocopo	4,920	4 ponds, good	Qda. El Rosario	5	Qda. Morocopo, but not discharged	8		365	6
13	Multiflo	Morocopo	1,500	Tanks	Qda. El Limon	10	Qda. Morocopo	8		365	3
14	Granulca	Guaicaipuro	2,318	3 ponds	Deep well	25	Tuy River	8	7	365	1
15	El Sacrificio	Guaicaipuro	134	5 septic tanks	Deep well	1	Qda. Guayas	10	7	365	3
16	Las Mercedes	Guaicaipuro	255	2 ponds, good	Spring water	6	Qda. Guayas, but not discharged	8	7	365	8
17	Agropecuaria 67	Boca de Cagua	1,400	9 tanks and 3 ponds, poor function	Spring water and deep well	5	Tuy River	8	7	365	3
18	Santa Maria o Fatima	Boca de Cagua	2,400	2 ponds, very poor function	Deep well	30	Tuy River	8	7	365	3
19	Agropecuaria Retamal	Retamal	768	-	-	6	Qda. Guayas	8	7	365	4
20	Agropecuaria la Fronoa	Qda. Guayas	350	-	Deep well	3	Qda. Guayas	8	6	365	6

Volume of wastewater was reported as same as using water volume.

Table 1.1-3(2/2) Inventory of Piggeries

Middle Basin

No	Name	Location	Animal numbers	Treatment system	Water source	Volume of using water (tons/day)	Volume of wastewater (tons/day)	Water body receiving ww	Working hours (h/d)	Working days (d/week)	Working days (d/year)	Number of workers
21	El Marques	Tacata	7,000	2 ponds	2 wells	70	50	Tuy River	8	6.5	338	11
22	Guaicaipuro	Cua	300	Ponds	-	-	-	Qda. Aparnate	8	7	365	2
23	Rancho Grande	Ocumare del Tuy	2,000	Ponds	Well	10	7	Not discharged	8	7	365	3
24	Langreana	Ocumare del Tuy	3,000	Ponds	Well	10.5	9	Not discharged	10	7	365	2
25	San Bernardo	Ocumare del Tuy	1,800	3 ponds	Well	15	10	For irrigation	8	7	365	5
26	Averense	Ocumare del Tuy	1,500	3 ponds	Tuy River	40	30	Tuy River	8	6	312	1
27	Nichita	Ocumare del Tuy	-	3 ponds	-	-	-	-	-	7	365	-
28	Canose	Ocumare del Tuy	3,000	3 ponds	1 well	15	10	Tuy River	8	7	365	4
29	Cabrales	Ocumare del Tuy	80	2 ponds	Municipal water supply	4	3	Not discharged	8	7	365	1
30	La Chicharra	Charallave	-	None exist	-	-	-	*Qda. Cantarrana	8	7	365	-
31	Las Gondolas	Charallave	4,000	None exist	Well, delivered	35	20	*Qda. Cantarrana	8	7	365	6
32	La Cooperativa	Charallave	113	1 pond	Delivered by tanker	3	3	Not discharged	8	7	365	3
33	La Mata	Charallave	275	2 ponds	Delivered by tanker	8	8	Not discharged	8	7	365	2

*Wastewater does not flow into Quebrada Charallave in the dry season.

Table 1.1-4 Numbers of Piggeries and Pigs, and Water Bodies receiving Wastewater

Water body and location	Treatment condition	Piggeries	Number of pigs	No discharge of wastes (tons/day)	Well treated wastes (tons/day)	None or poor treatment (tons/day)
Tuy River and Boca de Cagua	Well treated	1	2,318	-	25	-
	None or poor treatment	2	3,800	-	-	35
	No discharge of wastes	0	0	0	-	-
	Subtotal	3	6,118	0	25	35
Qda. Morocopo	Well treated	4	10,700	-	66	-
	None or poor treatment	4	10,800	-	-	71
	No discharge of wastes	3	12,000	85	-	-
	Subtotal	11	33,500	85	66	71
Qda. Guayas	Well treated	4	4,251	-	1	-
	None or poor treatment	0	0	-	-	29
	No discharge of wastes	2	4,544	12	-	-
	Subtotal	6	8,795	12	1	29
Subtotal in the upper basin		20	48,413	97	92	135
Tacata (Tuy River)	Well treated	0	0	-	0	-
	None or poor treatment	1	7,000	-	-	50
	No discharge of wastes	0	0	0	-	-
	Subtotal	1	7,000	0	0	50
Cua (Tarma River)	Well treated	1	300	-	?	-
	None or poor treatment	0	0	-	-	0
	No discharge of wastes	0	0	0	-	-
	Subtotal	1	300	0	?	0
Ocumare del Tuy (Tuy River)	Well treated	2+1*	4,500	-	55	-
	None or poor treatment	0	0	-	-	0
	No discharge of wastes	4	6,880	0	-	-
	Subtotal	7	11,380	0	55	0
Charallave (Qda. Cantarran)	Well treated	0	0	-	0	-
	None or poor treatment	0	0	-	-	0
	No discharge of wastes	3*1*	4,388	31	-	-
	Subtotal	4	4,388	31	0	0
Subtotal in the middle basin		13	23,068	31	55	50
Total in the basin		33	71,481	128	147	185

* 3 ponds exist in this piggery, but no information of pig numbers or treatment condition

Note: No information of good or poor about treatment efficiency, therefore in case the treatment exist it was dealt with good treatment efficiency.

Table 1.1-5 Comparison of Numbers of Piggeries and Pigs between 1988 and 1996

			Upper basin	Middle basin	Subtotal	Total
1988*	Piggery	No treatment	16	14	30	
		With treatment	12	4	16	
		Subtotal	28	18	46	
	Pigs		38,000	32,000		70,000
1996	Piggery	None or poor treatment	6	4	10	
		Well treated	9	1	10	
		No discharging ww	5	8	13	
		Subtotal	20	13	33	
	Pigs	None or poor treatment	14,600	7,000	21,600	
		Well treated	17,269	4,800	22,069	
		No discharging ww	16,544	11,268	27,812	
		Subtotal	48,413	23,068		71,481

*: After "Diagnostico de las Fuentes de Contaminacion en la Cuenca del Rio Tuy", E. R. Gunwald. A. (1989)

Table 1.2-1 (1/2) Number of Sampling Sites for Water Quality Analysis during the Study

Analysis Item	Tuy River	Tributary	Sand quarry flushing water	Total
Water Discharge	10	14	-	24
Odor	10	14	-	24
Color	10	14	-	24
Water Temperature	10	14	-	24
pH	10	14	-	24
EC	10	14	-	24
DO	10	14	-	24
BOD	10	14	-	24
COD	10	14	-	24
TOC	10	14	-	24
SS	10	14	-	24
Turbidity	10	14	-	24
TN	10	14	-	24
TP	10	14	-	24
NH4	10	14	-	24
NO2+3	10	14	-	24
PO4	10	14	-	24
N-Hexane Extract	10	14	-	24
Hg	10	-	-	10
As	10	-	-	10
Cd	10	-	-	10
Pb	10	14	-	24
Se	10	-	-	10
Cr	10	14	-	24
Cu	10	14	-	24
Zn	10	14	-	24
Ni	10	14	-	24
TS	10	14	-	24
VS	10	14	-	24
VSS	10	14	-	24
Total Coliform	10	14	-	24
Fecal Coliform	10	14	-	24
Cl	10	14	-	24
Sedimentation test	12	6	1	19

Table 1.2-1 (2/2) Number of Sampling Sites for Water Quality Analysis during the Study

Analysis Item	Industrial Wastewater			Livestock Wastewater	Domestic Wastewater	Total
	Non-food	Industrial Area	Food			
Water Discharge	26	4	17	13	10	70
Odor	26	4	17	13	10	70
Color	26	4	17	13	10	70
Water temperature	26	4	17	13	10	70
pH	26	4	17	13	10	70
EC	26	4	17	13	10	70
BOD	26	4	17	13	10	70
COD	26	4	17	13	10	70
TOC	26	4	17	13	10	70
SS	26	4	17	13	10	70
Turbidity	26	4	17	13	10	70
TN	26	4	17	13	10	70
TP	26	4	17	13	10	70
NH_4	26	4	17	13	10	70
NO_{2+3}	26	4	17	13	10	70
PO_4	26	4	17	13	10	70
N-Hexane Extract	26	4	17	13	-	60
Hg	26	4	-	-	-	30
As	26	4	-	-	-	30
Cd	26	4	-	-	-	30
Pb	26	4	-	-	-	30
Se	26	4	-	-	-	30
Cr	26	4	-	-	-	30
Cu	26	4	-	13	-	43
Zn	26	4	-	13	-	43
Ni	26	4	-	-	-	30

Table 1.3-1 Present Treatment Rate by Pollution Source

Factory

(mg/l)

Category		BOD			COD			SS		
		before	after	rate (%)	before	after	rate (%)	before	after	rate (%)
Food	F-1	67,200	2,220	96.7	110,361	11,496	89.6	14,700	2,453	83.3
	F-3	4,320	14	99.7	2,131	73	96.6	1,630	3	99.8
	F-4	1,920	34	98.2	4,133	32	99.2	1,063	216	79.7
	F-8	300	14	95.3	376	143	62.0	288	188	34.7
	F-9	288	5	98.3	413	58	86.0	256	228	10.9
	F-10	315	185	41.3	765	335	56.2	179	68	62.0
	Ave			88.2			81.6			61.7
Non-Food	N-26	10	4	60.0	58	10	82.8	214	92	57.0
	N-18	20	20	0.0	166	100	39.8	190	316	-66.3
	N-41		192		4,035	3,242	19.7	456	324	28.9
	N-42				184	376	-104.3	192	224	-16.7
	N-27	150			428	317	25.9	92	280	-204.3
	N-34	16	2	87.5	754	6,110	-710.3	522	1,768	-238.7
	N-35	635	177	72.1	714	547	23.4	40	224	-460.0
	N-40	42	54	0.0	120	280	-133.3	8	8	0.0
	Ave			43.9			-94.6			-112.5

Piggery

(mg/l)

	BOD			COD			SS		
	before	after	rate (%)	before	after	rate (%)	before	after	rate (%)
P-8	8,976	47	99.5	20,800	640	96.9	22,625	81	99.6
P-5	3,100	116	96.3	13,705	896	93.5	5,870	146	97.5
P-13	14,500	1,170	91.9	11,049	1,832	83.4	5,900	333	94.4
Ave			95.9			91.3			97.2

Household

(mg/l)

	BOD			COD			SS		
	before	after	rate (%)	before	after	rate (%)	before	after	rate (%)
D-7	101	56	44.6	60	119	-98.3	48	32	33.3

Table 1.3-2 Decrease of Pollution Load by Removing of Solid for Piggery

Removal rate of solids			0%	50%	70%	90%
BOD	feces	(g)	183	92	55	18
	urine	(g)	15	15	15	15
	total	(g)	198	107	70	33
	Treatment rate	(%)	-	54	35	17
	Concentration	(mg/l)	33,000	24,000	18,000	10,000
SS	feces	(g)	669	335	200	67
	urine	(g)	14	14	14	14
	total	(g)	683	349	214	81
	Treatment rate	(%)	-	51	31	12
	Concentration	(mg/l)	117,000	78,000	54,000	25,000

Source: A Guide of Treatment in Livestock Wastewater(1978)

Table 1.3-3 Treatment Rate of Heavy Metals at Factoies

(μg/l)

Category		Pb (SD=50)			Cr (SD=50)			Cu (SD=1000)		
		before	after	rate	before	after	rate	before	after	rate
Non-Food	N-26	<250	<250	-	333	<50	15	168	64	38
	N-18	<250	<250	-	<50	<50	-	63	<50	79
	N-41	<250	<250	-	200	<50	25	<50	100	200
	N-42	<250	<250	-	150	150	100	<50	100	200
	N-27	<250	<250	-	<50	90	180	100	80	80
	N-34	7270	3450	47	1100	2100	191	3900	1100	28
	N-35	<250	<250	-	<50	400	800	70	<50	71
	N-40	<250	<250	-	<50	177	354	<50	<50	-
	Ave			47			1665			697
Category		Zn (SD=5000)			Ni			Hg (SD=5)		
		before	after	rate	before	after	rate	before	after	rate
Non-Food	N-26	83	65	78	465	<50	11	2	1	82
	N-18	1,915	90	5	20,837	255	1	4	3	87
	N-41	248	83	33	80	98	123	3	3	112
	N-42	40	2,228	5,570	139	100	72	3	3	96
	N-27	48	48	100	<50	<50	-	1	5	500
	N-34	2,543	229	9	697	1,230	176	10	2	20
	N-35	200	7,300	3,650	<50	<50	-	2	-	-
	N-40	500	400	80	<50	<50	-	3	-	-
	Ave			9,525			383			898
Category		As (SD=50)			Cd (SD=10)			Se (SD=10)		
		before	after	rate	before	after	rate	before	after	rate
Non-Food	N-26	BLD	BLD	-	BLD	BLD	-	BLD	BLD	-
	N-18	BLD	10	-	BLD	BLD	-	BLD	BLD	-
	N-41	BLD	BLD	-	BLD	BLD	-	BLD	0.5	-
	N-42	11	BLD	-	ND	BLD	-	BLD	BLD	-
	N-27	11	BLD	-	BLD	BLD	-	BLD	BLD	-
	N-34	29	13	45	BLD	BLD	-	BLD	BLD	-
	N-35	BLD	10	-	BLD	41	-	BLD	BLD	-
	N-40	11	BLD	-	BLD	BLD	-	BLD	BLD	-
	Ave			45			0			0

(SD=) : Standard for discharge to river

Table 2.2-1 Cost of Installation of Treatment Plants for Existing Factories and Piggeries

Industrial Category	Areas	Production Discharge m3/day	Discharge of not-fulfiling water quality standard (1) m3/day without T.P.	(2) m3/day with T.P.	Cost* $1,000
Food Factories	El. Consejo	929	306	158	492
	Las Tejerias	2,034	671	346	878
	Qda.Guayas	681	225	116	361
	Paracotos	48	16	8	25
	Cua	6	2	1	3
	Charallave	2,949	973	501	1,263
	Ocumare	427	141	73	226
	S.F.de Yare	70	23	12	37
	Total	7,142	2,357	1,214	2,786
Non-food Factory	El. Consejo	0	0	0	0
	Las Tejerias	2,770	1,274	305	2,800
	Qda.Guayas	9	4	1	9
	Paracotos	286	131	31	289
	Cua	192	88	21	194
	Charallave	4,301	1,978	473	3,348
	Ocumare	357	164	39	361
	S.F.de Yare	1,490	685	164	1,506
	Total	9,404	4,326	1,034	8,507
Piggeries	El. Consejo	0	0	0	0
	Las Tejerias	409	123	205	341
	Qda.Guayas	161	48	81	154
	Paracotos	0	0	0	0
	Qda.Guare	76	23	38	73
	Cua	3	1	2	3
	Charallave	98	29	49	87
	Ocumare	49	15	25	47
	S.F.de Yare	0	0	0	0
	Total	796	239	398	705
Total					11,998

Note: *Cost=(1)x(Unit cost) + (2)x(Unit cost)x0.5
Unit cost of Food factory : 1,277 (US$/m3/day)
Unit cost of Non-food factory 1,963(US$/m3/day)
Unit cost of Piggery : 1,739(US$/m3/day)

Table 2.2-2 Cost for Installation of Treatment Plants for Newly Built by 2003

Industrial Category	Areas	Production Discharge m3/day	Discharge to be treated (1) m3/day	Cost* $1,000
Food Factories	El. Consejo	527	527	673
	Las Tejerias	904	904	1,155
	Qda.Guayas	298	298	380
	Paracotos	28	28	36
	Cua	2	2	3
	Charallave	1,288	1,288	1,646
	Ocumare	254	254	324
	S.F.de Yare	33	33	42
	Total	3,335	3,335	4,260
Non-food Factory	El. Consejo	0	0	0
	Las Tejerias	986	986	1,936
	Qda.Guayas	6	6	13
	Paracotos	180	180	354
	Cua	70	70	138
	Charallave	1,507	1,507	2,958
	Ocumare	116	116	228
	S.F.de Yare	461	461	905
	Total	3,327	3,327	6,531
Piggeries	El. Consejo	.|	.|	.|
	Las Tejerias	.|	.|	.|
	Qda.Guayas	.|	.|	.|
	Paracotos	.|	.|	.|
	Qda.Guare	.|	.|	.|
	Cua	.|	.|	.|
	Charallave	.|	.|	.|
	Ocumare	.|	.|	.|
	S.F.de Yare	.|	.|	.|
	Total	.|	.|	.|
Total				10,791

Note

(Unit cost) of Food factory : 1,277 (us$/m3/day)

(Unit cost) of Non-food factory : 1,963 (us$/m3/day)

Piggery does not increase

Table 2.2-3 Cost for Installation of Treatment Plants for Newly Built from 2003 to 2010

Industrial Category	Areas	Production Discharge m3/day	Discharge to be treated (1) m3/day	Cost* $1,000
Food Factories	El. Consejo	909	909	1,161
	Las Tejerias	1,559	1,559	1,991
	Qda.Guayas	513	513	656
	Paracotos	49	49	62
	Cua	4	4	5
	Charallave	2,221	2,221	2,838
	Ocumare	438	438	559
	S.F.de Yare	57	57	73
	Total	5,751	5,751	7,346
Non-food Factory	El. Consejo	0	0	0
	Las Tejerias	1,700	1,700	3,338
	Qda.Guayas	11	11	22
	Paracotos	311	311	610
	Cua	121	121	238
	Charallave	2,598	2,598	5,100
	Ocumare	200	200	393
	S.F.de Yare	794	794	1,560
	Total	5,736	5,736	11,260
Piggeries	El. Consejo	.	.	.
	Las Tejerias	.	.	.
	Qda.Guayas	.	.	.
	Paracotos	.	.	.
	Qda.Guare	.	.	.
	Cua	.	.	.
	Charallave	.	.	.
	Ocumare	.	.	.
	S.F.de Yare	.	.	.
	Total	.	.	.
Total				18,606

Note

(Unit cost) of Food factory : 1,277 (us$/m3/day)

(Unit cost) of Non-food factory : 1,963 (us$/m3/day)

Piggery does not increase

Table 2.2-4 Cost for finstallation of Treatment Plant for Factories Discharging Elements of Odor, Color and Heavy Metals

Item	Industrial Category	Discharge which have to be treated by new treatment plant (m3/day)		(3)Unit cost	Treatment cost
		(1) with T.P	(2)withoutT.P.	$/m3/day	$1000
Toxicant	Tannery and Metal planting	166	40	1,963	365
Odor and color	Distillery	474	220	1,277	746
	Synthetic resin	430	104	1,963	946
Total		---	---	---	2,057

Table2.3-1 **Effectiveness to Reduce Organic Pollution (Factories and Piggeries)**

Category	Areas	Effectiveness (g/sec)	Cost (mil. US$)	Unit Cost (mil.US$/g)	Economic Priority
Factory	EL Consejo	3.89	1.04	0.27	2
	Las Tejerias	0.22	1.61	7.32	7
	Qda. Guayas	0.08	0.4	5	6
	Paracotos	0.06	0.65	10.83	8
	Cua	0.01	0.01	1	5
	Charallave	0.89	1.38	1.55	4
	Ocumare del Tuy	18.36	0.47	0.03	1
	S.F. de Yare	2.45	1.11	0.45	3
Piggery	Las Tejerias	0.09	0.158	1.76	4
	Qda. Guayas	0.04	0.093	2.33	5
	Paracotos	0.54	0.013	0.02	1
	Cua	0.01	0.003	0.3	3
	Charallave	0.18	0.015	0.08	2
	Ocumare del Tuy	-	-	-	-
	S.F. de Yare	-	-	-	-

Table2.3－2 Cost of Treatment Plant by Factory and Piggery Size

	Size	No. of Employee (Person or Head of pigs)	Average Water Treatment Volume (m3)	Installation Cost for Treatment Plant(mil.Bs)	Water Treatment Cost (mil. Bs/m^3)
Factory	Large	300<	448	547	1.22
	Mid-Small	300>	128	376	2.93
Piggery	Large	7,000<	105	60.5	0.58
	Mid-Small	7,000>	22	33.5	1.52

Table.3.2-1 Condition of Water Quality Discharged from Factory

Classification of Factories		Total Factories Number	Factories Number Sampled			
			Total	Fulfiling Standard	Not-fulfiling Std.	
Industry	Scale				T.P. exist	no-T.P.
Food Production	large	5	5	3	1	1
	middle	9	9	2	1	6
	small	7	7	5	0	2
Manufacturing of Textile	large	4	2	1	0	1
	middle	5	4	1	1	2
	small	6	3	1	0	2
Chemical & others	large	4	2	1	1	0
	middle	9	3	2	0	1
	small	15	3	2	0	1
Metal Manufacturing	large	5	4	1	1	2
	middle	11	6	5	0	1
	small	12	6	1	0	5
Tannery	large	0				
	middle	0				
	small	3	3	0	0	3
Sand Quarries	large	0				
	middle	0				
	small	8	8	0	0	8
Piggery	large	11	5		4	1
	middle	10	4	2	1	1
	small	12	4		3	1
Sub-Total	large	29	18	6	7	5
	middle	44	26	12	3	11
	small	63	34	9	3	22
Total		136	78	27	13	38

note : T.P. is Wastwater Treatment Plant

Table.3.2-2 Installation Cost of Existing Treatment Plant

Food Product Industry

Reference Number	Discharge (m3/day)	Employee	Surveyed Cost ($)
F2	25	119	104,000
F3	1,008	328	1,001,168
F4	200	390	344,800
F8	32	14	63,850
F9	320	440	510,800
F66	43	90	117,100
other area	500		276,000

Manufacturing of Textile

Reference Number	Discharge (m3/day)	Employee	Surveyed Cost ($)
N13	552	227	420,100
N15	749	379	389,800
N28	30	37	132,000
N41	80	45	160,000

Chemical Industry

Reference Number	Discharge (m3/day)	Employee	Surveyed Cost ($)
N14	1	11	30,000
N17	9	236	200,000
N25	50	700	465,000
N32	300	1,039	267,492
N33	20	50	76,000
N38	90	300	81,600

Tannery

Reference Number	Discharge (m3/day)	Employee	Surveyed Cost ($)
N10	11	6	
N11	60	59	46,780
N93	59	41	

Metal Manufacturing

Reference Number	Discharge (m3/day)	Employee	Surveyed Cost ($)
N16	42	211	175,042
N18	15	296	40,634
N21	29	41	30,946
N26	100	350	156,000
N31	11	63	50,000
N40	40	160	74,136
N77	7	25	122,200

Sand Quarries

Reference Number	Discharge (m3/day)	Employee	Surveyed Cost ($)
S1	2,000	11	14,924
S2	1,000	8	
S3	1,200	7	

Piggery

Reference Number	Discharge (m3/day)	Piggs	Surveyed Cost ($)
No.13	10	1,500	12,000
N0.25	13	1,800	28,000

Table.3.2-3 Major Removal Substances

Industrial Category	Major Removal Substances	Charactaristics of Organic Substance
Food production	Organic Substance	Easy Biodegradability
Manufacturing of textile	Organic Substance	Biodegradability
Chemical & others	Organic Substance	Difficult Biodegradability
Tannery	Organic Substance + Heavy Metal	Easy Biodegradability
Metal manufacturing	Heavy Metal	---
Sand quarries	Turbid	---
Piggeries	Organic Substance	Easy Biodegradability

Table.3.2-4 Discharge and Number of Factories Classified by Scale

Item	Discharge (m3/day)			No. of Factories		
Scale	large	middle	small	large	middle	small
Food production	500	200	40	5	9	7
Manufacturing of textile	300	100	30	4	5	6
Chemical & others	100	40	20	4	9	15
Tannery	--	--	50	--	--	3
Metal manufacturing	100	30	10	5	11	12
Sand quarries	--	--	2000	--	--	8
Piggeries	40	15	5	11	10	12
Total	--	--	--	29	44	63

Table.3.3-1 Specifications of Standard Treatment Plants

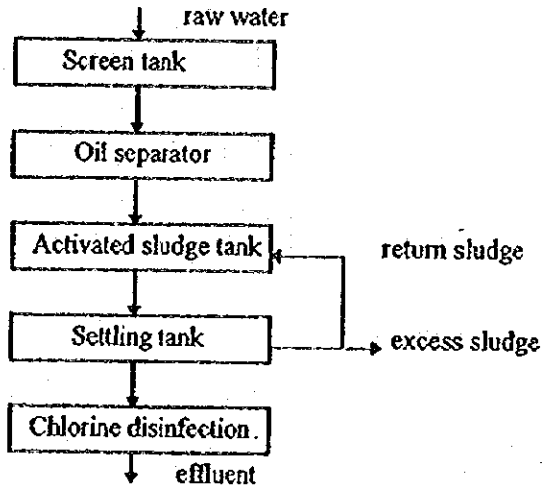
Industrial Category	Capacity m3/day	Water Quality (mg/l) Influent	Effluent	Products	Treatment Method
Food Production	200	BOD 2000 SS 500	60 80	Ham,Sausage Meat	Activated Sludge
Manufacturing of Textile	100	BOD 400 SS 200 pH 3-11	60 80 6-9	Cotton Wool	Catalystic Oxidation
Chemical & others	40	BOD 250 COD 1000 pH 3-11	60 350 6-9	Detergent Paint Cosmetics	Coagulated sedimentation
Metal Manufacturing	30	Cr 100 Cu 30	2 1	Automobil Car-parts	Coagulated sedimentation
Tannery	50	Cr 100 BOD 700 SS 500	2 60 80	Leather	Coagulated sedimentation Activated Sludge
Sand Quarries	2000	SS 15000	80	Sand	Coagulated sedimentation
Piggeries	15	BOD 7000 SS 10000	60 80		Aerated Lagoon

Table.3.3-2(1/7) Outline of Specification and Composition of Standard Treatment Plant (Biological Treatment Process)

1. Condition of Wastewater

Industry	Quality of raw water	Quality of treated water	Scale of Quantity	Quantity to be treated
Food Production	BOD: 2000mg/l SS: 500mg/l	BOD: 60mg/l SS: 80mg/l	middle	200 m3/day
			large	500 m3/day
			small	40 m3/day

2. Flowchart of treatment (standard case)



3. Composition of treatment system

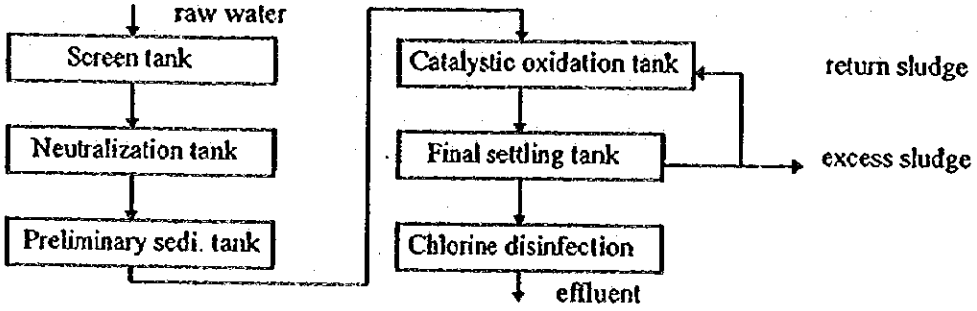
Category	Item	Residence time	Abstract	Tank capacity (m3)			Cost ratio*	
				middle	large	small	large	small
Treatment tank	Screen tank	10 min.	extended aeration & oil separation	1.4	3.5	no	1.6	0
	Oil separator	6 hours		50	125	10	1.6	0.3
	Activated sludge tank	24 hours		200	500	40	1.6	0.3
	Settling tank	2 hours		18	40	3	1.6	0.3
	Chlorination unit	-		-	-	-	-	-
Incidental facilities	Pump & Aerator etc.						2.0	0.3
Instrumentation & Control	Measuring device Control system						1.2	0.7

Table.3.3-2(2/7) Outline of Specification and Composition of Standard Treatment Plant
(Combination of Biological and Physio-Chemical Treatment Process)

1. Condition of Wastewater

Industry	Quality of raw water	Quality of treated water	Scale of Quantity	Quantity to be treated
Manufacturing of textile	BOD: 400mg/l SS: 200mg/l	BOD: 60mg/l SS: 80mg/l	middle	100 m3/day
			large	300 m3/day
			small	30 m3/day

2. Flowchart of treatment (standard case)



3. Composition of treatment system

Category	Item	Residence time	Abstract	Tank capacity (m3) middle	large	small	Cost ratio* large	small
Treatment tank	Screen tank	10 min.	catalystic oxidation & solid-liquid separation	1	2	no	1.6	0
	Neutralization	30 min.		2	.5	0.5	1.6	0.4
	Pre. settling tank	30 min.		2	5	0.5	1.6	0.4
	Catalystic oxidation tank	4 hours		17	50	5	1.6	0.4
	Settling tank	60 min.		5	13	1.5	1.6	0.4
	Chlorination unit	-		-	-	-	-	-
Incidental facilities	Pump Aerator Mixing unit etc.						1.5	0.5
Instrumentation & Control	Measuring device Control system						1.3	0.7

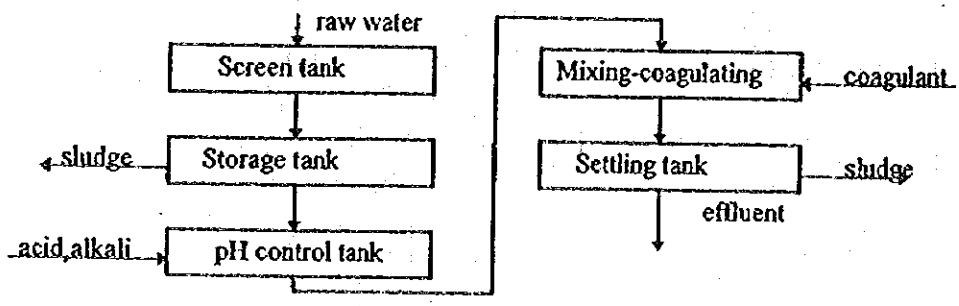
Table.3.3-2(3/7) Outline of Specification and Composition of Standard Treatment Plant

(Physio-Chemical Treatment Process)

1. Condition of Wastewater

Industry	Quality of raw water	Quality of treated water	Scale of Quantity	Quantity to be treated
Chemical and others	BOD: 250mg/l SS: 100mg/l COD: 1000mg/l	BOD: 60mg/l SS: 80mg/l	middle	40 m3/day
			large	100 m3/day
			small	20 m3/day

2. Flowchart of treatment (standard case)



3. Composition of treatment system

Category	Item	Residence time	Abstract	Tank capacity (m3) middle	large	small	Cost ratio* large	small
Treatment tank	Screen tank	10 min.	Coagulation & solid-liquid separation	0.3	0.7	0.1	1.6	0.6
	Storage tank	6 hours		10	25	5	1.6	0.6
	pH control tank	30 min.		0.8	2.0	0.4	1.6	0.6
	Mixing-coagulating tank	30 min.		0.8	2.0	0.4	1.6	0.6
	Settling tank	6 hours		10	25	5	1.6	0.6
Incidental facilities	Pump Aerator Mixing unit etc.						1.5	0.5
Instrumentation & Control	Measuringdevice Control system						1.2	0.8

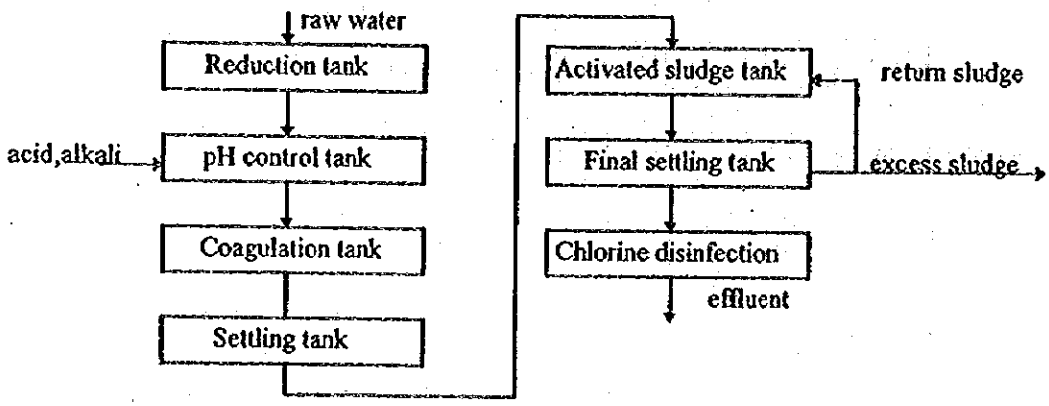
Table.3.3-2(4/7) Outline of Specification and Composition of Standard Treatment Plant

(Combination of Biological and Physio-Chemical Treatment Process)

1. Condition of Wastewater

Industry	Quality of raw water	Quality of treated water	Scale of Quantity	Quantity to be treated
Tannery	BOD: 700mg/l	BOD: 60mg/l	middle	-
	SS: 500mg/l	SS: 80mg/l	large	-
	Cr: 100mg/l	Cr: 2mg/l	small	50 m3/day

2. Flowchart of treatment (standard case)



3. Composition of treatment system

Category	Item	Residence time	Abstract	Tank capacity (m3) middle	large	small	Cost ratio* large	
Treatment tank	Reduction tank	1 hour	Reduction, Coagulation & solid-liquid separation	-	-	2.0	-	-
	pH control tank	30 min.		-	-	1.0	-	-
	Coagulation tank	30 min.		-	-	1.0	-	-
	Settling tank	2 hours		-	-	4.0	-	-
	Aeration tank	4 hours		-	-	8.0	-	-
	Final settling tank	1 hour		-	-	2.0	-	-
	Chlorination unit	-		-	-	-	-	-
Incidental facilities	Pump Aerator Mixing unit etc.						-	-
Instrumentation & Control	Measuring device Control system						-	-

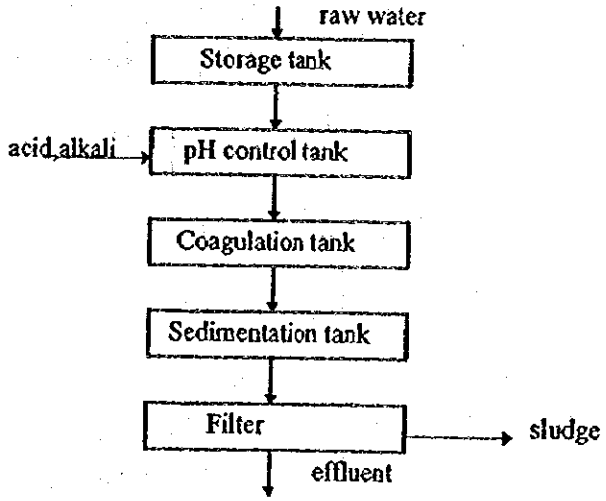
Table.3.3-2(5/7) Outline of Specification and Composition of Standard Treatment Plant

(Physio-Chemical Treatment Process)

1. Condition of Wastewater

Industry	Quality of raw water	Quality of treated water	Scale of Quantity	Quantity to be treated
Metal manufacturing	Cr:100mg/l Cu: 30mg/l	Cr: 2mg/l Cu: 1mg/l	middle	30 m3/day
			large	100 m3/day
			small	10 m3/day

2. Flowchart of treatment (standard case)



3. Composition of treatment system

Category	Item	Residence time	Abstract	Tank capacity (m3)			Cost ratio*	
				middle	large	small	large	small
Treatment tank	Storage tank	12 hours	Coagulation solid-liquid separation	15	50	5	1.5	0.6
	pH control tank	30 min.		0.6	2	0.2	1.5	0.6
	Coagulation tank	30 min.		0.6	2	0.2	1.5	0.6
	Sedim. tank	6 hours		7.5	25	2.5	1.5	0.6
Incidental facilities	Pump Mixing unit Filter etc.						1.3	0.8
Instrumentation & Control	Measuringdevice Filling system						1.2	0.8

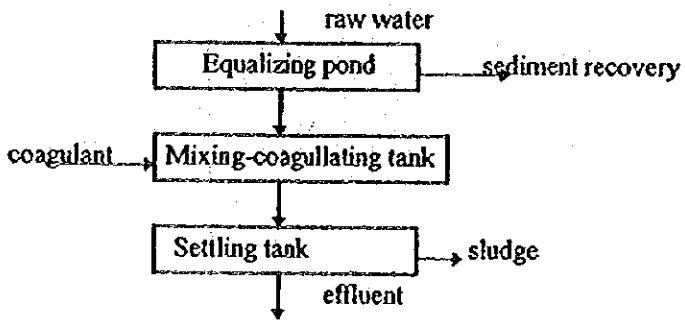
Table.3.3-2(6/7) Outline of Specification and Composition of Standard Treatment Plant

(Physio-Chemical Treatment Process)

1. Condition of Wastewater

Industry	Quality of raw water	Quality of treated water	Scale of Quantity	Quantity to be treated
Sand quarries	SS: 2000 mg/l	SS: 80mg/l	middle	-
			large	-
			small	2000 m3/day

2. Flowchart of treatment (standard case)



3. Composition of treatment system

Category	Item	Residence time	Abstract	Tank capacity (m3)			Cost ratio*	
				middle	large	small	large	small
Treatment tank	Equalizing pond	24 hours	Coagulation and solid-liquid separation	-	-	2000		
	Mixing-coagulating tank	10 min.		-	-	15		
	Settling pond	120 min.		-	-	180		
Incidental facilities	Pump Mixing unit							
Instrumentation & Control	Filling system							

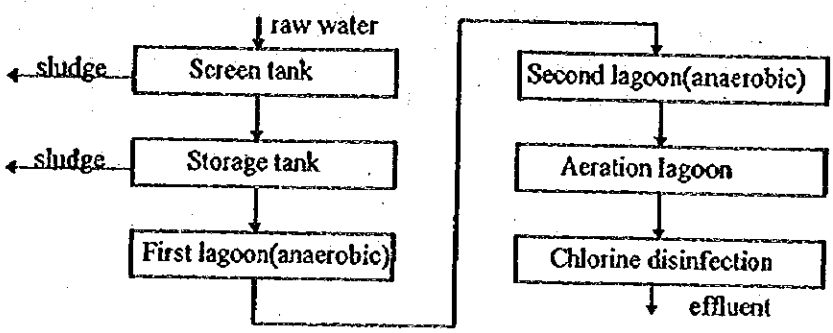
Table.3.3-2(7/7) Outline of Specification and Composition of Standard Treatment Plant

(Biological Treatment Process)

1. Condition of Wastewater

Industry	Quality of raw water	Quality of treated water	Scale of Quantity	Quantity to be treated
Piggery	BOD: 7000mg/l SS: 10000mg/l	BOD: 60mg/l SS: 80mg/l	middle	15 m3/day
			large	5 m3/day
			small	40 m3/day

2. Flowchart of treatment (standard case)



3. Composition of treatment system

Category	Item	Residence time	Abstract	Tank capacity (m3) middle	large	small	Cost ratio* large	
Treatment tank	Screen tank	1 hour	solid-liquid separation & aeration lagoon	1	2	1	1.8	0.6
	Storage tank	24 hour		15	40	5	1.8	0.6
	First lagoon	10 days		150	400	50	1.8	0.6
	Second lagoon	10 days		150	400	50	1.8	0.6
	Aeration lagoon	30 days		450	1200	150	1.8	0.6
	Chlorination unit	-		-	-	-	1.8	0.6
Incidental facilities	Floating aerator Pump etc.						1.8	0.4
Instrumentation & Control	Measuring device Control system						1.3	0.6

Table.3.3-3 Unit Cost of Standard Treatment Plant

Treatment Plant Process	Industry	Scale	Quantity (m^3/day)	Installation Cost (Thousand US$)			
				eatment Ta	dental Facil	Instrument	Total
Biological	Food	Small	40	66	30	56	152
		Middle	200	220	100	80	400
		Large	500	352	200	96	648
Biological plus Physio-chemical	Textile	Small	30	40	40	70	150
		Middle	100	100	80	100	280
		Large	300	160	120	130	410
Physio-chemical	Chemical	Small	20	24	40	96	160
		Middle	40	40	80	120	240
		Large	100	64	120	144	328
Physio-chemical	Metal	Small	-	-	-	-	-
		Middle	30	40	20	65	125
		Large	100	60	26	78	164
Sedimentation	Sand Quarrie	Small	2,000	5	8	2	15
		Middle	-	-	-	-	-
		Large	-	-	-	-	-

Table 3.4-1 Cost for Installation of Treatment Plant for Existing Factories and Piggeries

Classification of Factories		(1)Unit Cost of Treatment Plant (..)	Factory Number GACETA Not-satisfaction		Total	Cost* (..)
Industry	Scale		(2)No Treatment Plant	(3)Partly Equipped		
Food Production	large	651,000	1	1	2	976,500
	middle	400,000	6	1	7	2,600,000
	small	149,900	2	0	2	299,800
Manufacturing of Textile	large	422,600	2	0	2	845,200
	middle	280,000	2	1	3	700,000
	small	149,700	4	0	4	598,800
Chemical & others	large	225,400	1	1	2	338,100
	middle	170,000	3	0	3	510,000
	small	90,000	11	0	11	990,000
Metal Manufacturing	large	339,000	3	1	4	1,186,500
	middle	188,000	3	0	3	564,000
	small	75,500	10	0	10	755,000
Tannery	large					0
	middle					0
	small	230,000	3	0	3	690,000
Sand Quarries	large					0
	middle					0
	small	68,000	8	0	8	544,000
Piggery	large	76,200	9	2	11	762,000
	middle	50,000	3	2	5	200,000
	small	27,800	9	3	12	291,900
Sub-Total	large	.!	16	5	21	4,108,300
	middle	.!	17	4	21	4,574,000
	small	.!	47	3	50	4,169,500
Total			80	12	92	12,851,800

Note : *Cost =(1)x(2)+(1)x(3)x0.5

Table 3.4-2 Operation & Maintenance Cost of Existing Factories and Piggeries

Industry	Construction Cost.i...j	Rate of O/M Cost in Construction Cost(%)	Annual O/M Cost ($/year)
Food Production	3,876,300	2.85	110,475
Manufacturing of Textile	2,144,000	4.98	106,771
Chemical & others	1,838,100	5.87	107,896
Metal Manufacturing	2,505,500	5.10	127,781
Tannery	690,000	5.50	37,950
Sand Quarries	544,000	5.20	28,288
Piggery	1,253,900	5.20	65,203
Total	-|	-|	584,364

Table 3.5-1 Cost for Installation of Treatment Plant for Newly Built by 2003

Classification of Factories		Unit Cost of Treatment Plant	Factory Number Constructed	Cost
Industry	Scale	(..)	until 2003	(..)
Food Production	large	651,000	2	1,302,000
	middle	400,000	4	1,600,000
	small	149,900	3	449,700
Manufacturing of Textile	large	422,600	1	422,600
	middle	280,000	2	560,000
	small	149,700	2	299,400
Chemical & others	large	225,400	2	450,800
	middle	170,000	5	850,000
	small	90,000	9	810,000
Metal Manufacturing	large	339,000	2	678,000
	middle	188,000	5	940,000
	small	75,500	5	377,500
Tannery	large			
	middle			
	small	230,000	1	230,000
Sand Quarries	large			
	middle			
	small	68,000	1	68,000
Piggery	large	-"	-"	-"
	middle	-"	-"	-"
	small	-"	-"	-"
Sub-Total	large	-"	7	2,853,400
	middle	-"	16	3,950,000
	small	-"	21	2,234,600
Total			44	9,038,000

Table 3.5-2 Operation & Maintenance Cost of Newly Built Factories by 2003

Industry	Construction Cost.i...j	Rate of O/M Cost in Construction Cost(%)	Annual O/M Cost ($/year)
Food Production	3,351,700	2.85	95,523
Manufacturing of Textile	1,282,000	4.98	63,844
Chemical & others	2,110,800	5.87	123,904
Metal Manufacturing	1,995,500	5.10	101,771
Tannery	230,000	5.50	12,650
Sand Quarries	68,000	5.20	3,536
Piggery	.¦	.¦	.¦
Total	.¦	.¦	401,228