



# ***Tuna Canning Industry***

### **3.1.1 INTRODUCTION**

#### **3.1.1.1 Industry Description**

Tuna canning is one of the 10 subsectors under food manufacturing. It comprises about 7 per cent of the total food manufacturing industry. Tuna canning industry is composed of enterprises that process and can raw tuna fish meat, either fresh or frozen. There are several types of canned tuna: flaked, grated, solid packed and/or chunks. The primary product of the cannery is the solid pack. The Philippine tuna canning industry mainly serves the export market, with around 95 percent of its total production being sold abroad. Canned tuna has consistently been one of the country's top ten exports of processed food, and until recently, it was one of the top twenty major exports of the Philippines (PDCP Bank Industry Digest, 1993).

#### **3.1.1.2 Scope and Limitations of the Study**

This study covers the tuna canning industry, under Philippine Standard Industry Classification (PSIC) Code 31151, and classified under the broad industry group: Food Manufacturing sector. The study did not include sardine/mackerel canning. The pollutants estimated, in both physical and monetary terms, were Particulate Matter (PM) and BOD for air and water, respectively. Other pollutants generated by the sector such as suspended solids, nitrogen, oil and grease were not estimated due to data limitations.

#### **3.1.1.3 Production Process and Pollutants Generated**

Tuna canning involves the process of receiving and sorting, butchering, pre-cooking and cooling, skinning and loining, packing, retorting, and labeling and warehousing (see Figure 3.1.1). These processes generate wastes, particularly wastewater contaminated with fish blood, fish juice and fish oils. Solid wastes generated include rejected fish, fish scraps and unusable packing materials. Boiler smoke and steam cause air emissions.

### **3.1.2 SOURCES AND METHODS**

#### **3.1.2.1 Data Sources**

Data on volume of tuna fish caught for 1988 to 1994 were gathered from the Selected Fishery Statistics of the BAS. Data on tuna fish imports were taken from the Foreign Trade Statistics of the NSO and the export data from the Bureau of Export Trade Promotion (BETP). Air emission and water effluent factors were taken from the Assessment of Sources of Air, Water and Land Pollution of the World Health Organization (WHO, 1993). Data on pollution control devices and their respective capital, and operating plus maintenance costs were collected from previous studies of ENRAP (Orbeta, 1993).

The GVA of food manufacturing were taken from the National Accounts compilation, published by the NSCB. The IPIN of "other miscellaneous durable equipment" and the Consumer Price Index (CPI) of "all items" (see Appendix Table 3.1.1) were used to extrapolate the annual capital cost and annual operating and maintenance cost of pollution control devices for years 1989-1994, since the only available data was for 1988.

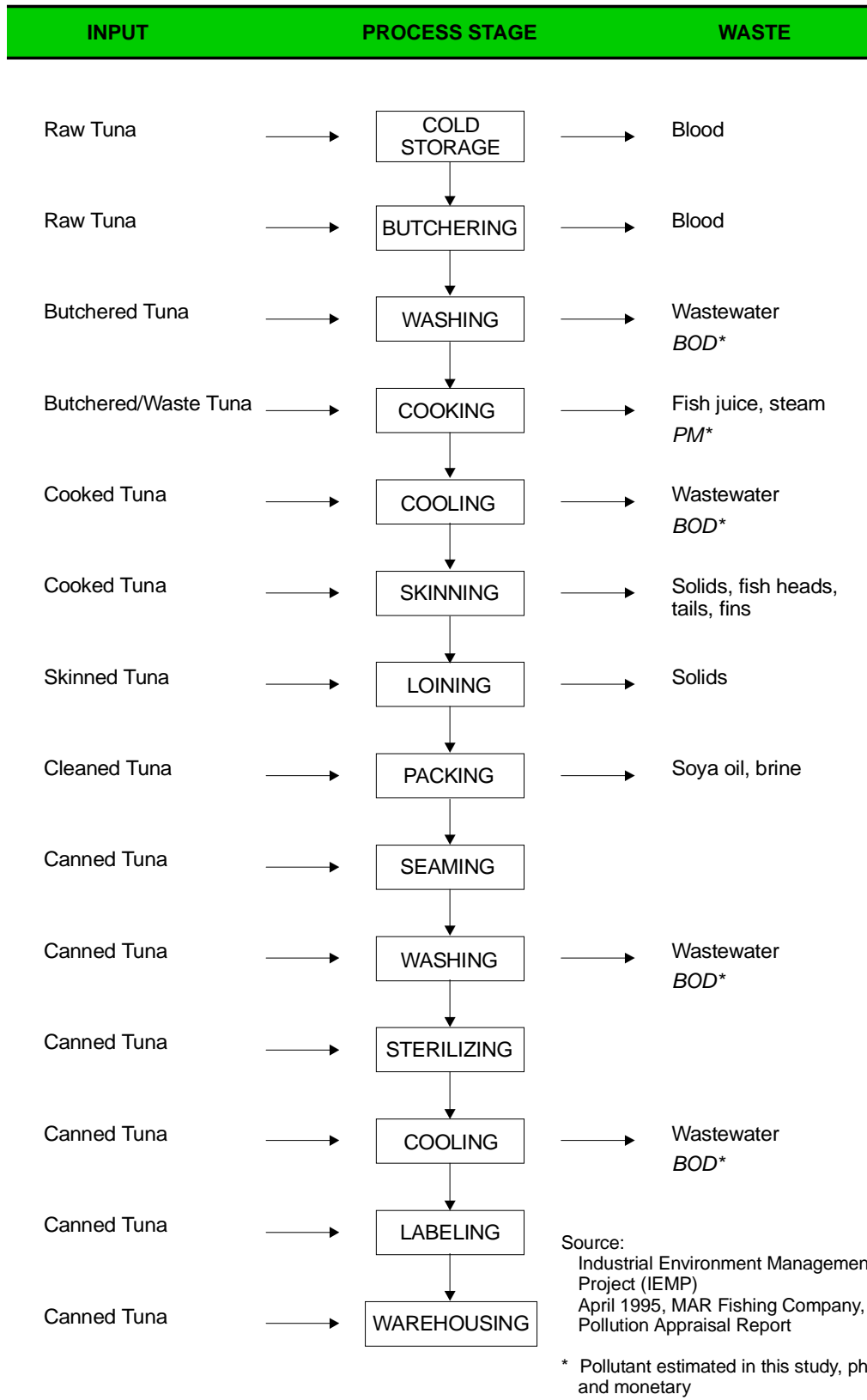


FIGURE 3.1.1 TUNA CANNING PROCESS FLOW

### 3.1.2.2 Estimation Methodology

#### 3.1.2.2.1 Physical Estimation

The data on volume of tuna fish caught from Selected Fishery Statistics of the BAS was adjusted by 20 percent to represent the under-coverage. Imports of tuna fish were added to the adjusted volume of tuna fish caught, minus the total exports, to come up with the total tuna fish supply.

Out of the total supply, 50 percent was assumed to undergo canning processes. The 50 percent was derived from the estimate in the Food Balance Sheet (FBS, see Appendix Table 3.1.2). The estimated volume of tuna fish that goes to canning was multiplied by the emission or effluent factor to generate total emission. More specifically, emissions/effluents of tuna manufacturing were estimated as:

- Effluents to water:

$$\text{BOD}_5 \text{ (in MT)} = \text{Tuna Fish for Canning (in Mt)} \times 13.4 \text{ kg/Mt}/1000$$

- Emissions to Air:

$$\text{PM (in MT)} = \text{Tuna Fish for Canning (in Mt)} \times .05 \text{ kg/Mt}/1000$$

#### 3.1.2.2.2 Monetary Estimation

In estimating the cost of controlling pollutants generated by the tuna canning industry, the sum of annualized capital cost of pollution control equipment per metric ton of pollutant (AnCC) and the annual cost of operating and maintaining the pollution control device (AOMC) was multiplied by the emission/effluent. The pollution control devices for tuna canning are the scrubbers, for controlling PM emissions, and anaerobic facultative ponds, for the control of BOD<sub>5</sub> effluents. In this study, the environmental cost of the tuna industry was estimated as the sum of PM and BOD<sub>5</sub>'s control cost, which are estimated as follows:

- BOD<sub>5</sub> Control cost (in Pesos)

$$= \text{BOD}_5 \text{ (in MT)} \times [\text{AnCC of Anaerobic Facultative Ponds} + \text{AOMC of Anaerobic Facultative Ponds (in Pesos per MT of pollutant)}]$$

- PM Control cost (in Pesos)

$$= \text{PM (in MT)} \times [\text{AnCC of Scrubber} + \text{AOMC of Scrubber (in Pesos per MT of pollutant)}]$$

The benchmark data on the annualized capital cost and annualized operating and maintenance costs was for 1988 only. The annualized capital cost for the succeeding years was extrapolated using the growth trends of the IPIN of "other miscellaneous durable equipment" from the National Accounts of the NSCB. On the other hand, the annualized operating and maintenance costs were extrapolated using the CPI for "all Items" from the NSO (see Appendix Table 3.1.1).

### 3.1.3 RESULTS

#### 3.1.3.1 Physical Estimates

##### 3.1.3.1.1 Water Effluents

The wastewater pollutants in tuna canning are BOD<sub>5</sub>, suspended solids (SS), nitrates (N), and oil and grease (O & G). Due to data limitations, the study estimated only the BOD<sub>5</sub> effluents, both in physical and monetary terms. In physical terms, the average annual emission of BOD<sub>5</sub> was about 2,200 MT (Table 3.1.1). In 1990, the estimated BOD<sub>5</sub> emission reached 2,600 MT due to the increase in volume of tuna fish canned.

**TABLE 3.1.1 VOLUME OF TUNA FISH CANNED, BOD<sub>5</sub> EFFLUENTS AND PM EMISSIONS, IN METRIC TONS, 1988-1994**

YEAR	PRODUCTION	BOD <sub>5</sub>	PM
1988	162,920	2,183	8.146
1989	179,865	2,410	8.993
1990	194,047	2,600	9.702
1991	188410	2,525	9.421
1992	156,248	2,094	7.812
1993	117,625	1,576	5.881
1994	154,006	2,064	7.700

##### 3.1.3.1.2 Air Emissions

The fuel burned during fish canning emits mostly particulate matters in air. However, according to the U.S. Environmental Protection Agency (EPA, 1990), fish canning processes do not generate significant air pollution. From 1988-1994, the largest emission of PM was registered in 1990, with an estimated volume of 9.7 MT (see Table 3.1.1). The resulting trend in the level of emissions was dictated by the volume of fish that goes into canning, using a constant emission factor, from 1988-1994.

#### 3.1.3.2 Monetary Estimates

##### 3.1.3.2.1 Water Effluents

The estimated total cost of controlling BOD<sub>5</sub> effluents was P 5.3 million and P10 million in 1988 and 1994, respectively (see Table 3.1.2). Due to the increasing trend of prices used in the estimation, the average cost of controlling BOD<sub>5</sub> per MT almost doubled from P 2.4 thousand to P 4.9 thousand in 1988 and 1994, respectively. Thus, the annualized capital cost and operating and maintenance cost of controlling BOD<sub>5</sub> effluents in tuna canning industry increased at an average of 13.1 percent per annum (see Table 3.1.3).

The increase or decrease in the level of pollution (effluent/emission) caused by the tuna canning industry was dependent on the volume of tuna fish canned and was subjected to price changes. The absence of any indicator or parameter that relates to the changes in the levels of effluents/emission limits the analysis of its impact to the environment.

However, future undertakings will consider the acceptable standards used in assessing environmental quality.

**TABLE 3.1.2 TOTAL ENVIRONMENTAL COST: CONTROL OF BOD<sub>5</sub> AND PM, IN THOUSAND PESOS, 1988-1994**

Year	Total Degradation Cost	Cost Of Controlling BOD <sub>5</sub> Using Facultative Ponds			Cost Of Controlling PM Using Scrubber		
		Total	AnCC	AOMC	Total	AnCC	AOMC
1988	5,285	5,263	2,851	2,412	22	20	2
1989	6,279	6,253	3,265	2,988	25	23	2
1990	7,980	7,947	4,266	3,680	34	31	3
1991	9,313	9,273	5,032	4,241	39	36	3
1992	8,162	8,128	4,296	3,832	34	31	3
1993	7,154	7,122	4,019	3,103	31	29	2
1994	10,063	10,019	5,588	4,431	43	40	3

### 3.1.3.2.2 Air Emissions

The monetary estimates of PM emissions, using the annualized capital cost and annual operating and maintenance cost of scrubber was small, compared to the monetary estimates of BOD<sub>5</sub> effluents. This was due to the relatively small BOD<sub>5</sub> emission factor. In 1988, total cost was only P 22,000. This however increased to P 43,000 in 1994.

### 3.1.3.3 Environmentally Adjusted Net Value Added (EVA)

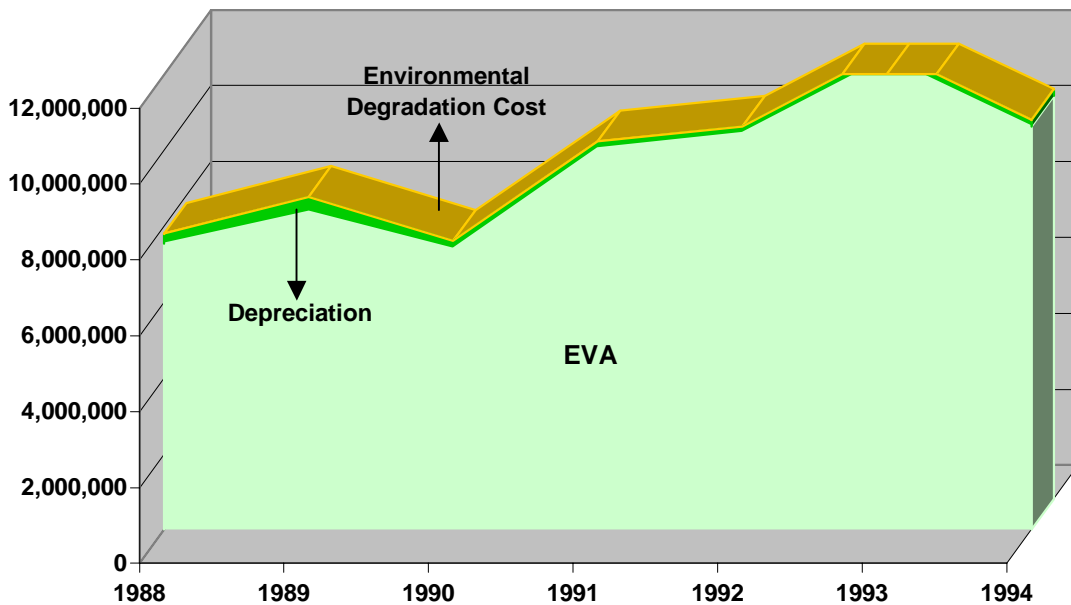
To get the environmentally adjusted net value added of fish canning industry (Table 3.1.3), the cost of controlling PM and BOD<sub>5</sub> were deducted from the net value added. The NVA of the sector was derived by deducting the estimated depreciation from the GVA. Environmental cost of tuna canning (BOD<sub>5</sub> and PM control cost) amounted to less than 0.07 percent of the NVA of fish canning (see Figure 3.1.2). This may be due to the exclusion of other fish variety in the process weight used in the study, such as sardines and the non-valuation of other pollutants of the industry.

Environmental degradation cost of the tuna canning industry from 1988 to 1994 grew at an average of 13 percent per annum. The highest growth in degradation cost was registered in 1993-1994 posting a growth rate of 41 percent. The second highest growth was reported in 1989-1990 at 27.09 percent. These trends were due to changes in the process weight and changes in prices.

**TABLE 3.1.3 ENVIRONMENTALLY ADJUSTED NET VALUE ADDED (EVA) OF FISH CANNING INDUSTRY, IN THOUSAND PESOS (AT CURRENT PRICES), 1988-1994**

Year	GVA Of Fish Canning Industry [1]	Depreciation [2]	NVA Of Fish Canning [3] = [1]-[2]	Environmental Cost Of Tuna Canning			EVA Of Fish Canning Industry [5] = [3]-[4]
				Total [4]	Anaerobic Facultative Ponds	Scrubber	
1988	7,798,220	259,423	7,538,797	5,286	5,263	22	7,533,512
1989	8,769,344	378,060	8,291,284	6,279	6,253	25	8,385,005
1990	7,613,181	204,699	7,408,482	7,980	7,947	34	7,400,500
1991	10,227,858	172,186	10,055,672	9,313	9,273	39	10,046,359
1992	10,621,904	153,072	10,468,832	8,162	8,128	34	10,460,870
1993	12,621,521	192,158	12,429,363	7,154	7,122	31	12,422,209
1994	10,801,539	168,641	10,632,898	10,063	10,019	43	10,622,835

<sup>1</sup> GVA for fish canning was estimated using the ratio of fish canning industry to total food industry based on the ASE/CE. Fish canning GVA includes GVA of canning of other fish (other than tuna).



**FIGURE 3.1.2 FISH CANNING INDUSTRY: EVA, DEPRECIATION AND ENVIRONMENTAL COST, IN THOUSAND PESOS (AT CURRENT PRICES), 1988-1994**

APPENDIX TABLE 3.1.1

## COST OF POLLUTION CONTROL DEVICES (PESOS/MT), 1988-1994

YEAR	ANAEROBIC FACULTATIVE PONDS			SCRUBBER			IPIN - OMDE (1+g)	CPI - All Items (1+g)
	Total Cost	AnCC	AOMC	Total Cost	AnCC	AOMC		
1988	2,411	1,306	1,105	2,741	2,511	230		
1989	2,595	1,355	1,240	2,863	2,605	258	1.04	1.12
1990	3,056	1,641	1,415	3,449	3,155	295	1.21	1.14
1991	3,672	1,993	1,679	4,181	3,832	350	1.22	1.19
1992	3,882	2,052	1,830	4,326	3,945	381	1.03	1.09
1993	4,519	2,550	1,969	5,313	4,903	410	1.24	1.08
1994	4,854	2,707	2,147	5,652	5,205	447	1.06	1.09

Note:

OMDE: Other Miscellaneous Durable Equipment

Sources of Data:

Estimation of Direct Environmental Waste Disposal Services (Orbeta, 1995)

National Accounts, NSCB

CPI, NSO

APPENDIX 3.1.2

## VOLUME OF TUNA FISH USED FOR CANNING, IN METRIC TONS, 1988-1994

Year	Fish caught (1)	20 percent (2)= (1)*(0.2)	Total Production (3)= (1) + (2)	Import (4)=(3)/2	Export (5)	Total Supply (6)=(3)+(4)-(5)	Tuna fish for canning (7)= (6) * (.5)
1988	274,044	54,809	328,853	18,552	21,566	325,839	162,920
1989	302,244	60,449	362,693	6,437	9,401	359,729	179,865
1990	313,371	62,674	376,045	21,672	9,624	388,093	194,047
1991	339,074	67,815	406,889	21,155	51,225	376,819	188,410
1992	285,803	57,161	342,964	19,607	50,075	312,496	156,248
1993	243,306	48,661	291,967	11,579	68,297	235,249	117,625
1994	304,748	60,950	365,698	16,561	74,248	308,011	154,006

Sources of Data:

(1) Selected Fishery Statistics, BAS

(2) 20 percent represents the under-coverage of fish caught.

(4) Foreign Trade Statistics, NSO

(5) Bureau of Export Trade and Promotion

(7) Food Balance Sheet, 50 percent of the total fish production goes to canning

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# *Textile Industry*

### **3.2.1 INTRODUCTION**

#### **3.2.1.1 Industry Description**

The textile industry in the Philippines was established in the 1950s following the government's import substitution policies. The industry is composed of several subsectors namely: spinning mills, that engage in the production of yarn from fiber; weaving and knitting mills that converts the yarns into fabrics; and dyeing, printing and finishing mills which make the fabric appealing to the consumers. Weaving and knitting mills are the biggest sub-sectors with 34 weaving mills and 148 knitting firms.

#### **3.2.1.2 Scope and Limitations of the Study**

This study covers only processed-based pollution (air emission/water effluents), on PM and BOD. Although a number of pollutants such as Carbon Monoxide (CO), Sulphur Oxides (SOx) and Nitrogen Oxides (NOx) for air were also identified, it was not included in the estimation since the above pollutants are fuel-based and not process-based. Hazardous chemicals such as bleaching and dyeing agents, and volatile organic compounds (VOC), were likewise excluded in the estimation of water effluents.

#### **3.2.1.3 Production Process and Pollutants Generated**

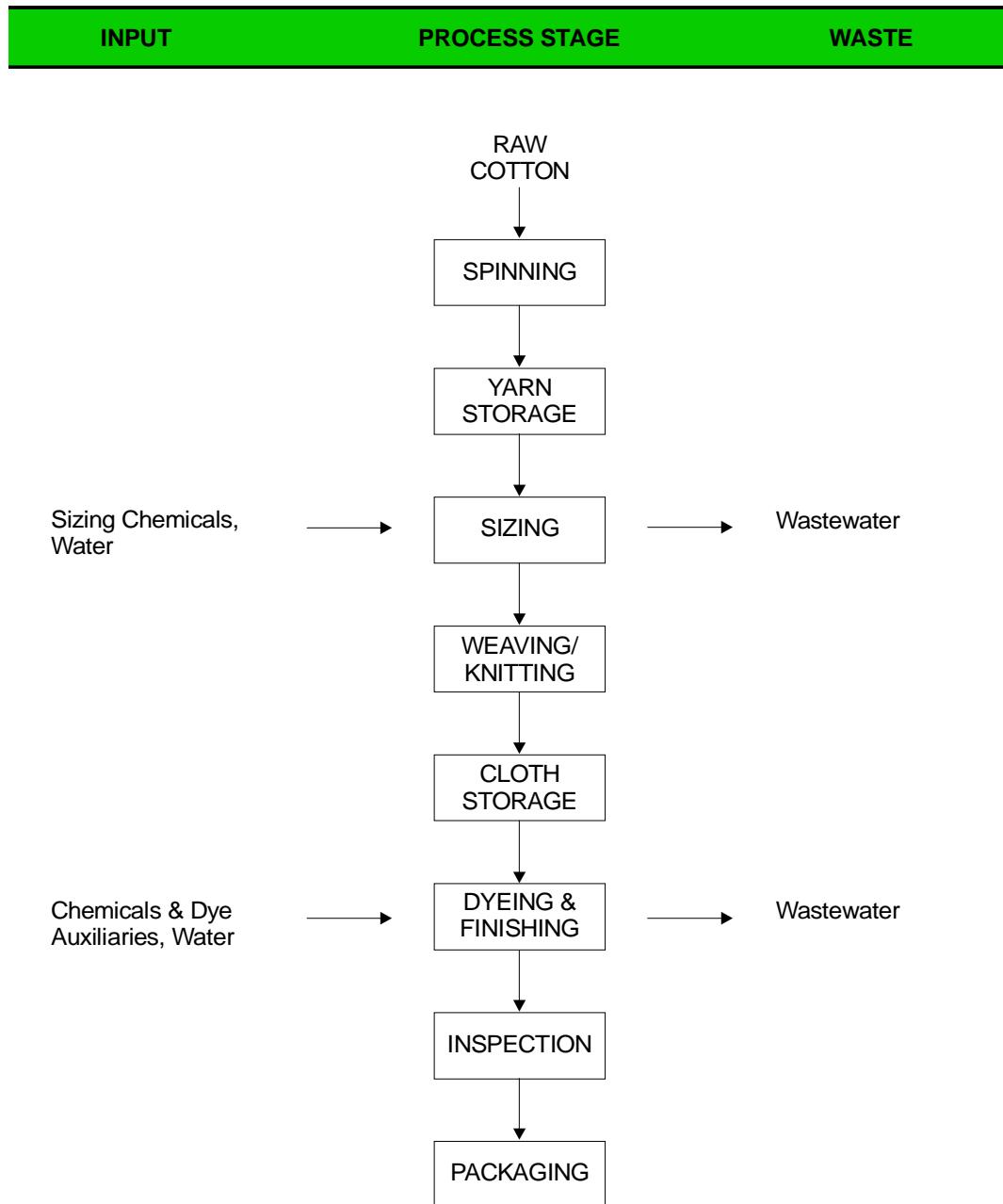
Each fiber strand, or yarn, is composed of many fibers twisted together by an operation called spinning. When two or more yarns are interlaced in the process of weaving which is carried out on a machine called a loom, a length of cloth is made. However, when a single continuous length of yarn is looped into a fabric, the operation is called knitting. Industrially, knitting is also carried out on machines. For natural fibers, such as cotton, processes involved are blending, carding, combing, spinning and reeling. Figure 3.2.1 shows an illustrated process of textile manufacturing and the various wastes emanating from it.

During the production process, raw cotton is carded, spooled and warped, slashed (filled with starch), drawn and knitted into cloth before sending to the finishing mill for final production. Wastewater is insignificant in this process because no water is introduced in the system. However, this stage is responsible for most of the air emissions, specifically, particulate matter. The composition of PM is mostly cottonseeds, barks, and other parts of the cotton plant not directly used in the textile milling. BOD is produced when the slashing compound (starch) is used to improve the cloth. Chemical pollutants are also produced when the cloth is bleached, dyed, and mercerised.

### **3.2.2 SOURCES AND METHODS**

#### **3.2.2.1 Data Sources**

Data on the volume of production for 1988 and the data on the annualized capital and maintenance cost of the treatment methods were taken from Estimation Of Direct Environmental Waste Disposal Services (Orbeta, 1992). Emission and effluent factors were taken from the Rapid Assessment of Source of Air, Water and Land Pollution (Economopoulos, 1993).



Source:  
Philippine Textile Research Institute

**FIGURE 3.2.1 TEXTILE INDUSTRY PROCESS FLOW**

The annual growth rate at constant prices of the GVA of the textile industry from the National Accounts publication of the NSCB was used to extrapolate the 1988 volume of production to 1989 to 1994. Data on the annualized capital and operating maintenance cost was only for 1988. Capital costs for years 1989-1994, the trend of the IPIN of "Other Miscellaneous Durable Equipment" was utilized as a growth indicator. The growth of CPI on "All Items" from the Price Division of the NSO was likewise used to extrapolate the 1988 operating and maintenance costs to years 1989 to 1994 (see Appendix Table 3.2.1).

### 3.2.2.2 Estimation Methodology

#### 3.2.2.2.1 Physical Estimation

The 1988 volume of textile production was extrapolated up to 1994 using the growth rate of the GVA in textile industry at constant 1985 prices (see Appendix Table 3.2.2). The general formula applied to estimate the air and water pollutants is:

$$\text{Emission/Effluent} = \text{Total Volume of Production of textile} \times \text{Emission/Effluent Factor}$$

To be more specific, the following equations were used in the study:

- Effluents to water:

$$\text{BOD}_5 \text{ in MT} = \text{Volume of textile production in Mt.} \times 155 \text{ kg/Mt}/1000.$$

- Emissions to Air:

$$\text{PM in MT} = \text{Volume of textile production in Mt.} \times 7 \text{ kg/Mt}/1000$$

#### 3.2.2.2.2 Monetary Estimation

In estimating the cost incurred in controlling pollutants generated by the textile industry, the AnCC and AOMC of fabric filter and sludge drying beds were employed. These two devices were used to control air emission and wastewater discharges caused by the textile industry, respectively.

The costs of controlling the emission and/or discharges were estimated using the product of the volume of pollutants and the total capital and operating and maintenance cost per unit of pollutant.

Hence, in computing for the cost of controlling emissions/effluents such as BOD<sub>5</sub> and PM, the following equations were used:

- BOD<sub>5</sub> Control cost (in Pesos)

$$= \text{BOD}_5 \text{ (in MT)} \times [\text{AnCC of Sludge Drying Bed} + \text{AOMC of Sludge Drying Bed (in pesos/MT)}]$$

- PM emission control cost (in Pesos)

$$= \text{PM (in MT)} \times [\text{AnCC of Fabric Filter} + \text{AOMC of Fabric Filter (in Pesos/MT)}]$$

### 3.2.3 RESULTS

#### 3.2.3.1 Physical Estimates

Using constant effluent and emission factors for the whole period under study means that trends in the volume of BOD<sub>5</sub> and PM were dictated by the level of production of textile. The resulting volume of emissions and effluents are given in Table 3.2.1. Since the estimated volume of production of cotton textile had been decreasing from 1988 to 1994, it follows that both BOD<sub>5</sub> and PM pollutants generated by the textile industry was on a downward trend.

**TABLE 3.2.1 VOLUME OF PRODUCTION OF COTTON TEXTILE INDUSTRY, BOD<sub>5</sub> AND PM, IN METRIC TONS, 1988-1994**

Year	Volume of Production	BOD <sub>5</sub>	PM
1988	146,300	22,677	1,024
1989	161,530	25,037	1,131
1990	143,729	22,278	1,006
1991	139,532	21,628	977
1992	122,761	19,028	859
1993	121,864	18,889	853
1994	112,859	17,493	790

#### 3.2.3.2 Monetary Estimates

The cost of controlling pollution in 1988 was estimated at P 73.4 million, the lowest ever recorded during the reference period (see Table 3.2.2). The highest cost was recorded during the 1993-1994 period at P 113 million.

On the average, the share of degradation cost (PM + BOD<sub>5</sub>) of the cotton textile industry to the NVA of the total textile industry was pegged at 1.15 percent from 1988-1994 (see Table 3.2.3 and Figure 3.2.2).

The relatively small share of the degradation cost to total NVA of the textile industry may be attributed to the non-valuation of other textile industries, pollution control cost and non-estimation of other pollutants caused by the cotton textile industries.

**TABLE 3.2.2 ENVIRONMENTAL DEGRADATION COST FOR BOD<sub>5</sub> AND PM, IN THOUSAND PESOS, 1988-1994**

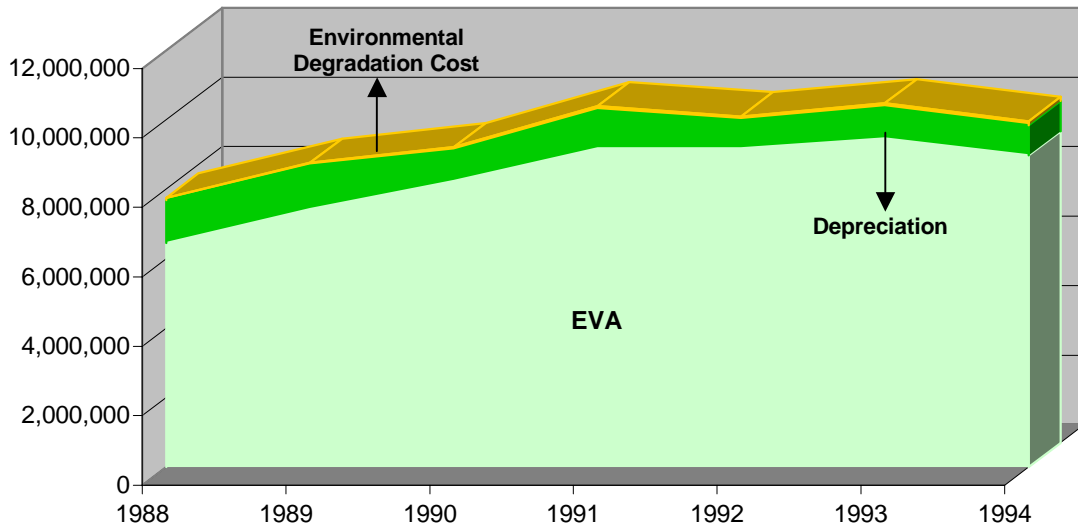
Year	Total Degradation Cost	BOD <sub>5</sub> Control Cost using Sludge Drying Bed			PM Control Cost using Fabric Filter		
		Total	AnCC	AOMC	Total	AnCC	AOMC
1988	73,384	70,616	29,344	41,272	2,768	2,532	236
1989	87,933	84,739	33,613	51,127	3,194	2,902	292
1990	91,584	88,162	36,223	51,939	3,422	3,126	296
1991	106,594	102,535	42,711	59,825	4,029	3,687	342
1992	99,698	96,033	38,686	57,346	3,665	3,338	327
1993	113,461	108,992	47,732	61,260	4,469	4,119	350
1994	113,192	108,788	46,927	61,861	4,403	4,050	353

**3.2.3.3 Environmentally Adjusted Net Value Added (EVA)**

At current prices, the EVA of the textile industry has increased from 11 percent to 15 percent during the years covered. The share of environmental degradation cost is directly proportional to the value added generated through time (see Table 3.2.3).

**TABLE 3.2.3 ENVIRONMENTALLY ADJUSTED NET VALUE ADDED (EVA) OF TEXTILE INDUSTRY, IN THOUSAND PESOS (AT CURRENT PRICES), 1988-1994**

Year	GVA	Depreciation	NVA of Textile	Total Degradation Cost of Cotton Textile Industry			EVA
				TOTAL	BOD Control Cost	PM Control Cost	
1988	7,754,504	1,226,724	6,527,780	73,384	70,616	2,768	6,454,396
1989	8,753,740	1,246,135	7,507,605	87,933	84,739	3,194	7,419,672
1990	9,204,037	879,651	8,324,386	91,584	88,162	3,422	8,232,802
1991	10,383,858	1,101,510	9,282,348	106,594	102,535	4,029	9,175,784
1992	10,094,157	811,393	9,282,764	99,698	96,033	3,665	9,183,066
1993	10,468,022	888,951	9,579,071	113,461	108,992	4,469	9,465,610
1994	9,955,587	866,982	9,088,605	113,192	108,788	4,403	8,975,413



**FIGURE 3.2.2 TEXTILE COTTON INDUSTRY: EVA, DEPRECIATION AND ENVIRONMENTAL COST (AT CURRENT PRICES), 1988-1994**

### 3.2.4 RECOMMENDATION

The data on the AnCC and AOMC relate only to one year (1988). There is a need to establish another benchmark level and not just extrapolate the existing ones using trend indicators. Moreover, data on other pollutants and their pollution control technology, i.e. VOC, etc. together with their respective cost should be established.

APPENDIX TABLE 3.2.1

## COST OF POLLUTION CONTROL DEVICES, PESOS/MT, 1988-1994

YEAR	FABRIC FILTER			SLUDGE DRYING BED			IPIN - OMDE (1 + g)	CPI - All Items (1 + g)
	Total Cost	AnCC	AOMC	Total Cost	AnCC	AOMC		
1988	2,703	2,473	230	3,114	1,294	1,820		
1989	2,824	2,566	258	3,385	1,343	2,042	1.04	1.12
1990	3,402	3,107	295	3,957	1,626	2,331	1.21	1.14
1991	4,123	3,774	350	4,741	1,975	2,766	1.22	1.19
1992	4,266	3,885	381	5,047	2,033	3,014	1.03	1.09
1993	5,239	4,829	410	5,770	2,527	3,243	1.24	1.08
1994	5,573	5,126	447	6,219	2,682	3,536	1.06	1.09

Sources of Data :

Estimation of Direct Environmental Waste Disposal Services (Orbeta, 1995)  
National Accounts, NSCB  
CPI, NSO

APPENDIX TABLE 3.2.2

VOLUME OF PRODUCTION IN COTTON TEXTILE INDUSTRY, IN METRIC TONS, AND  
GVA GROWTH RATE (AT CONSTANT PRICES), 1988-1994

YEAR	Volume of Production	GVA Growth Rate (%) <sup>2/</sup>
1988	146,300 <sup>1/</sup>	
1989	161,530	10.41
1990	143,729	-11.02
1991	139,532	-2.92
1992	122,760	-12.02
1993	121,864	-0.73
1994	112,858	-7.39

Source of Data:

<sup>1/</sup> ENRAP Phase III<sup>2/</sup> National Accounts, NSCB

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# ***Leather Tanning***

### 3.3.1 INTRODUCTION

#### 3.3.1.1 Industry Description

Tanning industry in the Philippines is composed of approximately 70-100 establishments, mostly located in the province of Bulacan particularly in the town of Meycauyan. It employs around 3,800 people. Most of these tanneries are backyard-operated and very few can be classified as large-scale. The leather tanning industry has an estimated aggregate annual rated capacity of 46.5 million square feet of finished leather. The tanning industry is very pollutive due to the vast quantities of wastewater generated during the process. Moreover, most tanneries have inadequate water treatment facilities or do not treat their effluents at all.

#### 3.3.1.2 Scope and Limitations of the Study

The study on leather tanning only accounted for the BOD generated in water effluents of the beamhouse and tanyard processes of the industry in as much as BOD constitutes the most significant pollutant in the tanning process.

#### 3.3.1.3 Production Process and Pollutants Generated

Tanning is the process of converting animal hides to leather. There are three (3) major stages in the tanning process (see Figure 3.3.1):

- a) **beamhouse** operations wherein hides are cleaned and conditioned to ensure their correct moisture content;
- b) **tanyard** operations where tanning proper takes place, and
- c) **finishing** operations where tanned hides are given the desired color, texture and thickness

In the beamhouse operations, animal hides are soaked, washed, unhaired, limed and fleshed. Water is the major input in this process. It is estimated that around 61 kilograms (kg) of water are needed for every kg. of raw hide processed. The process generates BOD, chemical oxygen demand (COD), suspended solids and dissolved solids (DS). The generation of BOD, which is the measure of the amount of oxygen required to completely oxidize a quantity of organic matter by biological process, is the most significant adverse effect of beamhouse operations.

The tanyard process, on the other hand, involves deliming and bating wherein salts of ammonium chloride or ammonium sulfate, water, and various enzymes are used, thereby producing discharges of BOD, COD, DS, sulfuric acid (H<sub>2</sub>S), and compounds of ammonia. After this, acid and burn solutions are used in the pickling. The same pollutants are produced during this process. Chrome, vegetable tans and water are used as input in actual tanning. Waste products generated during actual tanning are spent chrome tans. The tanyard process then proceeds with sammying, splitting and shaving where residual chrome tans and split and shaved matters are produced as wastes.

The finishing stage involves retanning, dyeing, fat-liquoring, drying and finishing. This stage is considered the least pollutive of all tanning activities. The beamhouse operations, which account for 70-90 percent of the total effluents, generate the biggest bulk of effluents in the tanning process.

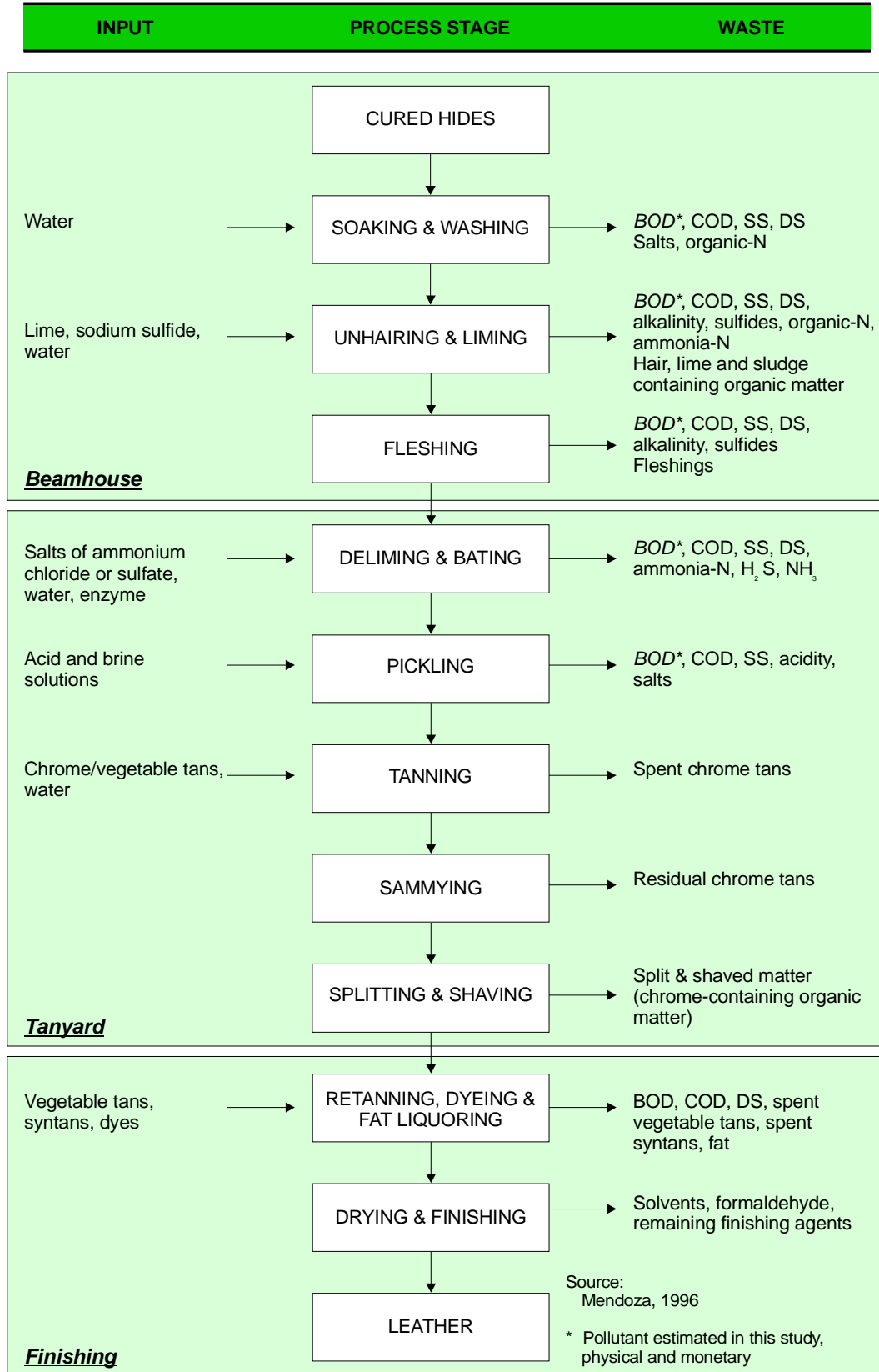


FIGURE 3.3.1 LEATHER TANNING PROCESS FLOW

#### 3.3.1.4 Treatment Process of Pollutants

The leather tanning industry employs end-of-pipe technology in treating pollutants/effluents. The end-of-pipe wastewater treatment for tannery effluents consists of four stages:

- 1) **screening or preliminary treatment** removes large objects in order to prevent damage to subsequent treatment process and equipment's by the use of a hand-cleaned bar rack.
- 2) **flow equalization** uses an equalization basin to balance the diurnal and seasonal fluctuations in the quantity and quality of wastewater flowing into the treatment facilities thus, preventing damage to these facilities.
- 3) **upflow anaerobic sludge blanket (UASB)** is an application of the principles of fermentation process, wherein several groups of anaerobic and facultative organisms assimilate and break down organic matter primarily into carbon dioxide and methane.
- 4) **trickling filter** process consists of a fixed bed of rock media over which wastewater is applied for aerobic biological treatment.

### 3.3.2 SOURCES AND METHODS

#### 3.3.2.1 Data Sources

The basic information used in the estimation was derived from the results of the survey and study on the Meycauayan tanning industry conducted by Mendoza in 1996. In the study, 17 tanneries were sampled employing the stratified random sampling technique, using the size of the tanneries as strata, and the list of establishments from Philippine Council for Agriculture, Forestry and Natural Resources, Research and Development (PCARRD) as the frame. The survey enumerated 40-57 percent of small and medium tanneries and tried to cover all large tanneries. However, the data for some large tanneries were not collected because of the unavailability of respondents at the time of the conduct of the survey.

Other sources of data were the Annual Survey of Establishments (ASE), Census of Establishments (CE), and the National Accounts of the Philippines published by the NSCB.

#### 3.3.2.2 Estimation Methodology

##### 3.3.2.2.1 Physical Estimation

The parameters used in the physical estimates of BOD discharges were the volume of hide treated and volume of wastewater generated during beamhouse and tanyard processes. The computed BOD load in the survey study conducted by Mendoza (1996) was used as basic data for estimating the BOD load for the leather tanning industry. The weighted average BOD load, by size of tannery, generated during beamhouse and tanyard operations was derived using the average BOD loads per type of operation. On the other hand, the volume of wastewater flow, by size of tannery, was used as weights (refer to Appendix 3.3.1).

The volume of hide production for 1988-1993 was extrapolated using the 1994 data on hide production by applying the growth rate of the value of output of the leather industry. The growth trends by size of tannery were calculated, using the results of ASE/CE and the IPIN of the GVA for leather manufacturing. This is then deflated using the IPIN of the GVA of leather industry. The trends of the deflated value of output were assumed to approximate the movement of the volume of beamhouse and tanyard production of the leather tanning industry from 1988 to 1993. Both small and medium tanneries adopted the growth trends of the small establishments from ASE/CE, while the growth rates of the value of output of the large establishments were used for the extrapolation of beamhouse and tanyard production of large tanneries. The estimated hide production both for beamhouse and tanyard and the wastewater ratio obtained from the study conducted by Mendoza (1996) were used to derive the estimated wastewater flow, that is,

$$\text{Wastewater flow (li)} = \text{Hide production (MT)} \times \text{wastewater ratios (liter per MT)}$$

where,

wastewater ratio = is the amount of wastewater for every MT of hide processed by tanneries

**TABLE 3.3.1 AVERAGE PRODUCTION OF LEATHER, WASTEWATER FLOW RATIO AND BOD LOAD, BY SIZE OF TANNERIES, 1994**

Size	Beamhouse			Tanyard		
	Average Production of Leather (MT/year)	Wastewater flow ratio (liters/kg)	BOD Load (mg/li)	Average Production of Leather (MT/year)	Wastewater flow ratio (liters/kg)	BOD Load (mg/li)
Large	17,679.8	8.707	3,314	14,258.2	6.842	1,737
Medium	1,846.9	7.561	3,804	1,612.0	6.624	2,243
Small	698.7	4.289	3,754	526.2	3.427	2,935

Source: Mendoza, 1996

The ratio of wastewater flow per unit of beamhouse/tanyard production, derived from Table 3.3.1, was then multiplied by the computed volume of hides in beamhouse and tanyard processes to get the estimated wastewater flow. These are then multiplied by BOD load per liter to derive total BOD discharges, that is,

$$\text{BOD Discharges in MT} = \text{Wastewater flow in liter} \times \text{BOD Load / liter}$$

### 3.3.2.2 Monetary Estimation

The average cost of treating a liter of wastewater in beamhouse and tanyard production for 1994 (Table 3.3.2) was taken from the study of Mendoza (1996). These are translated in terms of cost of treatment per unit of BOD. The costs are then extrapolated back to 1988 using growth trends in the IPIN of other miscellaneous durable equipment (see Appendix Table 3.3.1).

Total cost of treating wastes from beamhouse and tanyard processes of the leather tanning industry were derived by multiplying the average cost of treating wastewater and the estimated wastewater flow from both the beamhouse and the tanyard processes. All discharges were valued on the assumption that the carrying capacity of the Meycauyan River, where wastewater is discharged, has already been exceeded.

**TABLE 3.3.2 AVERAGE COST OF TREATING WASTEWATER, IN PESOS, 1994**

Size	Cost per Liter of Wastewater	Cost per kg. of BOD	
		Beamhouse	Tanyard
Large	0.02	6.03	11.51
Medium	0.04	10.52	17.83
Small	0.13	34.63	44.29

Source: Mendoza, 1996

### 3.3.3 RESULTS

#### 3.3.3.1 Physical Estimates

Table 3.3.3 shows the estimated BOD in wastewater discharges from beamhouse and tanyard production of the leather tanning industry from 1988 to 1994. Three-fourths of the total BOD is discharged through the beamhouse process. Large tanneries account for the highest contribution to BOD discharge.

**TABLE 3.3.3 ESTIMATED BOD IN WASTEWATER DISCHARGES OF BEAMHOUSE AND TANNERIES, BY SIZE, IN METRIC TONS, 1988-1994**

YEAR	TOTAL	BEAMHOUSE				TANNERIES			
		Total	Large	Medium	Small	Total	Large	Medium	Small
1988	716.2	519.3	319.4	164.9	34.9	196.9	106.1	74.4	16.4
1989	881.3	657.5	613.7	36.1	7.7	223.8	203.9	16.3	3.6
1990	954.2	713.0	677.3	29.4	6.2	241.2	225.0	13.2	2.9
1991	1,365.3	1,021.0	979.2	34.5	7.3	344.3	325.3	15.6	3.4
1992	1,427.5	1,066.5	1,011.5	45.4	9.6	361.0	336.0	20.5	4.5
1993	694.1	517.4	478.3	32.3	6.8	176.6	158.9	14.6	3.2
1994	773.2	574.5	510.2	53.1	11.3	198.7	169.5	24.0	5.3

From 1988 to 1992, there was a steady increase in BOD discharges of large tanneries. There was a decrease in the level of discharges in 1993 primarily because of the decline in production. However, an increase in BOD discharge was again recorded in 1994. The highest level of BOD discharge was recorded in 1991 and 1992 with an average annual discharge of 1,396 MT.

The BOD generated by small and medium-sized tanneries dropped considerably from its 1988 level. In effect the share of small and medium-sized tanneries to total BOD dropped from 40.6 percent in 1988 to 12.1 percent in 1994.

### 3.3.3.2 Monetary Estimates

The unit cost of treating wastewater discharges is higher during the tanyard process than in the beamhouse process (see Table 3.3.2). This is due to higher BOD concentration of wastewater generated in the tanyard process. However, because of the higher volume of wastewater generated in the beamhouse process, its total treatment cost is higher (Table 3.3.4). Total maintenance costs amounted to P 6.6 million in 1994, up from the P 3.9 million in 1988.

**TABLE 3.3.4 TOTAL COST OF TREATING WASTEWATER IN LEATHER TANNING INDUSTRY, IN THOUSAND PESOS, 1988-1994**

YEAR	TOTAL				BEAMHOUSE				TANNERIES			
	Total	Large	Medium	Small	Total	Large	Medium	Small	Total	Large	Medium	Small
1988	3,935	1,521	1,478	936	2,353	931	838	584	1,582	590	641	352
1989	3,579	3,030	336	213	2,178	1,855	190	133	1,401	1,176	146	80
1990	4,591	4,050	331	210	2,798	2,479	188	131	1,793	1,571	144	79
1991	7,881	7,110	472	299	4,806	4,352	267	187	3,075	2,758	205	112
1992	8,605	7,562	639	404	5,243	4,629	362	252	3,362	2,933	277	152
1993	5,366	4,444	565	368	3,263	2,720	320	223	2,103	1,724	245	134
1994	6,640	5,030	986	624	4,027	3,079	559	390	2,613	1,951	427	234

### 3.3.3.3 Environmentally Adjusted Net Value Added (EVA)

At current prices, the EVA of the leather tanning industry is about 8.2 percent to 18.7 percent lower than the NVA of the sector during the years covered. The ratio of EVA to NVA has decreased from 1988 to 1994. Conversely, the share on environment degradation cost relative to the value added generated has increased through time (Figure 3.3.2).

**TABLE 3.3.5 ENVIRONMENTALLY ADJUSTED NET VALUE ADDED (EVA), IN THOUSAND PESOS (AT CURRENT PRICES), 1988-1994**

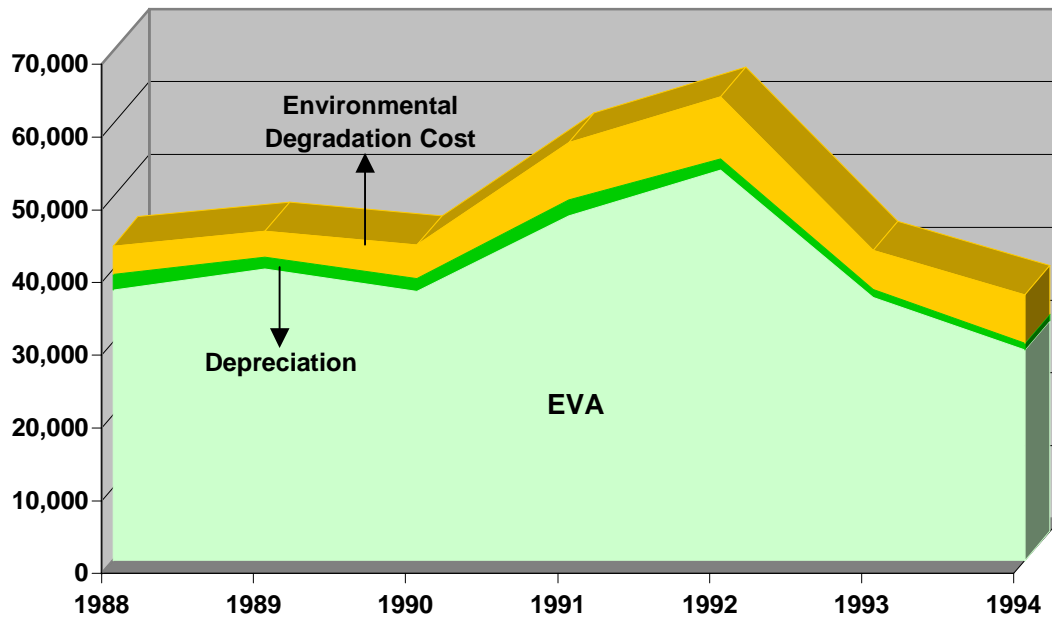
YEAR	GVA <sup>1</sup> [1]	DEPRECIATION [2]	NVA [3]=[1]-[2]	ENVIRONMENTAL COST [4]	EVA [5]=[3]-[4]
1988	43,248	2,120	41,128	3,935	37,193
1989	45,281	1,653	43,628	3,579	40,049
1990	43,361	1,751	41,610	4,591	37,019
1991	57,492	2,276	55,216	7,881	47,335
1992	63,798	1,530	62,268	8,605	53,663
1993	42,592	1,081	41,511	5,366	36,145
1994	36,527	949	35,578	6,640	28,938

<sup>1</sup> Derived by multiplying the GVA of the leather industry by the share in output of the leather tanning to total leather industry.

Source:

GVA: National Accounts, NSCB

Shares: ASE/CE, NSO



**FIGURE 3.3.2 LEATHER TANNING INDUSTRY: EVA, DEPRECIATION AND ENVIRONMENTAL COST, IN THOUSAND PESOS (AT CURRENT PRICES), 1988-1994**

### 3.3.4 RECOMMENDATIONS

As data on actual production, BOD load, and cost of treatment relate only to one year (1994), there is a need in the future to establish another benchmark level and not just extrapolate the existing ones using trend indicators. It may also be worthwhile to determine the amount of other pollutants, in addition to BOD, that might be generated by the industry. Moreover, the toxicity of the discharges in the tanyard process should be investigated.

APPENDIX TABLE 3.3.1

**BEAMHOUSE AND TANYARD PRODUCTION, WASTEWATER FLOW AND BOD LOAD OF SAMPLE TANNERIES BY SIZE OF TANNERY, 1994**

Tannery	Number of Sample Tannery	Beamhouse Production (Kg. Hides/mo.)	Beamhouse Wastewater Flow (Liters/mo.)	BOD Load/Tannery (mg./Liter)
Large	5	368,329	3,207,038	3,314
Medium	4	76,953	581,832	3,804
Small/Cottage	5	23,291	99,894	3,754
Tannery	Number of Sample Tannery	Tanyard Production (Kg. Hides/mo.)	Tanyard Wastewater Flow (Liters/mo.)	BOD Load/Tannery (mg./Liter)
Large	5	297,045	2,032,489	1,737
Medium	4	67,167	444,934	2,243
Small/Cottage	5	17,540	60,117	2,935

Source: Mendoza, 1996

APPENDIX TABLE 3.3.2

**COST OF WASTEWATER TREATMENT (PESOS/Kg), 1988-1994**

Year	Beamhouse Process			Tanyard Process			IPIN	
	Large	Medium	Small/Cottage	Large	Medium	Small/Cottage	OMDE (1985=100)	OMDE (1994=100)
1988	2.91	5.08	16.72	5.56	8.61	21.39	103.90	0.48
1989	3.02	5.27	17.34	5.76	8.93	22.18	107.75	0.50
1990	3.66	6.38	21.00	6.98	10.81	26.86	130.49	0.61
1991	4.44	7.75	25.50	8.48	13.13	32.62	158.45	0.74
1992	4.57	7.98	26.26	8.73	13.52	33.58	163.13	0.76
1993	5.68	9.91	32.63	10.85	16.80	41.74	202.75	0.94
1994	6.03	10.52	34.63	11.51	17.83	44.29	215.15	1.00

APPENDIX TABLE 3.3.3

BEAMHOUSE PRODUCTION, WASTEWATER FLOW AND BOD LOAD (BLOWN UP DATA), BY SIZE OF TANNERY, 1994

Tannery	Beamhouse Production (Kg. of Hides/Year)	Wastewater Flow (Liters/Year)	Beamhouse BOD Load (mg./Liter)	Total BOD Discharges in Beamhouse (Kg.)
TOTAL	20,225,394	170,898,612		574,517
Large 25%	17,679,792	153,937,824	3,314	510,150
Medium 50%	1,846,872	13,963,968	3,804	53,115
Small/Cottage 40%	698,730	2,996,820	3,754	11,251

APPENDIX TABLE 3.3.4

TANYARD PRODUCTION, WASTEWATER FLOW AND BOD LOAD (BLOWN-UP DATA), BY SIZE OF TANNERY, 1994

Tannery	Tanyard Production (Kg. of Hides/Year)	Wastewater Flow (Liters/Year)	Tanyard BOD Load (mg./Liter)	Total BOD Discharges in Tanyard (Kg.)
TOTAL	16,396,368	110,041,398		198,706
Large 25%	14,258,160	97,559,472	1,737	169,462
Medium 50%	1,612,008	10,678,416	2,243	23,950
Small/Cottage 40%	526,200	1,803,510	2,935	5,294

APPENDIX TABLE 3.3.5

## ESTIMATION OF PRODUCTION TRENDS, 1988-1994

YEAR	OUTPUT (at Current Prices)		IPIN		OUTPUT (at constant 1994 prices)			
	Large	Small/ Cottage	GVA (1985=100)	GVA (1994=100)	Large	Growth Rate	Small/ Cottage	Growth Rate
1988	105,810	44,808	128.81	0.89	119,085		50,429	
1989	206,923	9,995	131.11	0.90	228,797	92.1 percent	11,052	-78.1 percent
1990	231,838	8,263	133.11	0.92	252,495	10.4 percent	8,999	-18.6 percent
1991	379,296	10,972	150.63	1.04	365,044	44.6 percent	10,560	17.3 percent
1992	408,522	15,033	157.05	1.08	377,099	3.3 percent	13,877	31.4 percent
1993	204,979	11,352	166.67	1.15	178,291	-52.7 percent	9,874	-28.8 percent
1994	190,187	16,240	144.97	1.00	190,187	6.7 percent	16,240	64.5 percent

APPENDIX TABLE 3.3.6

ESTIMATED HIDE PRODUCTION OF LEATHER TANNERIES, IN THOUSAND  
KILOGRAMS, 1988-1994

YEAR	Beamhouse Production of Hides				Tanyard Production of Hide			
	Total	Large	Medium	Small/ Cottage	Total	Large	Medium	Small/ Cottage
1988	18,975	11,070	5,735	2,170	15,567	8,928	5,006	1,634
1989	23,001	21,269	1,257	475	18,608	17,153	1,097	358
1990	24,883	23,472	1,023	387	20,114	18,929	893	292
1991	35,590	33,934	1,201	454	28,757	27,367	1,048	342
1992	37,230	35,055	1,578	597	30,098	28,271	1,377	450
1993	18,122	16,574	1,123	425	14,666	13,366	980	320
1994	20,225	17,680	1,847	699	16,396	14,258	1,612	526

### APPENDIX 3.3.7

#### ESTIMATION OF LEATHER PRODUCTION AND PROCESS RATE, 1994

Estimates of BOD discharges for 1994 were built up using the basic information derived from the survey study of Mendoza (1996). Parameters from the survey, the total volume of hides that passed through the beamhouse and tanyard processes, as well as the wastewater generated for each process were totaled by tannery size. The average beamhouse and tanyard BOD load, by size of tannery, was then derived as the weighted average of the beamhouse and tanyard BOD load of the responding tanneries, using the volume of wastewater flow, by tannery, as weights (see Appendix Table 3.3.2).

The derived beamhouse and tanyard production and the corresponding wastewater flow, for each tannery size were then blown-up to get an approximation of the country's total beamhouse and tanyard production and the corresponding wastewater flow. Adjustments were based on a 25, 50 and 40 percent coverage ratio for large, medium and small-sized tanneries, respectively, in the survey study. For large tanneries, the 25 percent coverage ratio was computed by getting the ratio of the five responding establishments to the total production capacity of the eleven large establishments included in the frame. For the medium-sized tanneries, it was taken that the samples constitute 50 percent of the total number of tanneries. On the other hand, for the small/cottage tanneries, the lower 40 percent coverage was adopted on the assumption that the samples deleted from the frame (because their sizes could not be identified) are actually small tanneries. These blown-up figures for the beamhouse and tanyard production, and wastewater generated represented the benchmark estimate for 1994. The results are presented in Appendix Table 3.3.3 and Appendix Table 3.3.4.

### APPENDIX 3.3.8

#### EXTRAPOLATION OF HIDE PRODUCTION

The 1994 production of hides was extrapolated back to years 1988 to 1993 using the growth of value of output of the leather industry at constant prices. The values of production at current prices for small and large establishments were taken from the results of the ASE and the CE. These were then deflated using the IPIN of the GVA of leather industry as taken from the National Accounts (Refer to Appendix Table 3.3.5). The trends of the deflated value of output were assumed to approximate the movement of the volume of beamhouse and tanyard production of the leather tanning industry from 1988 to 1993 (see Appendix Table 3.3.6). Both small and medium tanneries adopted the growth trends of the small establishments from ASE/CE, while the growth rates of the value of output of the large establishments were used for the extrapolation of beamhouse and tanyard production of large tanneries.

$$\text{Production}_{t-1} = \text{Production}_t / (K \text{ output}_t / K \text{ output}_{t-1})$$

where:

Production = volume of hides produced by leather tanneries

K output = output at constant 1994 prices (estimated as value of output at current prices deflated by corresponding IPIN of GVA of leather manufacturing, rebased to 1994).

$$= \frac{\text{ASE/CE output}}{\text{IPIN}_{t_{94=100}}}$$

$$\text{IPIN}_{t_{94=100}} = \frac{\text{IPIN}_{t_{85=100}}}{\text{IPIN}_{1994_{85=100}}}$$

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# ***Paint Manufacturing***

### **3.4.1 INTRODUCTION**

#### **3.4.1.1 Industry Description**

The paint manufacturing industry in the Philippines was established in 1911. This particular subsector comprises establishments primarily engaged in the manufacture of paints (in paste and ready mixed form), varnishes, lacquers, enamels, putties, wood fillers, and sealers, paint and varnish removers, and allied paint products like concrete neutralizers, multicoated paints, rust inhibitors and others. The estimated market for the paint industry in 1994 was valued at approximately ₱ 5.6 billion. Of this, 80 percent goes to architectural and 20 percent goes into industrial use. Geographically, 70 percent of the market is in Metro Manila and the rest of Luzon while 30 percent is in the Visayas and Mindanao.

#### **3.4.1.2 Scope and Limitations of the Study**

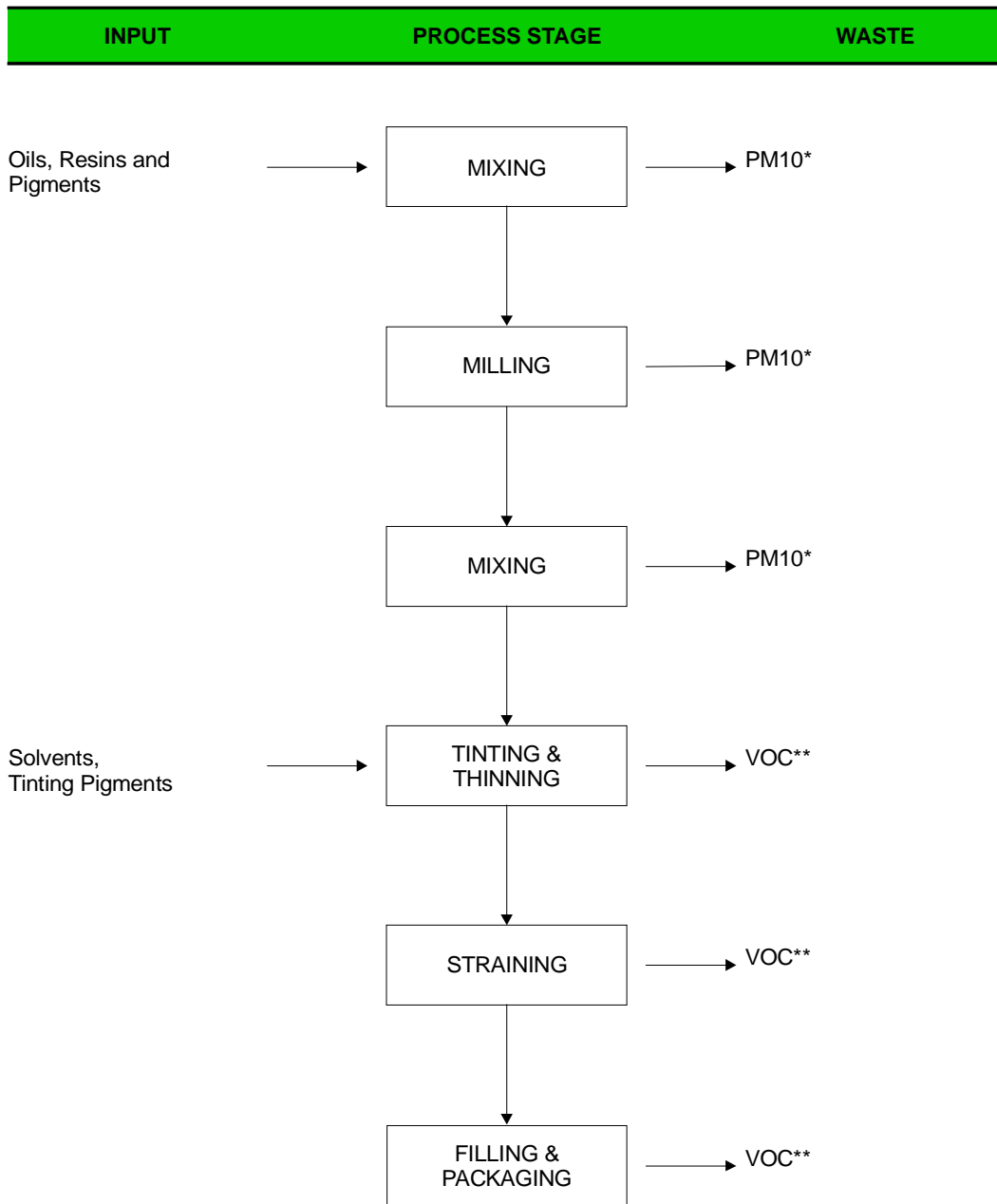
Paint manufacturing industry is part of the basic chemical industry. This study covers establishments under the PSIC 35211 - Manufacture of Paint. Specifically, the study measures the air emissions of particulate matter (PM10) and VOC generated as a result of the volatility of the raw materials used in the production of paints. However, monetary valuation of VOC is not estimated due to the absence of information regarding its control technology. What is estimated in this study is the maintenance cost of controlling PM10 emissions through the use of fabric filter. No water effluents are included in the study.

#### **3.4.1.3 Production Process and Pollutants Generated**

Paint making is essentially the art of reproducibly dispersing pigments in vehicles and duplicating the color and properties of a finished paint to a given standard. Paints are composed of three basic ingredients: pigments, binders or vehicles, and solvents. Pigments may either be natural or synthetic compounds whose amount in paint varies by weight. The liquid portion known as the vehicle consists of resins, drying oils, or both, and a solvent.

Paint manufacturing processes are of two types: solvent-based and water-based. The production of solvent-based paints begins by mixing resins, dry pigments and/or dry pre-dispersed pigments and pigment extenders in a high-speed mixer. During this operation, solvents and plasticizers are also added (see Figure 3.4.1). The water-based paint process is very similar to the solvent-based process. The only difference is the substitution of water for solvent and the sequencing of material additions. Preparations of water-based paints begin by mixing water, ammonia, and a dispersant in a mixer.

The two major types of air emissions that occur during the production process of paint are PM10 and VOC. Particulate matter is emitted from the pigment dust while VOC is emitted from the bulk storage of resins and solvents and from their use in open processing equipment's such as mix tanks.



Source:  
Dutch Boy Philippines

\* Pollutant estimated in this study, physical and monetary

\*\* Pollutant estimated in this study, physical only

**FIGURE 3.4.1 PAINT MANUFACTURING PROCESS FLOW**

### 3.4.2 SOURCES AND METHODS

#### 3.4.2.1 Data Sources

Value of production was taken from the ASE. The wholesale prices of paint used were from the NSO. Emission factors based on Assessment of Sources of Air, Water and Land Pollution published by the WHO (1993) were used to derive the air pollution loads including PM10 and VOC. Cost of treating PM10 was obtained from the study of ENRAP Phase III (Orbeta, 1993). Finally, GVA was derived from the National Accounts published by the NSCB.

#### 3.4.2.2 Estimation Methodology

##### 3.4.2.2.1 Physical Estimation

The volume of production was derived by dividing the value of production by the price of paint per kilo (see Appendix Table 3.4.1). Air pollution discharges were estimated using the general formula:

Emission = Volume of production x emission factor

More specifically, emissions to air were estimated as:

VOC (In MT) = Volume of Paint Production (In Mt) x 15 kg/Mt/1000  
 PM10 (In MT) = Volume of Paint Production (In Mt) x 5 kg/Mt/1000

##### 3.4.2.2.2 Monetary Estimation

Environmental cost of the paint industry was derived by getting the AnCC plus AOMC of the air pollutant treatment, e.g., fabric filter, multiplied by the air pollution discharges of the industry. A fabric filter or a baghouse is used for particle removal. The unit may consist of several hundred-filter bags.

To be more specific, environmental cost (in pesos) was estimated as:

Environmental cost = PM in MT x (AnCC of Fabric Filter + AOMC of Fabric Filter in pesos per MT)

The AnCC and the AOMC of fabric filter were used to extrapolate the 1989-1994 costs using the growth rate of the IPIN of "other miscellaneous durable equipment" and the growth rate of the CPI for "all items" (see Appendix Table 3.4.2).

### 3.4.3 RESULTS

#### 3.4.3.1 Physical Estimates

The paint industry contributes solid wastes and air pollution to the environment. Air emission is the most obvious pollutant that the paint industry emits to the environment. The two major types of air emissions that are discharged in the production of paint industry are PM10 and VOC. Table 3.4.1 shows the PM10 and VOC discharges by the paint industry for 1988 to 1994.

**TABLE 3.4.1 VOLUME OF PRODUCTION, VOC AND PM10 EMISSIONS, IN METRIC TONS AND PM CONTROL COST, IN THOUSAND PESOS, 1988-1994**

YEAR	VOLUME OF PRODUCTION	VOC	PM10	PM10 CONTROL COST		
				TOTAL	AnCC	AOMC
1988	78,722	1,182	394	1,065	974	91
1989	96,825	1,452	484	1,367	1,242	125
1990	93,044	1,396	465	1,582	1,445	137
1991	80,430	1,206	402	1,658	1,517	141
1992	89,614	1,344	448	1,911	1,741	171
1993	127,649	1,915	638	3,342	3,081	261
1994	131,415	1,971	657	3,662	3,368	294

Note:

AnCC: Annualized Capital Cost

AOMC: Annualized Operating and Maintenance Cost

VOC accounts for 75 percent of pollutants emitted by paint manufacturing industries from 1988 to 1994. The period between 1993 to 1994 showed the highest level of VOC and PM10 emissions mainly due to an increasing trend in paint production for the same period.

### 3.4.3.2 Monetary Estimates

The environmental cost of PM discharges in 1988 was estimated at P 1.1 million (Table 3.4.1). This increased to P 3.7 million in 1994 as paint production rapidly increased. Although VOC accounted for the bulk of pollutants emitted by paint manufacturing industries, the environmental cost of controlling it was not covered due to lack of information regarding its control.

### 3.4.3.3 Environmentally Adjusted Net Value Added (EVA)

The EVA of paint industry is shown in Table 3.4.2 and in Figure 3.4.2. It is noted that environmental cost, as defined in this study, was almost negligible at about 0.2 percent of the NVA of the paint industry. Hence, EVA of the paint industry at current prices has the same trend as its GVA.

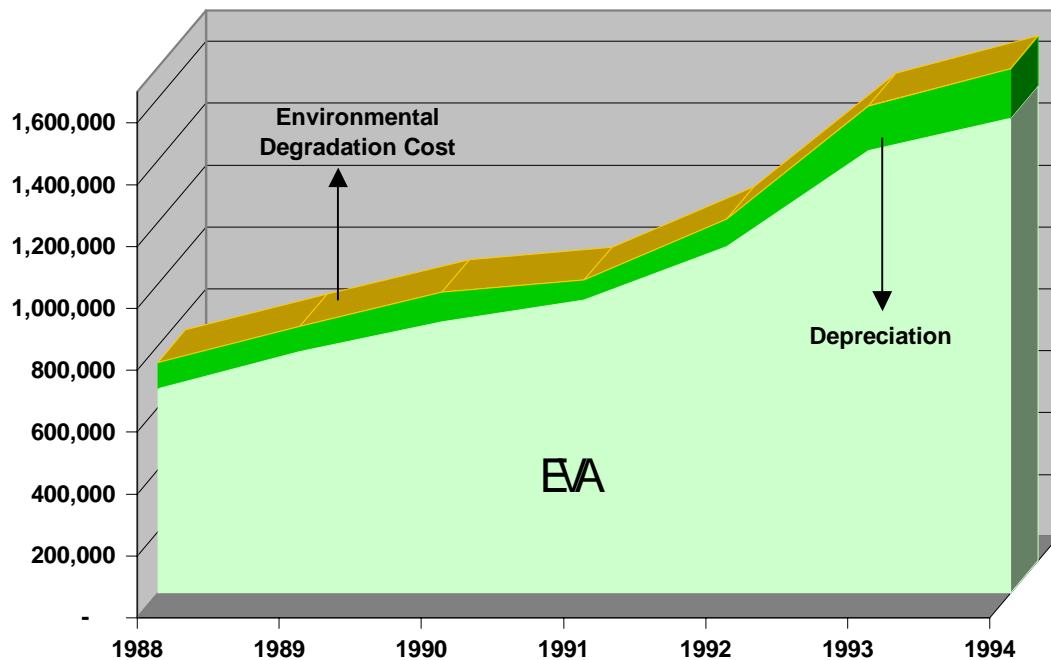
## 3.4.4 RECOMMENDATIONS

The data on the AnCC and AOMC relate only to one year, 1988. There is a need to establish another benchmark level and not just extrapolate the existing ones using trend indicators. Moreover, data on pollution control technology for VOC and their respective cost should be established.

**TABLE 3.4.2 ENVIRONMENTALLY ADJUSTED NET VALUE ADDED (EVA), IN THOUSAND PESOS (AT CURRENT PRICES), 1988-1994**

YEAR	GVA [1]	DEPRECIATION [2]	NVA [3] = [1]-[2]	ENVIRONMENTAL COST <sup>1</sup> [4]	EVA [5] = [3]-[4]
1988	746,000	82,744	663,256	1,065	662,191
1989	862,527	79,372	783,155	1,367	781,788
1990	973,293	94,118	879,175	1,582	877,593
1991	1,012,851	63,292	949,175	1,658	947,901
1992	1,209,564	87,579	1,121,985	1,911	1,120,074
1993	1,576,526	141,585	1,434,941	3,342	1,431,599
1994	1,696,618	156,253	1,540,365	3,662	1,536,703

<sup>1</sup> Refer to the PM<sub>10</sub> control cost of Fabric Filter



**FIGURE 3.4.2 PAINT MANUFACTURING INDUSTRY: EVA, DEPRECIATION AND ENVIRONMENTAL COST, IN THOUSAND PESOS (AT CURRENT PRICES), 1988-1994**

APPENDIX TABLE 3.4.1

## VALUE AND VOLUME OF PRODUCTION, 1988-1994

Year	Value of Production (in '000 ₱)	Price (per gallon)	Price (per kilo) 1 gal. = 5 kg.	Volume of Production (in metric tons)
1988	2,497,848	158.54	31.71	78,772
1989	2,852,457	147.31	29.46	96,825
1990	3,313,302	178.07	35.61	93,044
1991	3,559,035	221.27	44.25	80,430
1992	4,067,576	226.94	45.39	89,614
1993	5,251,468	205.71	41.14	127,649
1994	5,382,756	204.82	40.96	131,415

Source: ASE, NSO

APPENDIX TABLE 3.4.2

## COST OF POLLUTION CONTROL DEVICES (PESOS/MT), 1988-1994

YEAR	FABRIC FILTER			IPIN – OMDE	CPI – All Items (1 + g)
	Total Cost	AnCC	AOMC		
1988	2,703	2,473	230		
1989	2,824	2,566	258	1.0375	1.1220
1990	3,402	3,107	295	1.2110	1.1417
1991	4,123	3,774	350	1.2146	1.1865
1992	4,266	3,885	381	1.0295	1.0895
1993	5,239	4,829	410	1.2429	1.0761
1994	5,573	5,126	447	1.0616	1.0904

Source: Estimation of Direct Environmental Waste Disposal Services, by E. Orbeta  
ASE, NSO  
National Accounts, NSCB

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# ***Sugar Milling***

### 3.5.1 INTRODUCTION

#### 3.5.1.1 Industry Description

Sugar is a traditional export commodity of the Philippines and a major earner of foreign exchange for the economy. In 1996, the Philippines sugar industry is comprised of 37 sugar districts in 17 provinces covering a total of 370,000 hectares, of which, 81 percent are 10 hectares and below (PSMA, 1996). There are 100,000 farm operators in the entire industry, employing a total of 556,000 agricultural workers and 25,000 mill workers. Eighty one to 90 percent of the total production is consumed locally, while 10 to 15 percent is exported to the USA.

Sugar cane consists of 15 percent fiber and 85 percent water and soluble solids. The major by-products of the sugar industry are bagasse, pressed mud or pressed cake, and molasses. The production of bagasse depends upon the fiber content of the sugar cane, which varies from 13 to 17 percent of cane, and depending on the area where the cane is cultivated. On the average, bagasse production is about 15 percent of the cane crushed. The production of pressed mud is about 3 percent of the cane in sulphitation factories and 7 percent in the carbonation factories. The sulphitation press mud also contains sugar cane wax, which varies from 8 to 10 percent of the mud. Molasses is the main product of the cane sugar industry. Production of molasses depends largely upon the quantity, and to some extent, upon the quality of the cane crushed, varying from region to region. Its average production is 4.4 percent of cane processed.

#### 3.5.1.2 Scope and Limitation of the Study

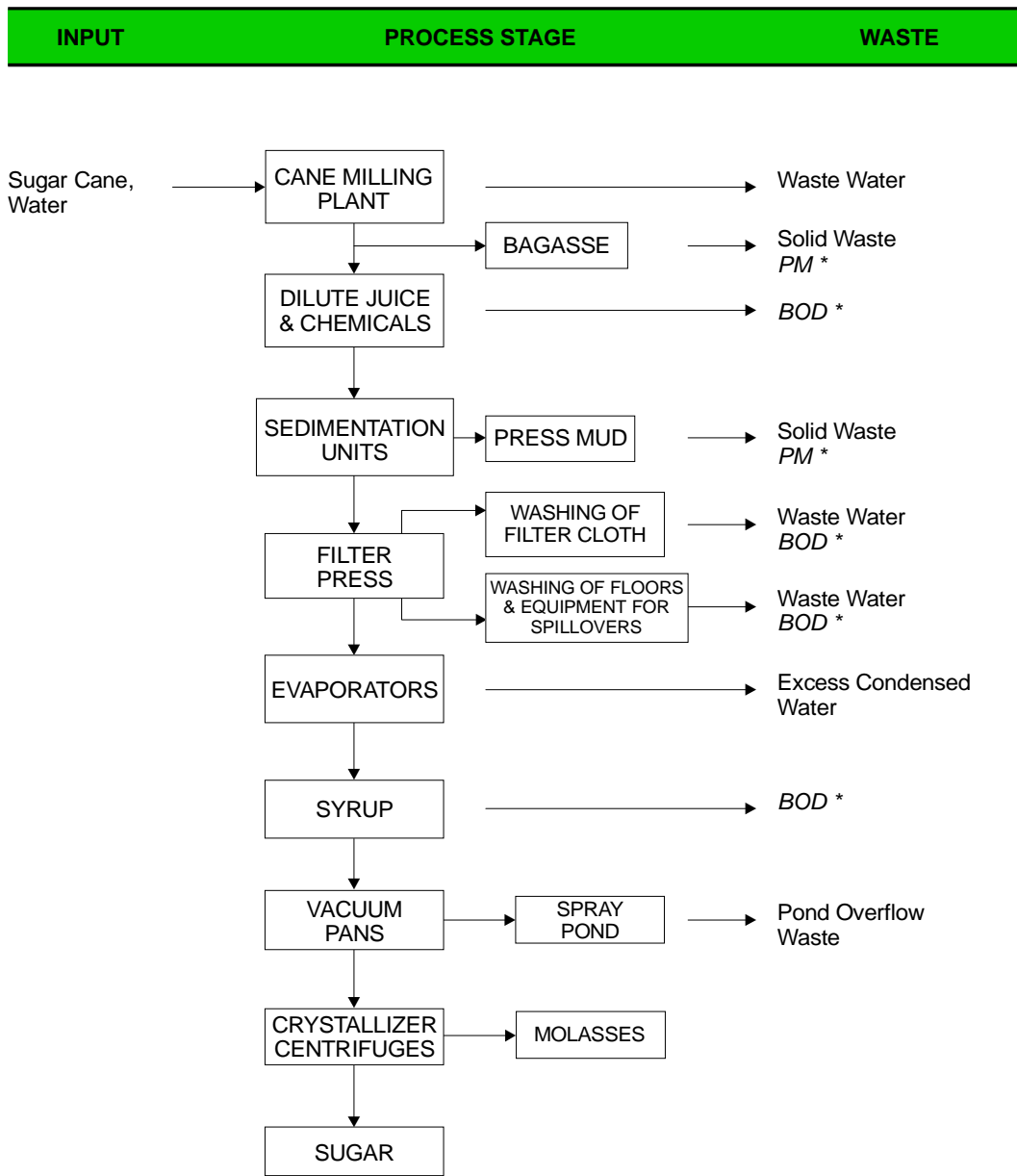
The estimation covers both physical and monetary accounting of pollution generated by raw sugar production. Particulate matter (PM) for air and BOD for water are the pollutants estimated in this study.

#### 3.5.1.3 Production Process

The first stage in sugar milling is done in the cane carrier section where the cane is dumped (see Figure 3.5.1). It is tipped into a feeding table and passed through the cane knives. The cane is crushed through a crushing machine and disintegrated to extract the juice. Hot water is added to help macerate the canes. In this stage, a large amount of water is used for extracting the juice and for cooling the bearings of mill tandems. This cooling water picks up oils and grease as well as some juice from spillover and leakage.

The boilers use the bagasse from millers as fuel to generate steam to run the turbine generators and other steam driven equipment. Combustion of bagasse for steam and power generation emits air-borne particulates, which form the bulk of air pollutants. The air emissions are the fly ash, bottom ash and flue gas. Fly ash has adverse effects on human health and plant life. These fly ash and particulates can damage vegetation by covering the surface of leaves, soil clothes, buildings and other structures and pose a health hazard when inhaled into the lungs with air.

The next stage is done in the clarification section where the heated juice is treated with lime to reduce its acidity. The mixture then goes through the heaters, then to the settling tanks or clarifiers where the clear juice is drawn off successively from the top. The impurities and mud settled at the bottom of the clarifiers are then pumped to vacuum filters to separate the juice.



Source:  
Victorias Milling & Refinery

\* Pollutant estimated in this study, physical and monetary

FIGURE 3.5.1 SUGAR MILLING PROCESS FLOW

The heavy syrup is readied for further evaporation in the vacuum pan where the sugar crystals are separated. The mixture of sugar crystals and mother liquor from the vacuum pan is called massecuite. The massecuite is dropped into mixers or crystallizers with revolving arms to keep the mass in motion for gradual cooling; then into centrifugal machine at high speed that throws off the molasses. At this point the raw sugar is collected. Improper handling of molasses as well as leakage and overflow from molasses storage tanks may seriously increase the pollution load of sugar factory wastewaters.

Wastes generated from the cane carrier section to the centrifuging section, such as condensing water, wash water, cooling water, spill and caustic washing, are typically characterized to have toxic cleaning substances, oil, lubricants, lime slurry and other organic substances.

The raw sugar is then weighed and stored in the sugar warehouse. From the warehouse, it is either shipped out for export or conveyed to the refinery for the manufacture of refined sugar.

### 3.5.2 SOURCES AND METHODS

#### 3.5.2.1 Data Sources

The effluent and emission factors used in this study were obtained from the Industrial Efficiency and Pollution Control Program (ENRAP II, 1992). Data on production of raw sugar were taken from the Sugar Regulatory Administration (SRA). Data on capital cost and operating plus maintenance cost for 1988 were gathered from ENRAP III (1993). Appendix Table 3.5.1 illustrates the extrapolation of the 1988 cost for the years 1989 to 1994. The CPI for 1988 to 1994 were taken from the NSO, and the IPIN, GVA, and depreciation were taken from the National Accounts of the Philippines published by the NSCB.

#### 3.5.2.2 Estimation Methodology

##### 3.5.2.2.1 Physical Estimation

Raw sugar production data from SRA were adjusted by 5 percent which is the undercoverage for production based on the estimates of raw sugar in agricultural sector. The adjusted production was then multiplied by the emission/effluent factor. The effluent factor for H<sub>2</sub>O is 2.6 Kg/MT. This means that for every MT of raw sugar produced, there is a corresponding 2.6-Kg of BOD generated. Similarly, emissions to air in the form of PM, are pegged at 20 Kg/MT of raw sugar produced. In this study, pollutants were estimated as:

- Effluent to water:  

$$\text{BOD}_5 \text{ in MT} = \text{Raw Sugar Production in Mt.} \times 2.6 \text{ kg/Mt}/1000.$$
- Emissions to Air:  

$$\text{PM in MT} = \text{Raw Sugar Production in Mt.} \times 20 \text{ kg/Mt}/1000$$

##### 3.5.2.2.2 Monetary Estimation

In estimating the environmental cost of producing raw sugar, the cost of controlling emissions or effluents per unit of pollutant was multiplied by the quantity of emissions/effluents. The general equation is:

$$EC = \text{Emission/Effluent} \times [\text{AnCC} + \text{AOMC of Pollution Control Device (PCD) per unit of pollution}]$$

where:

$$EC = \text{Environmental Cost}$$

For this study, the value of environmental degradation, in pesos, caused by the industry was calculated using the following equations:

- BOD<sub>5</sub> Control Cost  
= BOD<sub>5</sub> in MT x (AnCC of SC & AFL + AOMC of SC & AFL in pesos per MT)
- PM Emission Control Cost  
= PM in MT x (AnCC of Cyclone + AOMC of Cyclone in pesos per MT)

where:

$$\text{SC \& AFL} = \text{Sludge Collector and Aerated Facultative Lagoon}$$

### 3.5.3 RESULTS

#### 3.5.3.1 Physical Estimates

The increase in the production of raw sugar corresponds to an increase in the BOD<sub>5</sub> load generated in wastewater discharged during the milling processes. Similarly, PM emitted into the air increases with every increase in production.

In 1994, the estimated BOD<sub>5</sub> load was pegged at 5,534 MT, which is 33 percent higher than the BOD<sub>5</sub> load in 1998 registered at 3,704 MT. The PM emissions, on the other hand, increased to 42,570 MT in 1994 from 28,494 MT in 1998. This represents an increase of 49 percent in PM emissions during the period (see Table 3.5.1).

#### 3.5.3.2 Monetary Estimates

The environmental cost of discharging and emitting waste was estimated using the capital costs and operation and maintenance costs of pollution devices. The sludge collector and the aerated facultative lagoons are the pollution devices used in treating BOD<sub>5</sub>. On the other hand, the cyclone was used in controlling PM emissions.

Table 3.5.2 shows the estimated environmental costs of controlling pollution during the period 1988-1994. Data shows that controlling PM emissions was more costly than treating wastewater. This is due to the relative high price of pollution device designed to control air emission.

In 1988, the total control cost of treating BOD<sub>5</sub> in wastewater amounted to P 11.7 million. This increased threefold to P 35.4 million in 1994. PM emission control cost, on the other hand, was estimated at P 93.6 million in 1998 and this increased by 308 percent in 1994 to P288 million.

**TABLE 3.5.1 RAW SUGAR PRODUCTION, BOD<sub>5</sub> EFFLUENTS AND PM EMISSIONS, IN METRIC TONS, 1988-1994**

Year	Raw Sugar Production <sup>1</sup>	BOD <sub>5</sub>	PM
1988	1,424,715	3,704	28,494
1989	1,905,071	4,953	38,101
1990	1,710,253	4,447	34,205
1991	1,939,064	5,042	38,781
1992	1,947,216	5,063	38,944
1993	2,120,927	5,514	42,419
1994	2,128,509	5,534	42,570

<sup>1</sup> Adjusted Raw sugar production. SRA reported production was adjusted by 5 percent as an undercoverage adjustment

**TABLE 3.5.2 ENVIRONMENTAL COST: BOD<sub>5</sub> AND PM CONTROL COST, IN THOUSAND PESOS, 1988-1994**

Year	BOD <sub>5</sub> Control Cost							PM Control Cost		
	Total Control Cost <sup>1</sup>	AnCC			AoMC			Cyclone		
		Total	SC	AFL	Total	SC	AFL	Total	AnCC	AOMC
1988	11,697	7,434	3,671	3,763	4,263	2,978	1,285	93,603	85,624	7,978
1989	16,702	10,453	5,090	5,362	6,396	4,468	1,928	130,706	118,736	11,970
1990	17,766	11,090	5,535	5,555	6,557	4,580	1,977	141,360	129,091	12,269
1991	24,252	14,578	7,620	6,898	8,821	6,162	2,659	194,226	177,722	16,505
1992	25,604	14,121	7,878	6,244	9,651	6,741	2,909	201,798	183,740	18,058
1993	32,902	23,081	10,663	12,417	11,309	7,900	3,410	269,908	248,743	21,165
1994	35,373	25,242	11,356	13,885	12,376	8,645	3,731	288,055	264,895	23,160

<sup>1</sup> Total Control Cost-BOD<sub>5</sub> = Total AnCC + Total AOMC

### 3.5.3.3 Environmentally Adjusted Net Value Added (EVA)

In 1988, the share of environmental protection cost to the NVA of sugar industry was only 0.75 percent. The highest share occurred in 1993 at 1.50 percent (refer to Table 3.5.4 and Figure 3.5.2).

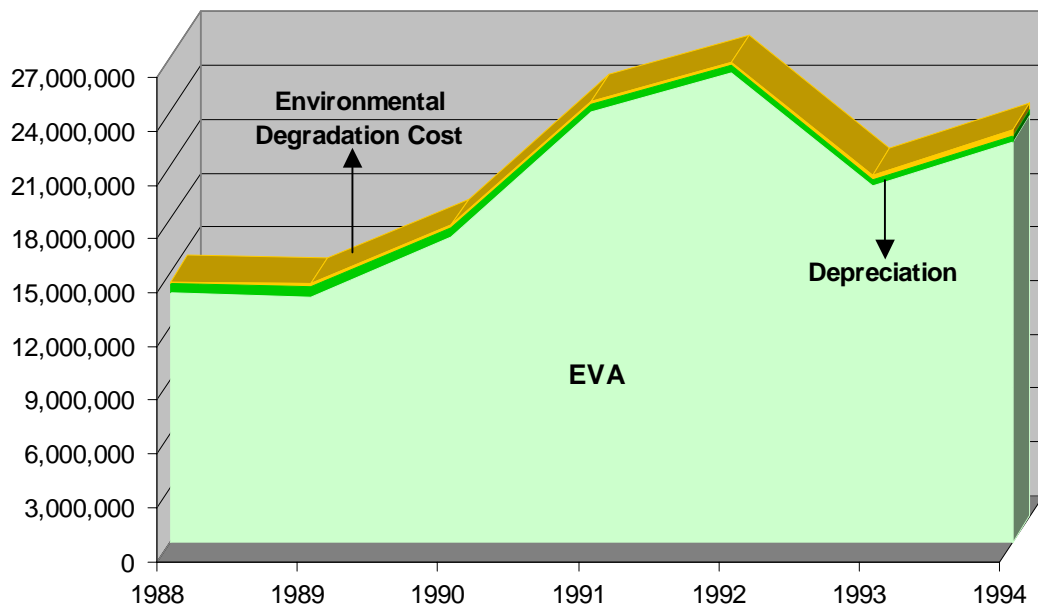
Meanwhile, the EVA (at current prices) registered a negative growth rate at 24.13 percent for 1992-1993. The highest positive growth was registered in 1990-1991 at 40.67 percent. The EVA average annual growth rate of the industry for the years 1988-1994 was 8.15 percent.

**TABLE 3.5.3 ENVIRONMENTALLY ADJUSTED NET VALUE ADDED (EVA), IN THOUSAND PESOS (AT CURRENT PRICES), 1988-1994**

YEAR	GVA <sup>1</sup> [1]	Depreciation [2]	NVA [3] = [1] - [2]	ENVIRONMENTAL COST <sup>2</sup>			EVA [5] = [3] - [4]
				Total [4]	PM Control cost	BOD <sub>5</sub> Control cost	
1988	14,487,439	481,953	14,005,486	105,300	11,697	93,603	13,900,186
1989	14,394,961	620,589	13,774,372	147,388	16,702	130,706	13,626,984
1990	17,663,475	474,927	17,188,548	159,135	17,766	141,360	17,029,413
1991	24,586,920	413,921	24,172,999	218,506	24,252	194,226	23,954,493
1992	26,787,989	386,042	26,401,947	227,412	25,604	201,798	26,174,535
1993	20,473,035	311,694	20,161,341	302,814	32,902	269,908	19,858,527
1994	22,981,998	358,810	22,623,188	323,444	35,373	288,055	22,299,744

<sup>1</sup> GVA for sugar milling estimated using the ratio of sugar milling industry to total food industry based on the ASE/CE.

<sup>2</sup> Environmental cost = PM and BOD<sub>5</sub> 's combined AnCC and AOMC.



**FIGURE 3.5.2 SUGAR MILLING INDUSTRY: EVA, DEPRECIATION AND ENVIRONMENTAL COST, IN THOUSAND PESOS (AT CURRENT PRICES), 1988-1994**

### 3.5.4 RECOMMENDATIONS

With the current emission and effluent factors obtained from foreign environmental protection agency, there is a need therefore to base these factors on local situations to be more objective.

APPENDIX TABLE 3.5.1

## AVERAGE COST OF POLLUTION CONTROL DEVICES, 1988-1994

Year	Sludge Collector			Aerative Facultative Lagoons			Cyclone			IPIN - OMDE (1+g)	CPI - All Items (1+g)
	Total Cost	AnCC	AOMC	Total Cost	AnCC	AOMC	Total Cost	AnCC	AOMC		
1988	1,795	991	804	1,363	1,016	347	3,285	3,005	280		
1989	1,930	1,028	902	1,443	1,054	389	3,432	3,118	314	1.04	1.12
1990	2,275	1,245	1,030	1,721	1,277	445	4,134	3,776	359	1.21	1.14
1991	2,734	1,512	1,222	2,078	1,550	527	5,011	4,586	426	1.22	1.19
1992	2,888	1,557	1,331	2,171	1,596	575	5,185	4,721	464	1.03	1.09
1993	3,368	1,935	1,433	2,602	1,984	618	6,367	5,868	499	1.24	1.08
1994	3,616	2,054	1,562	2,780	2,106	674	6,773	6,229	544	1.06	1.09

Source:

Estimation of Direct Environmental Waste Disposal Services (Orbeta, 1990).  
National Accounts of the Philippines, NSCB  
ASE/CE, NSO

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# ***Cement Manufacturing***

### 3.6.1 INTRODUCTION

#### 3.6.1.1 Industry Description

Cement is used for binding sand and gravel to form concrete, for uniting the surfaces of various materials or for coating surfaces for protection. Cement hardens by the evaporation of the plasticizing liquid, by internal chemical change, by hydration, or by the growth of interlacing sets of crystals. Other types of cement harden as they react with oxygen or carbon dioxide in the atmosphere.

There are currently nineteen (19) cement manufacturing firms operating all over the country, more than half of which are in the Luzon area. The industry's major products include Portland cement, clinker and pozzolan cement. From 1988 to 1994, the total cement production more than doubled from 3,519 thousand metric tons (MT) in 1988 to 7,885 thousand MT in 1994. This was due to the boom in the construction industry for the period, increasing demand for cement and jacking up prices to unparalleled proportions.

#### 3.6.1.2 Scope and Limitations of the Study

The study compiled the physical and monetary accounts showing air emissions generated from cement production. The emissions were estimated for particulate matter (PM) only, the industry being a major contributor to total PM emissions. Conventional air pollutants due to fuel use, such as oxides of nitrogen and sulfur, carbon monoxide and volatile organic compounds, were excluded. Moreover, water pollution due to this economic activity was not estimated.

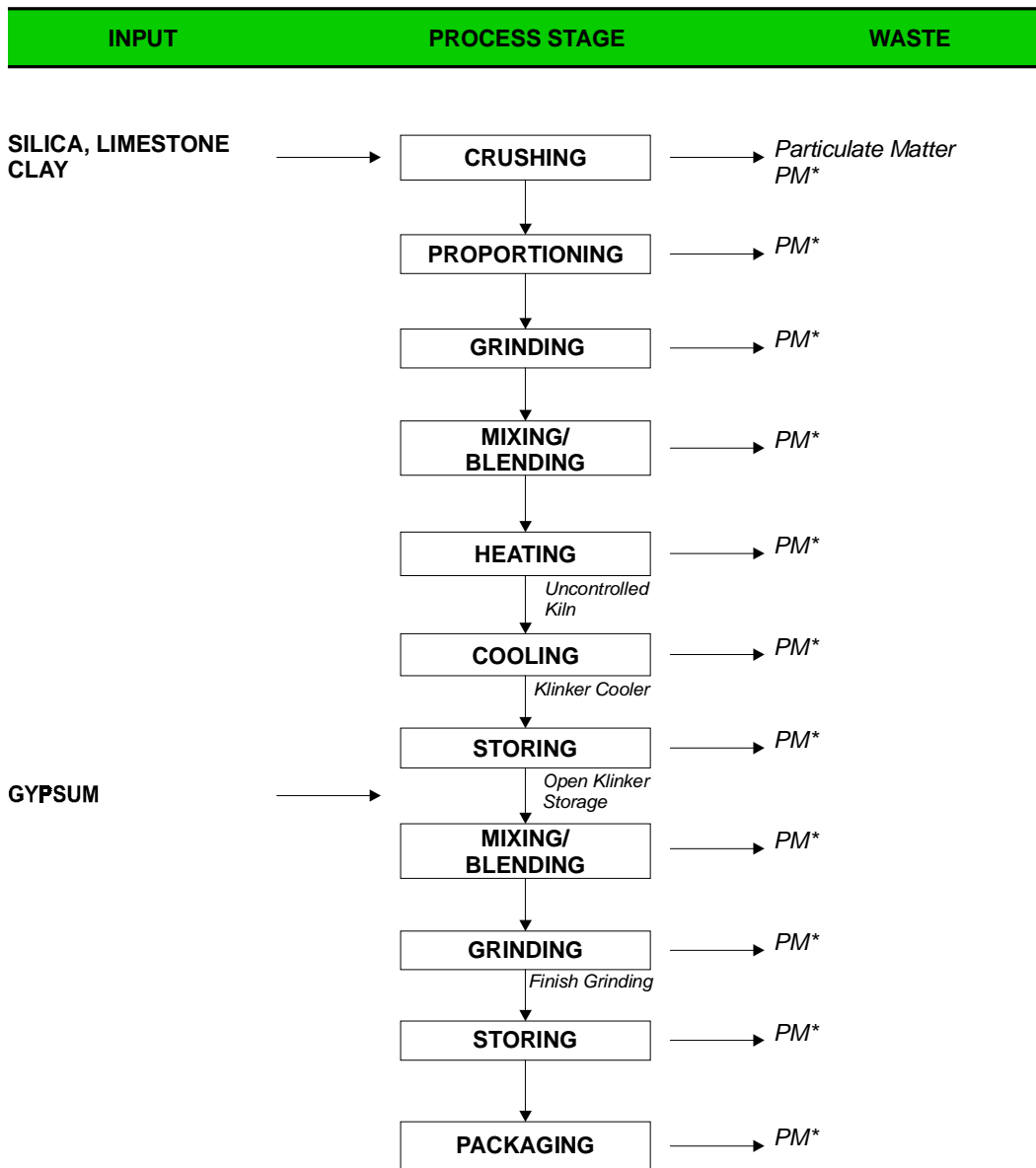
In addition, the extraction of raw materials for cement manufacturing was not considered. This was based on the premise that this study will be limited to the manufacturing aspect only.

The US-EPA and the WHO emission factors, from the ENRAP III Sectoral Study on the Portland Cement Industry, were used and expressed in terms of kg per MT of clinker. This presented a minor obstacle for the estimation since PM emissions due to coal crushing, conveying and storage are fuel-related. A more accurate estimation of the loads of this pollutant would be arrived at if the emission factors and process rates applied to them were also expressed in terms of fuel input instead of clinker output. However, since no fuel input-based emission factors were used, the emission factors based on clinker output will have to suffice, and subsequently, clinker production will be used as process rate for the estimation of PM due to coal use.

Furthermore, the emission factors used were for uncontrolled emissions. This assumes that all emissions of the Cement industry are unabated, effectively bloating the physical and consequently, the monetary accounts. The use of emission factors for controlled emissions would require additional parameters such as type, age, efficiency and the number of hours of operation of pollution control devices. These parameters, however, remain unavailable at the present time.

#### 3.6.1.3 Production Process and Pollutants Generated

Cement manufacturing plants employ three (3) basic types of production processes: wet, semi-dry with pre-calciner, and dry with pre-heater. The process type adopted by each establishment dictates the emission factors used in the estimation of the volume of pollution caused by its activity. See Figure 3.6.1 for the process flow.



Note:  
 \* Pollutant estimated in this study,  
 physical and monetary

FIGURE 3.6.1 DRY PROCESS FLOW

In the dry process, the raw materials from the storage bins are properly proportioned using automatic weigh feeders and are fed into the raw mill for mixing and grinding. The mixture, called raw material mix, is then conveyed into the silo for homogenization. The homogenized material mix is fed into the pre-heater using the heat emitted from the kiln. The raw material mix contains 60-70 percent limestone, 19-28 percent silica, 3-8 percent alumina, 0.3-6 percent iron oxide and 0.3-1 percent alkali materials.

The wet process is essentially similar to the dry process except for the difference in the proportioning and in the grinding process. In the initial grinding process, water is added. This produces a final homogenous mixture called slurry, which then undergoes the same steps of burning, cooling, addition of gypsum, and storage as in the dry process. In the wet process, proportioning can take place before or after the grinding stage. Another very important difference between the two processes is that the dry process is more cost effective. Less heat is required for moisture removal for the dry process due to its lesser moisture content and the use of a pre heater system. The pre-heated materials are then fed into the kiln for calcining and burned to a temperature of about 1,300°C to 1,500°C. Calcium carbonate ( $\text{CaCO}_3$ ) is then transformed to lime and blends with sulfur, alumina, silica and other oxides to produce clinker which is made up of tricalcium silicate ( $3\text{CaOSiO}_2$ ), dicalcium silicate ( $2\text{CaOSiO}_2$ ) and tricalcium aluminate ( $3\text{CaOAl}_2\text{O}_3$ ). The clinker is then mixed with gypsum and fed into the finish mill to produce cement.

The cement is stored in silos and further withdrawn by an air slide conveyor going to the centrifugal bucket elevator and screw-dropped into the storage bin and fed to the packing machine.

The cement manufacturing industry is one of the most pollutive industries in terms of PM emissions. This is due primarily to the dusty nature of its non-metallic mineral raw materials and its products as well as the combustion of coal during cement production. In fact, dust emissions are produced in practically all stages of production of clinker and cement, with the exception perhaps of the wet stages. The calcining process in the rotary kiln is the largest source of PM. Kiln emissions come from the burning of coal and the furnace at the lower end of the kiln and particles lifted by the hot gasses passing through the kiln. The advanced age and corresponding inefficiency of cement plants, the high cost of installing environmental protection equipment, and the poor maintenance of these equipment's, likewise contribute to this condition.

With regards to coal, only one out of the 18 cement firms operating in 1988 used fuel other than coal in their production process. The cement manufacturing industry, in fact, accounted for almost 40 percent of the country's total coal consumption at the time.

Aside from PM, cement plants also produce substantial amounts of  $\text{SO}_x$ ,  $\text{NO}_x$ , VOC, CO and carbon dioxide ( $\text{CO}_2$ ). Most of these pollutants are coal-related and released during the heating of the kilns.

### **3.6.2. SOURCES AND METHODS**

#### **3.6.2.1 Data Sources**

The sources of data for the study were administrative reports and special studies from different institutions. Process rates of cement and clinker production were taken from Philippine Cement Manufacturers Corporation (PHILCEMCO). Plant classifications by process type were lifted from the study of Onoda Engineering and Consulting Co. (1991).

Other sources of data were the ASE, CE, CPI of the NSO, and the National Accounts of the Philippines of the NSCB.

### 3.6.2.2 Estimation Methodology

#### 3.6.2.2.1 Physical Estimation

Instead of using the volume of production of cement as basis for the process rate, production data for clinker in MT, was used (refer to Appendix Table 3.6.1). This is to standardize the process rates, as there are several types of cement products that contain other raw materials in different proportions. In addition, the available emission factors from the USEPA and WHO are expressed in terms of clinker production. Table 3.6.1 shows the various emission factors of the different processes of production.

The 19 cement plants are classified by the type of process employed, i.e., wet, semi-dry, dry with pre-calciner and dry with pre-heater. However, due to the absence of data, the same emission factor was used for semi-dry and wet process cement plants and for the dry processes, with pre-calciner and pre-heater.

**TABLE 3.6.1 CLINKER PM EMISSION FACTORS IN KILOGRAMS PER METRIC TON OF CLINKER, BY SOURCE OF EMISSION AND TYPE OF PROCESS**

Emission Source	Process Type			
	Wet	Semi-dry	Dry with pre-calciner	Dry with pre-heater
Uncontrolled Kiln	65.00		130.00	
Clinker Cooler	4.60		4.60	
Open clinker storage	5.40		5.40	
Finish grinding	10.60		10.60	
Cement Packaging	2.20		2.20	
Primary and Secondary Crushing	4.20		4.20	
Coal crushing and conveying	5.46		5.46	
Coal storage	5.58		5.58	
<b>TOTAL</b>	<b>103.04</b>		<b>168.04</b>	

Source: USEPA and WHO

The PM factors were classified according to the stage of production, with further classification for the kiln according to process type. To compute for the emission, the process rate (clinker) was multiplied by the applicable emission factor per stage of production. For firms that do not have pollution control devices, uncontrolled emission factors were applied, while for firms that have pollution control devices, controlled emission factors were used. Furthermore, efficiency levels of the control technology, if available, were likewise applied to pollution loads of these plants. The formula for the physical estimation of pollution is:

$$PM_{pty} \text{ Emission} = (\sum_{ems} \text{Emission Factor}_{ems/pty}) \times (\text{Clinker production}_{pty})$$

where:

$$PM_{pty} \text{ Emission} = \text{PM emissions by process type}$$

$$pty = \text{Process type: wet (w), semi-dry (sd), dry with pre-calciner (d1) and dry with preheater (d2)}$$

Emission Factor<sub>ems /pty</sub> = Emission factor for each emission source for each process type

ems = Emission source: uncontrolled kiln, clinker cooler, open clinker storage, finish grinding, primary and secondary crushing, coal crushing and conveying and coal storage

Clinker production<sub>pty</sub> = Production of clinker by process type

### 3.6.2.2.2 Monetary Estimation

Upon estimation of the emissions, these physical estimates would have to be converted into monetary values (monetary estimates). The DBP Industrial Restructuring Study on Cement has come up with rough estimates of some of the necessary parameters. These include investment costs for pollution control and measuring devices, as well as operating costs.

The annual capital cost of electrostatic precipitator (ESP) is available only in 1988, which was derived from Valuation of Direct Environmental Waste Disposal Services (Orbeta, 1990). The succeeding years were estimated using the growth of IPIN of "other miscellaneous durable equipment". The annual operating and maintenance cost, on the other hand, used the growth of CPI for "all items" to update the prices of ESP (see Appendix Table 3.6.2).

In estimating the environmental degradation cost of cement industry (EDCCI) the sum of the annual capital cost (AnCC<sub>ESP</sub>) and the annual operating and maintenance cost (AOMC<sub>ESP</sub>) of ESP were multiplied by the total PM emission.

$$EDC_{CI} = E_{PM} \times (AnCC_{ESP} + AOMC_{ESP})$$

where:

EDC<sub>CI</sub> = Environmental Degradation Cost of Cement industry (in pesos)  
 AnCC<sub>ESP</sub> = Annualized Capital Cost of Electrostatic Precipitator  
 AOMC<sub>ESP</sub> = Annual Operating and Maintenance Cost of Electrostatic Precipitator  
 E<sub>PM</sub> = Total Emission of PM

## 3.6.3 RESULTS

### 3.6.3.1 Physical Estimates

For 1994, the total emission of PM in the cement industry reached 1.02 million MT. This corresponds to more than 100 percent increase of PM emission in 1988 pegged at 509,394 MT (see Table 3.6.2). Assuming a constant emission factor, the doubling of the volume of PM emission from 1988 to 1994 is a reflection of the increasing trend in cement production during the period under review.

Emissions of cement plants employing dry with pre-heater (d2) process were estimated to be about 65.8 percent of the total PM emissions (see Figure 3.6.2). This was due to the considerable volume of clinker production from this type of cement plant as well as a high cumulative emission factor of 168.04 kg/MT (see Table 3.6.2 and Appendix Table 3.6.1.).

TABLE 3.6.2 CLINKER PRODUCTION AND PM EMISSIONS, BY PROCESS TYPE, IN METRIC TONS, 1988-1994

YEAR	CLINKER PRODUCTION	PROCESS TYPE				
		Total PM Emission	Wet (w)	Semi-dry (sd)	Dry with pre-calciner (d1)	Dry with pre-heater (d2)
No. of Establishments		19	6	3	2	8
1988	3,519,226	509,394	110,244	19,707	36,338	342,104
1989	4,836,805	662,414	173,083	65,276	44,374	379,681
1990	5,168,017	708,581	190,036	63,368	51,752	403,425
1991	5,242,302	718,849	195,942	57,972	50,006	411,929
1992	5,261,726	717,822	204,763	58,954	33,930	420,176
1993	6,217,036	866,353	216,648	66,090	49,624	533,990
1994	7,885,012	1,020,324	303,675	95,703	49,848	571,097

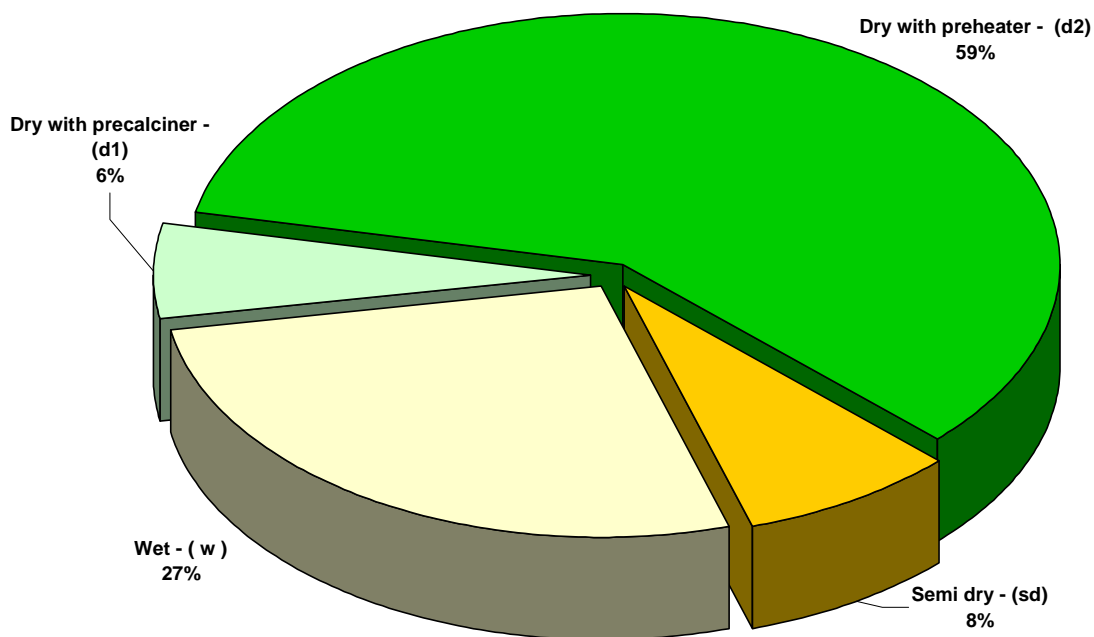


FIGURE 3.6.2 PM EMISSIONS BY PROCESS TYPE, IN METRIC TONS, 1988-1994

### 3.6.3.2 Monetary Estimates

The monetary estimates reveal an alarming trend for environmental degradation by the Cement Manufacturing Industry. Environmental degradation cost for the industry at current prices grew at a staggering 313 percent from 800 million pesos in 1988 to 3,305 million in 1994, or an average annual growth rate of 26.7 percent. Relative to NVA, the share of environmental degradation grew from 43.0 percent in 1988 to 57.7 percent in 1994. For 1993 and 1994, the damage to the environment caused by the industry effectively offset its benefit to the economy by more than half. Because of this increase in the share of environmental degradation cost, EVA for the industry grew at a slower annual rate of 14.8 percent, compared with the annual growth of 20.6 percent for NVA.

It should again be emphasized, however, that due to the lack of data for several parameters, emission factors for uncontrolled emissions were used for these estimates. This assumes that all emissions of the industry are unabated and escape into the environment. A more complete data set can be expected to yield substantially lower levels of pollution for the industry.

**TABLE 3.6.3 ENVIRONMENTALLY ADJUSTED NET VALUE ADDED (EVA), IN THOUSAND PESOS (AT CURRENT PRICES), 1988-1994**

YEAR	GVA [1]	Depreciation [2]	NVA [3]=[1]-[2]	Environmental Degradation Cost (EDC <sub>ci</sub> )			EVA [5] = [3]- [4]
				Total [4]	AnCC	AOMC	
1988	2,186,713	327,950	1,858,763	799,749	738,428	61,321	1,059,014
1989	3,511,691	274,376	3,237,315	1,085,723	996,257	89,466	2,151,592
1990	3,464,779	509,323	2,955,456	1,399,816	1,290,553	109,263	1,555,640
1991	4,782,301	758,879	4,023,422	1,721,744	1,590,223	131,521	2,301,678
1992	4,761,986	892,131	3,869,855	1,777,887	1,634,797	143,091	2,091,968
1993	6,029,086	1,193,284	4,835,802	2,638,158	2,452,325	185,833	2,197,644
1994	7,181,789	1,457,657	5,724,132	3,304,707	3,066,074	238,633	2,419,425

### 3.6.4 RECOMMENDATIONS

Recent publications on global warming listed the cement industry as one of the notorious anthropogenic sources of carbon emissions. It is therefore recommended that this pollutant be included in future estimations. Also, the above calculations were derived from process emission, hence emission due to coal use should be considered. To avoid outright generalization that cement firms are pollutive, the assumption that all of the pollution control devices employed by these firms are inefficient should be verified. To gain a more precise picture of the pollutiveness of cement manufacturing, the PM produced during quarrying and storage of raw materials should be included. Moreover, parameters used must conform to local conditions to present a more credible conclusion.

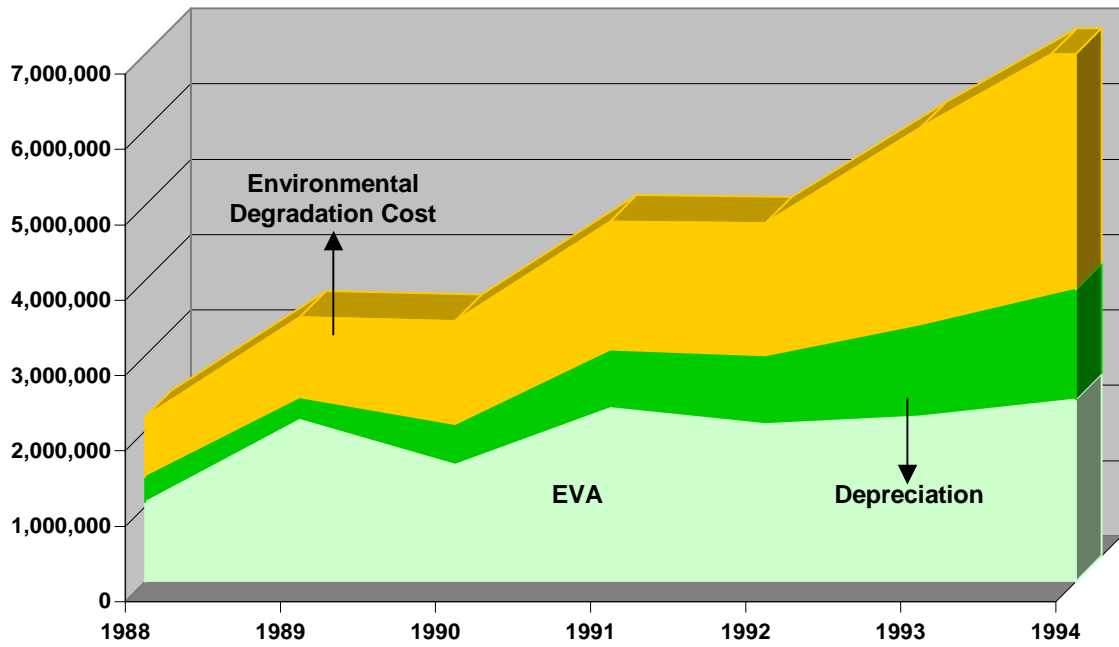


FIGURE 3.6.3 CEMENT MANUFACTURING: EVA, DEPRECIATION, ENVIRONMENTAL COST, IN THOUSAND PESOS (AT CURRENT PRICES), 1988-1994

APPENDIX TABLE 3.6.1

## CLINKER PRODUCTION, BY PROCESS TYPE, IN METRIC TONS, 1988-1994

Process Type	Production						
	1988 <sup>1</sup>	1989 <sup>1</sup>	1990 <sup>1</sup>	1991 <sup>1</sup>	1992	1993	1994
Dry w/ pre-calciner – (d1)	-	-	-	-	-	-	-
Dry w/ pre-heater – (d2)	2,041,802	2,259,471	2,400,766	2,451,373	2,500,452	3,177,755	3,398,579
Semi-dry – (sd)	191,256	633,502	614,983	562,617	572,144	708,070	1,098,709
Wet – (w)	1,286,167	1,943,832	2,152,269	2,228,312	2,189,130	2,331,211	3,073,892
<b>TOTAL</b>	<b>3,519,226</b>	<b>4,836,804</b>	<b>5,168,018</b>	<b>5,242,301</b>	<b>5,261,726</b>	<b>6,217,036</b>	<b>7,571,180</b>

<sup>1</sup> Converted from 40 kg bag volume

Source: Philippine Cement Manufacturers' Corporation (PHILCEMCO)

APPENDIX TABLE 3.6.2

## COST OF POLLUTION CONTROL DEVICES, PESOS PER METRIC TON, 1988-1994

YEAR	Electrostatic Precipitator (ESP)			IPIN - OMDE	CPI - All Items
	Total Cost	AnCC	AOMC		
1988	1,570.00	1,449.62	120.38		
1989	1,639.05	1,503.98	135.07	1.04	1.12
1990	1,975.53	1,821.32	154.21	1.21	1.14
1991	2,395.14	2,212.18	182.96	1.21	1.19
1992	2,476.78	2,277.44	199.34	1.03	1.09
1993	3,045.13	2,830.62	214.51	1.24	1.08
1994	3,238.89	3,004.99	233.90	1.06	1.09

Source:

CE/ASE, NSO

National Accounts, NSCB

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# ***Petroleum Refining***

### 3.7.1 INTRODUCTION

#### 3.7.1.1 Industry Description

The Philippine petroleum refining industry has long been controlled by three (3) major companies, namely: Pilipinas Shell Petroleum Corporation, Caltex Philippines, Inc., and Petron Corporation. Petron and Shell have the capacity to produce light end hydrocarbons to heavier kinds, while Caltex produce only the light ones with their slurry being exported abroad or sold to petrochemical plants. Petroleum refining comes from the principle that different molecular weights have different levels of boiling points, *i.e.* hydrocarbons with low molecular weights begin to vaporize at a temperature less than that required to boil water, whereas higher temperatures are required to distill larger and more complex molecules.

Petroleum refinery products include liquefied petroleum gas (LPG), gasoline, kerosene, aviation fuel, diesel fuel, fuel oils, lubricating oils, feedstock for the petrochemical industry and a thousand others. Its activities start with the receipt of crude for storage at the refinery including all petroleum handling and refining operations and terminate with storage preparatory to shipping the refined products from the refinery.

Crude was mostly imported from Middle East sources accounting for almost 80 percent while the Far East and domestic crude account for the rest. The whole industry employed only 1,742 personnel in 1981 but grew to 2,421 personnel in 1991 (NSO, 1992). The slow increase of employment in this particular industry as compared to others was attributed to the high technicality of the job it requires.

#### 3.7.1.2 Scope and Limitation of the Study

The study deals with air emissions of the production processes of petroleum industry. Volatile organic compound (VOC) emission from storage of crude and refined products in the refinery was not included. Also, water effluents and solid waste were not accounted.

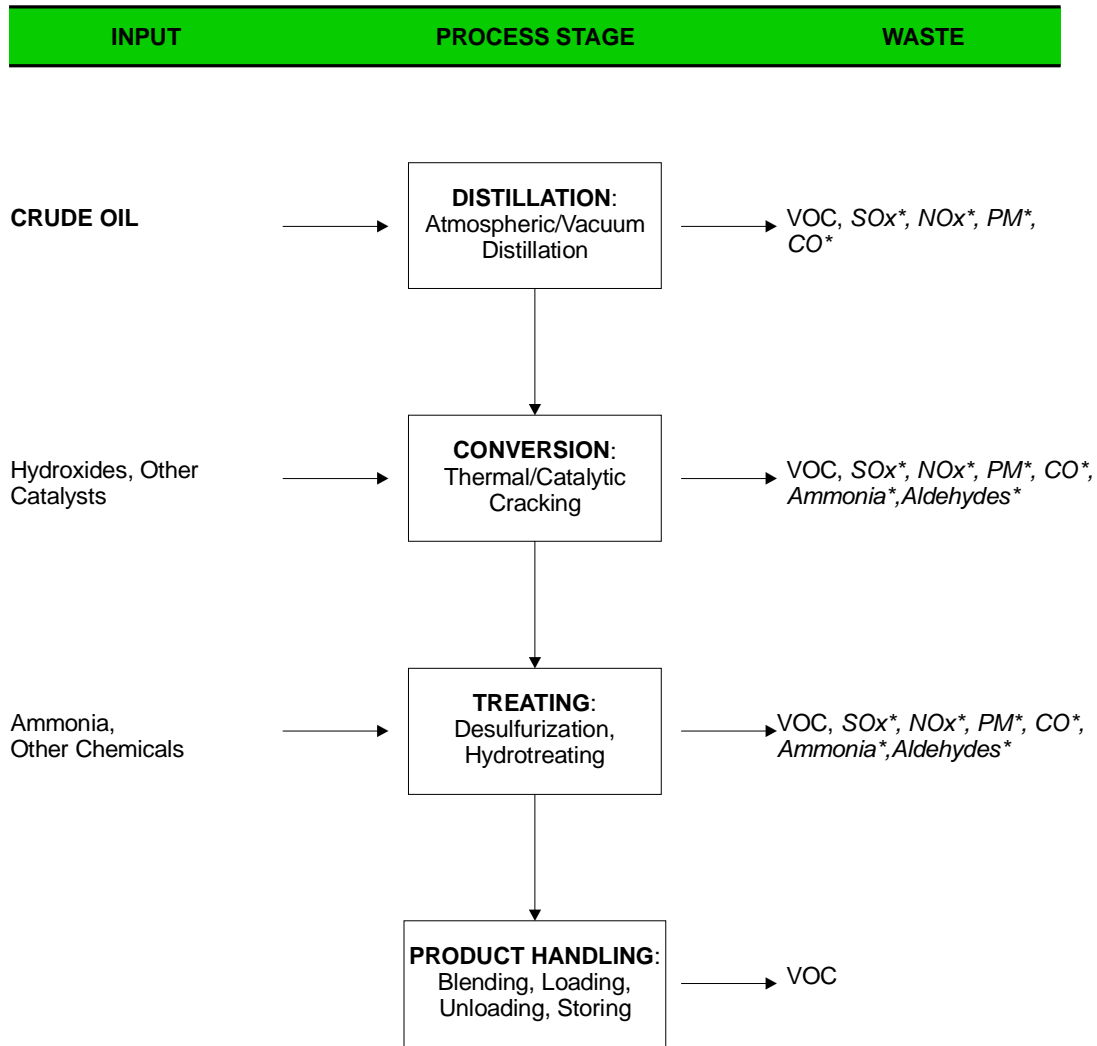
The cost of environmental degradation due to petroleum refinery was confined to the control cost of uncontrolled CO. This was done to avoid double counting. This further assumes that the scrubber has a 90 percent-100 percent efficiency in the removal of CO, PM, SO<sub>x</sub>, Ammonia and Aldehydes.

#### 3.7.1.3 Production Process and Pollutants Generated

The petroleum refining industry employs a wide variety of processes. The kind of crude oil feedstock and the petroleum products that are to be produced determines the refinery's processing flow. The US-EPA (1985) identified the major categories of processes. It involves separation, conversion, petroleum treating, feedstock and product handling and employs wide auxiliary processes to maintain the plant.

In the course of production of the desired petroleum products, pollutants are emitted simultaneously to both air and water. Volatile organic compounds (VOC) and CO are the primary pollutants emitted in the refining of petroleum.

Moreover, US-EPA specifically listed the following refining processes and facilities that are significant air pollutant contributors: vacuum distillation, catalytic cracking, thermal cracking processes, utility boilers, heaters, compressor engines, blowdown systems and sulfur recovery (Figure 3.7.1).



Source:  
Petron, Caltex and Shell

\* Pollutant estimated in this study, physical and monetary

**FIGURE 3.7.1 PETROLEUM REFINING PROCESS FLOW**

The process of petroleum refining involves materials that are highly volatile and extremely reactive. Thus, refineries use specific pollution control devices to contain these emissions. The ports or outlet of the emissions have been identified. These are associated with specific process, and are thus easier to identify. But, aside from the identified ports of possible emissions, there are VOC emission sources that are not associated with specific process but scattered throughout the refinery. These are called “fugitive emissions.” Fugitive emission sources include valves of all types, flanges, seals, process drains, oil/water separators, cooling towers, wastewater treatment plants and some activities that include storage and transfer operations. These emissions are attributed to the evaporation of leaked or spilled petroleum liquids and gas. Normally, good housekeeping and maintenance can control emission of this kind but this could not be totally discounted.

### 3.7.1.4 Assumptions

Due to the absence of data for the types of control equipment, the computation for environmental costs was based on the use of a scrubber as a pollution control device. It is used to control air pollutants such as CO, PM, SOx, NOx, aldehydes and ammonia. Of these, CO registered the highest total process emissions. As a result, in the monetary estimates, AnCC and AOMC of the pollution control device, were based on the uncontrolled emissions of CO. In effect, CO is used as proxy value in computing for the environmental degradation cost.

## 3.7.2 SOURCES AND METHODS

### 3.7.2.1 Data Sources

Production data were obtained from the NSCB and Department of Energy (DOE). Emission factors were based from the United States Environmental Protection Agency (USEPA) as well as the 1993 WHO Rapid Assessment of Sources of Air, Water and Land Pollution.

### 3.7.2.2 Estimation Methodology

#### 3.7.2.2.1 Physical Estimation

The air emissions estimated in this study were based on the emission in fluid catalytic cracking units (FCCU), moving-bed catalytic cracking units (MCCU), vacuum distillation (VC), blowdown systems (BS), fluid coking units (FCKU), vapor recovery and flaring systems (VRFS) only. Other identified ports of emission in the refinery such as storage, filling systems, etc. were not included.

Data on volume of crude input were used as process rate for this study. The data was multiplied by the emission factors to get the estimates of pollution in physical terms. Only emissions to air are estimated in this study.

$$\text{Emissions} = \text{Volume of crude input} \times \text{Emission factor} \quad \text{Eq. 1}$$

To take into account the multiplicity of emission ports generated by petroleum refineries (Table 3.7.1), the formula was enhanced to read as follows:

$$\text{TE} = \text{volume of crude input} \times [\text{EF}_1] + \text{volume of crude input} \times [\text{EF}_2] \dots + \text{volume of crude input} \times [\text{EF}_6]$$

$$= \text{volume of crude input} \times \left[ \sum_{p=1}^6 \text{EF}_p \right] \quad \text{Eq. 2}$$

where:

TE = total emissions generated by the petroleum refinery

p = type of emission port (e.g. Fluid Catalytic Cracking Units, Moving Bed Catalytic Cracking, etc.)

EF = emission factor

**TABLE 3.7.1 EMISSION FACTORS USED TO ESTIMATE THE POLLUTANTS GENERATED BY PETROLEUM REFINERIES (KG/UNIT)**

EMISSION TYPE	EMISSION PORTS					
	FCCU	MCCU	FCKU	BS	VD	VRSF
Particulate Matter (PM)	.695	.049	1.500			
SOx	1.413	1.413				.077
Carbon Monoxide (CO)	39.200	10.800				.012
Hydrocarbons	.630	.250		1.662	.052	.002
NOx	.204	.014				.054
Aldehydes	.054	.034				
Ammonia	.155	.017				

Note:

- FCCU: Fluid Catalytic Cracking Units
- MCCU: Moving Bed Catalytic Cracking Units
- FCKU: Fluid Coking Units
- BS: Blowdown System
- VD: Vacuum
- VRSF: Vapor Recovery System and Flaring

Source: US-EPA, Compilation of Air Pollution Emission Factors, Vol.1: Stationary Points and Area Sources, 1985

### 3.7.2.2.2 Monetary Estimation

The cost of using a scrubber was utilized to calculate the environmental degradation cost due to petroleum refining. This control device is used to control CO, PM, SOx, NOx, aldehydes and ammonia in the form of particulates, i.e. unburned, gaseous particles, etc. Although there are different control technologies for these different pollutants, the scrubber was employed as the pollution control device for petroleum refining due to data considerations.

For costing purposes, only the uncontrolled emissions were considered. Uncontrolled emissions were derived from the total emissions by adjusting for the 94 percent efficiency<sup>1</sup> of the industry, that is:

<sup>1</sup> GHG (Greenpeace International, 1993)

$$\begin{aligned}
 \text{Uncontrolled emissions} &= \text{Emissions} \times (1 - \text{Efficiency rate}) \\
 &= \text{Emissions} \times (1 - 0.94) \\
 &= \text{Emissions} \times (0.06)
 \end{aligned}
 \tag{Eq. 3}$$

In estimating the value of uncontrolled emissions generated by the refineries, the sum of the AnCC and AOMC of a scrubber, was multiplied to the uncontrolled emissions of CO, that is:

$$\begin{aligned}
 &\text{Environmental degradation cost in Pesos per MT of pollutant} \\
 &= \text{Uncontrolled CO Emissions in MT} \times (\text{AnCC}_{\text{Scrubber}} + \text{AOMC}_{\text{Scrubber}})
 \end{aligned}
 \tag{Eq. 4}$$

VOC was not included in the monetary estimates due to data gaps. The data on cost of its control technology, the vapor recovery system, are not available. Moreover, some experts argued that this particular pollutant could be harnessed back to the system for reuse. The refinery plant will just have to modify its production for maximum efficiency to reduce VOC emission.

In the calculation of the AnCC, the total cost of the scrubber was employed. Since the scrubber is utilized to control all six of air pollutants mentioned, the volume of one of the pollutants will suffice in the calculation for the environmental degradation costs. The resulting value will serve as a proxy value for the environmental degradation cost. In the physical estimates, CO registered a significantly high process emission value; thus, it was the one used in the monetary estimation.

### 3.7.3 RESULTS

#### 3.7.3.1 Physical estimates

As gleaned from Table 3.7.2, CO had the highest emissions among the pollutants covered in this study. This is because petroleum contains 80-85 percent carbon and was released in quantities generally proportional to the carbon content of the crude oil. More than half a million metric tons of CO, either free or oxidized to form carbon dioxide, was released annually from 1988-1994. The second most dominant pollutant is sulfur oxide. During the period of review, the average annual SOx emissions were about 36,000 metric tons. Other pollutants accounted for emissions were hydrocarbon, particulate matter, nitrous oxides, aldehydes and ammonia.

**TABLE 3.7.2 CRUDE RUN (IN '000 LITERS) AND TOTAL PROCESS EMISSIONS (IN MT) OF PETROLEUM INDUSTRY, BY TYPE OF AIR POLLUTANTS, 1988-1994**

YEAR	CRUDE RUN	PM	SO <sub>x</sub>	CO	HYDRO-CARBONS	NO <sub>x</sub>	ALDE-HYDES	AMMONIA
1988	10,773,121	24,175	31,274	538,785	27,967	2,930	948	1,853
1989	11,351,967	25,474	32,955	567,735	29,470	3,088	999	1,953
1990	12,887,237	28,919	37,412	644,517	33,455	3,505	1,134	2,217
1991	12,317,929	27,641	35,759	616,044	31,977	3,350	1,084	2,119
1992	13,787,541	30,939	40,025	689,543	35,792	3,750	1,213	2,371
1993	13,644,776	30,619	39,611	682,403	35,422	3,711	1,201	2,347
1994	13,954,152	31,313	40,509	697,875	36,225	3,796	1,228	2,400

Source - DOE: Crude run data in barrels was converted to crude run in liters using conversion rate: 1 barrel = 158.9 liters

#### 3.7.3.2 Monetary estimates

Total environmental cost was estimated at P 88.6 million in 1988. This amount increased yearly with an annual average of 18 percent, reaching P 236.7 million by 1994 (Table 3.7.3). The increase in environmental cost was largely due to the increasing levels of production for the same period.

**TABLE 3.7.3 ENVIRONMENTALLY ADJUSTED NET VALUE ADDED (EVA) PETROLEUM INDUSTRY, IN THOUSAND PESOS (AT CURRENT PRICES), 1988-1994**

YEAR	GVA [1]	Depreciation [2]	NVA [3] = [1] - [2]	Environmental Cost (Scrubber) <sup>1</sup>			EVA [5] = [3] - [4]
				Total [4]	AnCC	AOMC	
1988	19,319,000	655,384	18,663,616	88,599	81,160	7,439	18,575,017
1989	16,182,000	596,810	15,585,190	97,523	88,727	8,795	15,487,667
1990	26,089,895	857,365	25,232,530	133,380	121,981	11,399	25,099,150
1991	37,429,109	2,162,032	35,267,077	154,543	141,614	12,929	35,112,534
1992	35,510,054	2,055,032	33,454,200	178,953	163,186	15,767	33,275,247
1993	33,857,845	2,070,870	31,786,975	217,512	200,721	16,791	31,559,463
1994	34,505,551	2,164,276	32,341,275	236,642	217,920	18,722	32,104,633

Note:

AnCC: Annualized Capital Cost

AOMC: Annualized Operating and Management Cost

<sup>1</sup> Refer to Appendix 3.7.1 for details

Source:

ASE, NSO

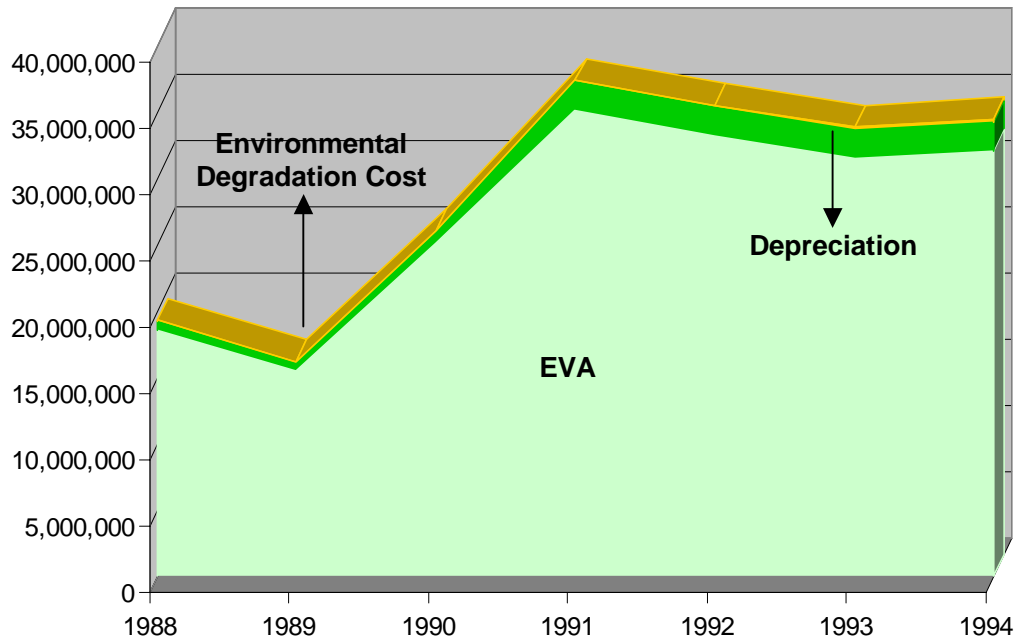
National Accounts, NSCB

### 3.7.3.3 Environmentally Adjusted Net Value Added (EVA)

Annual average growth of the industry from 1988 to 1994 was reported to be 13 percent (Figure 3.7.2). Meanwhile, the share of degradation cost to the net value added was lowest at 0.44 percent in 1991 while the highest was 0.73 percent in 1994.

### 3.7.4 RECOMMENDATION

As a pioneering study on the environmental aspect of the petroleum industry, there are numerous parameters and variables that need to be updated to present a more accurate report. The US-EPA identified a lot of possible ports of emission in the refinery that this study did not account for. The WHO report also identified several industry activities in the International Standard Industry Classification (ISIC) that should be included as part of refinery activities, i.e. wholesale distribution, wholesale storage, etc. Moreover, the parameters on emission and effluent factors should also be localized so as to fit existing local conditions. Data on pollution control devices and their respective efficiencies should also be validated regularly to produce an exact valuation of environmental cost of the industry.



**FIGURE 3.7.2** PEROLEUM REFINING INDUSTRY: EVA, DEPRECIATION AND ENVIRONMENTAL COST, IN THOUSAND PESOS (AT CURRENT PRICES), 1988-1994

APPENDIX 3.7.1

COST OF SCRUBBER AS A POLLUTION CONTROL DEVICE (PESOS/MT), 1988-1994

YEAR	SCRUBBER			IPIN - OMDE (1+g)	CPI - All Items (1+g)
	Total Cost	AnCC	AOMC		
1988	2,741	2,511	230		
1989	2,863	2,605	258	1.0375	1.122
1990	3,449	3,154	295	1.211	1.1417
1991	4,181	3,831	350	1.2146	1.1866
1992	4,325	3,944	381	1.0295	1.0895
1993	5,312	4,902	410	1.2429	1.0761
1994	5,651	5,204	447	1.0616	1.0903

Source:

Estimation of Direct Environmental Waste Disposal Services (Orbeta, 1995)  
National Accounts, NSCB  
ASE, NSO

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