Status of Mercury in Mexico
First Draft (June 2000)

This report was prepared by the National Institute of Ecology (*Instituto Nacional de Ecología*—INE), a deconcentrated body of the Ministry of the Environment, Natural Resources and Fisheries (*Secretaría de Medio Ambiente, Recursos Naturales y Pesca*—Semarnap).

The purpose of this report is to analyse the extraction, use, shipping and final disposal of waste contaminated with mercury throughout Mexico, so as to assess the quantities of this metal in circulation, and the emissions and discharges of this metal occurring on the country's territory. The report also considers the risks to the general public, and especially those segments most exposed to mercury; i.e., those that live in proximity to the largest emission sources or carry on work activities that involve the use of mercury.

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Abbreviations

ADM	Mexican Dental Association
ANIQ	National Chemical Industry Association
Bancomext	National External Trade Bank
BOD	Biochemical Oxygen Demand
Canacem	National Cement Industry Association
Canacintra	National Processing Industry Association
CEC	North American Commission for Environmental Cooperation
Cemex	Cementos Mexicanos
Cenica	National Environmental Information and Training Centre
CFE	Federal Electricity Commission
Cinvestav	IPN Centre for Advanced Research and Study
CNA	National Water Commission
COA	Annual Certificate of Operation
Conae	National Energy Efficiency Commission
Coremi	Council of Mineral Resources
CRETIB	Corrosive, Reactive, Explosive, Toxic, Ignitable or Biological/Infectious
Dgmryar	High-Risk Materials, Wastes and Activities Branch
DIF	Mexican Family Development Program
DMT	Toxic Materials Directorate
EPA	U.S. Environmental Protection Agency
GIS	Geographical Information System
IMSS	Mexican Institute of Social Security
INE	National Institute of Ecology
INEGI	National Institute of Statistics, Geography and Informatics
ISSSTE	Institute of Social Security and Social Services for Public Employees
LAU	Comprehensive Environmental License
LGEEPA	General Law on Ecological Balance and Environmental Protection
MBAS	Methylene blue active substances
MT	Metric ton
NAAEC	North American Agreement on Environmental Cooperation
NAFTA	North American Free Trade Agreement
NARAP	North American Regional Action Plan
NOM	Mexican Official Standard
OECD	Organization for Economic Cooperation and Development
Pemex	Petróleos Mexicanos
Profepa	Office of the Federal Attorney for Environmental Protection
PRTR	Pollutant Release and Transfer Registry
PUMA	University Environment Program
Sagar	Ministry of Agriculture, Animal Husbandry and Rural Development
SCT	Ministry of Communications and Transportation
Secofi	Ministry of Trade and Industrial Development
Sedena	Ministry of National Defense
Sedesol	Ministry of Social Development
Sedue	Ministry of Urban Development and Ecology

NOTE: *The data and quantities presented in this draft have been obtained from official and unofficial sources, both national and international. This data is under review to determine whether more accurate data is required.*

Semarnap	Ministry of the Environment, Natural Resources and Fisheries
SNIA	National Environmental Information System
Ssa	Ministry of Health
STPS	Ministry of Labour and Social Welfare
TSS	Total Suspended Solids

__NOTE:__ The data and quantities presented in this draft have been obtained from official and unofficial sources, both national and international. This data is under review to determine whether more accurate data is required.

1 Status and Trends

1.1. Emissions Inventory

1.1.1. Inventory of Toxics in Mexico

Industrial Emissions

The Pollutant Release and Transfer Registry (PRTR) is a component of the National Environmental Information System (*Sistema Nacional de Información Ambiental*—SNIA) bringing together information on air, water and soil pollution by means of relational databases, geographic information system (GIS) tools and estimation methods for air emissions, wastewater discharges and hazardous waste generation. Thanks to this inventory, it is possible to ascertain emissions and transfers of 105 pollutants in the country's various industrial sectors. So far, mercury emissions have not been included, since the final phase of training for companies in this pollutant is in progress, as is the establishment of the legal requirement to report these emissions (INE-Semarnap, 1999).

Air Emissions in Large Cities

In Mexico, there exists an air emissions inventory comprising 14 cities (Aguascalientes, Cananea, Coatzacoalcos, Federal District, Guadalajara, Ciudad Juárez, Manzanillo, Mexicali, Monterrey, Nacozari, Querétaro, San Luis Potosí, Tijuana and Toluca). The seven pollutants monitored and regulated are: ozone (O_3), inhalable particles (PM10), nitrogen dioxide (NO_2), sulfur dioxide (SO_2), carbon monoxide (CO), total suspended particles (TSP) and lead (Pb).

Mercury is not yet regulated, and so is not monitored. The National Institute of Ecology (*Instituto Nacional de Ecología*—INE), through its National Centre for Environmental Research and Training (*Centro Nacional de Investigación y Capacitación Ambiental*), has undertaken activities to develop mercury measurement capacity.

Incineration Emissions

A draft Mexican Official Standard (NOM-098-ECOL/99), in process of approval, will govern and determine the requirements and specifications for the adequate operation of incinerators as well as the maximum allowable air emissions and wastewater discharges and the management of solid waste produced by the incineration of municipal solid waste, hazardous waste, non-hazardous industrial waste and biological/infectious waste, with a view to reducing the risks they represent for health and the environment.

This standard sets the maximal allowable limit at 0.07 mg/m^3 for mercury emissions. Measurements must be taken every four months and the sampling time is one hour with an average of 3 samples over an 8-hour period. The data now being generated has not yet been systematized.

1.2. Environmental Monitoring

The National Water Commission (*Comisión Nacional del Agua*—CNA), an agency of the Semarnap, conducts systematic observation of the country's water quality through its National Water Quality Monitoring Network (*Red Nacional de Monitoreo de la Calidad del Agua*—RNM). The RNM has been in operation since 1974, the year that the first periodic monitoring program for national water quality was applied in 14 regions or work zones, each with its own laboratory, with a total of 239 sampling stations. The program expanded, by 1998, to involve 3,345 samples and a total of 101,576 analyses, with the number of stations increasing to 743. In 1999, 3,365 samples were taken and 102,179 analyses were performed.

The data generated by the CNA includes pH, hardness, alkalinity, total suspended solids (TSS), methylene blue active substances (MBAS) and biochemical oxygen demand (BOD). For mercury, in 1991, the Cuautitlán River in the State of Mexico and the Grand Canal in the Federal District exceeded the limit, with 0.3 and 0.2 mg/l, respectively. It should be noted that these rivers receive discharges from the metropolitan industrial zone. Between 1994 and 1998, the CNA did not report any river exceeding the standard.

Table 1.1. Legal framework applicable to work of Cinvestav (Hg mg/l).

Ecological water quality criteria CE-CCA-001/89. Hg = 0.001 mg/l
Technical Ecological Standard NTE-CRP-001/88 on hazardous waste (sediments). Hg = 0.2 mg/l
NOM-127-SSA1-1994 Potable water (surface water). Hg = 0.001 mg/l

Source: Cinvestav. 1994. *Evaluation of possible health effects.* Ministry of Social Development (*Secretaría de Desarrollo Social*—Sedesol), INE.

The Centre for Advanced Research and Study (*Centro de Investigación y Estudios Avanzados*—Cinvestav) of the National Polytechnic Institute (*Instituto Politécnico Nacional*—IPN), with INE funding, performed a study of four rivers over the period 1984–1994, which provided a relatively large amount of sampling data on various rivers and bodies of water, although the analytical methodology employed is unknown and the data is spatiotemporally diverse. In addition, since it is difficult to conduct a complete seasonal study with an appropriate sequence of all the rivers and bodies of water on the nation's territory, the study was unable to produce a characterization of the status of mercury. Moreover, although there is some similarity among the studies, the objectives and conditions are not the same, so it is very difficult to make comparisons, or to extrapolate and interpolate data. In general terms, it was observed that approximately 60% of the analyses exceeded the mercury standard very slightly (between 0.001 and 0.0017 mg/l); however, approximately 5% of the samples produced significantly high values, which could indeed cause severe harm to human health. The maximum allowable limits applicable at the time of the study were used as a benchmark (see previous table). The following are the highest values observed in surface water in three of the four rivers:

- In the San Juan River, the mercury limit was exceeded at 9 (32%) of the 28 sampling stations; the mercury concentration exceeded the standard 11 times, with a maximum recorded mercury value of 0.0011 mg/l (Cinvestav, 1994).

- In the Lerma-Chapala-Santiago system, the standard was exceeded at 6 (33%) of 18 stations; the mercury concentration exceeded the limit twice, and a maximum value of 0.0021 mg/l was recorded (Cinvestav, 1994).

- In the Coatzacoalcos River, the limit was exceeded at 3 (14%) of 22 sampling stations, and the mercury concentration exceeded the limit 380 times, with a maximum value of 0.38 mg/l recorded at the Pajaritos lagoon station (Cinvestav, 1994).

1.3. Trends

Mercury-containing minerals are found in 21 Mexican states (Aguascalientes, Chihuahua, Coahuila, Colima, Mexico, Durango, Guanajuato, Guerrero, Hidalgo, Jalisco, Michoacán, Morelos, Nayarit, Puebla, Querétaro, San Luis Potosí, Sinaloa, Sonora, Tamaulipas, Veracruz and Zacatecas), in the northern and central parts of the country. A 1994 report of the National Institute of Statistics, Geography and Informatics (*Instituto Nacional de Estadística, Geografía e Informática*—INEGI) on the history of mercury production mentions that this activity has been taking place since 1891. From 1920 to 1929, production was minimal, but it increased from that date on, reaching 1,118 tons in 1942. The declining price for this element on world markets has depressed production, with world production dropping from 6,100 MT in 1990 to 2,200 MT in 1994. In the latter year, Mexico contributed a mere 0.5% (11 tons). Between 1995 and 1999, no primary production was officially recorded for Mexico (*Anuario Estadístico de la Minería Mexicana* [Statistical Yearbook of Mexican Mining], 1999).

1.3.1. Patterns of Production

The Council of Mineral Resources (*Consejo de Recursos Minerales*—Coremi), in its state-by-state geological and mining monographs, states that of the total of 4,705 mines inventoried, 83 produce mercury. They are located in 8 states (Chihuahua, Durango, Mexico, Guanajuato, Guerrero, Querétaro, San Luis Potosí and Zacatecas). Of these, 66 report that they produce only mercury, while 17 produce mercury and one or more other minerals (Table 1.2). No study has yet been done on the status of each of these mines, since none has declared production to the Ministry of Trade and Industrial Development (*Secretaría de Comercio y Fomento Industrial*—Secofi) in the last 5 years (Table 1.3). However, it is possible that they are still being operated on a small-scale basis in order to produce mercury for the informal market.

Table 1.2. Mercury mines in Mexico

NOTE: *The data and quantities presented in this draft have been obtained from official and unofficial sources, both national and international. This data is under review to determine whether more accurate data is required.*

State	Mines producing only Hg	Mines producing Hg and other metals	Total
Chihuahua	6	1	7
Durango	6	9	15
Mexico	2		2
Guanajuato	1		1
Guerrero	1	3	4
Querétaro	14	3	17
San Luis Potosí	18		18
Zacatecas	18	1	19
Total	66	17	83

Source: Council of Mineral Resources. Geology/Mining Monographs for the states of: Chihuahua, 1994; Coahuila, 1993; Colima, 1994; Durango, 1993; Mexico, 1996; Guanajuato, 1992, Guerrero, 1999; Hidalgo, 1992; Jalisco, 1992, Michoacán, 1995; Nayarit, 1994; Oaxaca, 1996; Puebla, 1995; Querétaro, 1992; San Luis Potosí, 1992; Sinaloa, 1991; Sonora, 1992; Veracruz, 1994; Zacatecas, 1991.

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1.3.1.1. Primary Production

Table 1.3. Primary mercury production, 1985–98

Year	Production (tons)
1985	394
1986	185
1987	124
1988	345
1989	651
1990	735
1991	340
1992	21
1993	12
1994	11
1995	0
1996	0
1997	0
1998	0
1999	ND

Source: *Anuario Estadístico de la Minería Mexicana*, 1998. 1999 edition. Council of Mineral Resources. Bancomext, SNC, 1998.

1.3.1.2. Secondary Production

In Mexico, secondary mercury production occurs through reprocessing of old mine tailings at several former metal processing plants in Zacatecas, Guanajuato and San Luis Potosí, where the amalgamation patio system was used to obtain silver and gold. Today, a leaching system is used to recover silver, mercury and gold from the tailings, with gold present in smaller quantities. In Zacatecas, there are four registered plants (Table 1.4) where, in 1996 alone, 30–33 tons of mercury were produced, according to the Office of the Federal Attorney for Environmental Protection (*Procuraduría Federal de Protección al Ambiente*—Profepa). Also in Zacatecas, mercury has been found in the sediment of the Pedernalillo lagoon, a result of tailings contamination.

Table 1.4. Tailings processing plants in Zacatecas

Name	Products	Sub-products
Jales de Zacatecas, S.A. de C.V.	Silver precipitation: 600–900 kg/month	Mercury 350 kg/month
Beneficiadora de Jales de Zacatecas, S.A. de C.V.	Gold and silver precipitation: 1 ton/month	Mercury 1,207 kg/month
Jales del Centro, S.A. de C.V.	Gold and silver precipitation: 2 ton/month	Mercury 690 kg/month

Mercurio del Bordo, S.A. de C.V.	Gold and silver precipitation: 0.5 ton/month	Mercury 518 kg/month

Source: Office of the Deputy Attorney for Environmental Auditing, Profepa. July, 1996. *Directorio de la Minería Mexicana*, 1999.

In a preliminary study by the Universidad Nacional Autónoma de México (UNAM), similar data were obtained in 1999 for two of the companies listed in Table 1.4, and therefore it is believed that production has been maintained at the same level up to the present year.

1.3.2. National Consumption

In Mexico, the majority of mercury consumption, generally of secondary origin, is related to the manufacturing of chlorine, light bulbs, amalgams and instruments. Mercury consumption in Mexico in 1996 was 30–33 tons.

There is unquantified small-scale production corresponding to mercury consumption for non-essential uses (see Sections 1.3.3.6, Small-Scale Uses, and 1.3.3.7, Cultural and Religious Uses).

1.3.2.1. Import and Export

Except for 1998, in recent years Mexico has not needed to purchase mercury in large quantities abroad. According to the Catalogue of Exporting and Importing Companies (Secofi-Bancomext), in 1998, 6 companies purchased 13.7 tons of mercury abroad, among them two fluorescent bulb manufacturers and one restorative dentistry company. In recent years (1994–98), a total of about 12 tons of mercury was exported, including 7 in 1997 (Table 1.5.).

Table 1.5. Mercury imports and exports, 1985–98

Year	Imports (ton)	Exports (ton)
1985	7	92
1986	0	154
1987	0	121
1988	0.4	142
1989	276.1	91
1990	0.4	23.2
1991	2.15	0.3
1992	101.9	1.9
1993	40.5	0.3
1994	27.8	0.3
1995	5.78	0.3
1996	0.85	4
1997	0.87	7.0
1998	13.74	0.24

Source: *Anuario Estadístico de la Minería Mexicana*, 1998.

1999 edition. Council of Mineral Resources. Bancomext, SNC, 1998.

1.3.3. Patterns of Use

Note: In the absence of emissions estimation methodologies developed specifically for Mexico, the results of the calculations in this section were obtained from emission factors of the EPA (Environmental Protection Agency, 1997. *Locating and Estimating Air Emissions from Sources of Mercury and Mercury Compounds*), as well as Parcom-Atmos (*Parcom-Atmos Emission Factors Manual*, The Netherlands, 1992). These results should be viewed with caution (Appendix 3) since, among other things, Mexico's technological and climatic context is different, and as for the mining industry, the mercury content in the extracted minerals has not been analyzed. Regarding consumption data, these were estimated from official statistics and data provided by the various industries. The difference between emissions and consumption resides in the fact that the emissions go to the atmosphere, while the exact endpoint of the mercury consumed is not known (water, air, soil and whether the products are transformed or stay in the same form). The results are presented individually in sections by economic sector and service, as well as globally in the figures in Appendices 1 and 2 on consumption and emissions, respectively.

1.3.3.1. Chlorine and Caustic Soda Plants

The company Industria Mexicana de Cloro-Alcali (IMCA) currently produces 447,000 MT of chlorine per year, of which 147,000 (33% of national production) is produced using the mercury cathode process. The last plant of this type was commissioned in 1967 and there are no plans to build any new plants using this technology. It is important to note that the mercury used in these plants is primarily of secondary origin, from tailings recycling plants.

Table 1.6. Mexican mercury cell-based chlorine and caustic soda industry

Year	Chlorine production (ton/year)	Mercury used (tons Hg/year)
1995	121,846	5.258
1996	131,211	5.174
1997	134,786	5.403
1998	141,446	5.658
1999	133,352	5.767
Total	662,641	27.26

Source: National Chemical Industry Association (ANIQ), AC, 2000.

The waste generated by the brine treatment process consists of sludge mainly composed of calcium and magnesium (hydroxides and sulfides) with traces of mercury (< 0.001 mg/l discharge). The sludge, once filtered and partially dehydrated, is sent for controlled disposal in accordance with the applicable regulations.

NOTE: The data and quantities presented in this draft have been obtained from official and unofficial sources, both national and international. This data is under review to determine whether more accurate data is required.

As regards the program proposed by the Chlorine Institute in 1995 to phase down the use of mercury cells by 50% by 2005, IMCA is in a position to adopt it, but with 2001 as a baseline year, so that the goal would be attained in 2011.

For additional information, Appendix 4 presents a table provided by the National Chemical Industry Association (*Asociación Nacional de la Industria Química*—ANIQ) comparing Mexico with North America and Western Europe as regards mercury-cell chlorine production.

Consumption calculation:

Annual installed production capacity = 147,000 ton
Emission factor = 41.2 g/ton depending on mercury purchases (average).
Total emissions for 1998 = 5.658 ton (Appendix 1).

1.3.3.2. Thermometers and Sphygmomanometers

Mercury is used in various types of thermometers in the health-care sector, laboratories, industry and other sectors, with an approximate content of 1 g mercury per item. According to official statistics, the country has a total of 160,017 beds in the various public and private hospitals. Assuming one thermometer per bed and one out of four broken per week, a total of 40,000 thermometers are replaced per week, which, multiplied by 52 weeks, gives a total of 2,080,000. Adding the 160,000 initial ones, the total number of thermometers used in one year is 2,240,000, and the total mercury content is 2,240 kg/year.

Consumption calculation:

For sphygmomanometers, whose average mercury content is 6 g, if there is one for every four beds, then the total number is 40,000, which require maintenance four times per year. In this cleaning process, an average of 1 g is lost, representing consumption of 160 kg/year (Appendix 1).

Summing these two values yields total national hospital consumption of 2,400 kg per year (Appendix 1).

1.3.3.3. Dental Offices

According to official statistics, there are 10,781 dentists (Table 1.7), of whom, according to a Mexican Dental Association (*Asociación Dental Mexicana*) survey, 70% are still using the mortar and pestle technique. This practice generates approximately 200g/year of mercury per professional. The remaining 30% use pre-encapsulated amalgam.

Table 1.7. Hospital and dental services in Mexico

Institution	State	Hospital	Beds	Dental offices	Dentists

(IMSS)	Federal District	-----	27,616 *[3]	132 *[1]	1,834 Total *[2]
	States	-----	7,683 *[3]	691 *[1]	-----
(ISSSTE)	Federal District	99 Total +	4,154 +	108 +	946 Total *[2]
	States		9,358 +	324 +	-----
(Ssa) Health Centres,	Federal District	-----	2,012 *[2]	185 *[2]	356 *[2]
All 3rd level centres	States	-----	54,036*[2]	2,009 *[2]	2,084 *[2]
Private	Federal District	228 *[2]	7,191 *[3]	79 *[2]	4,613 Total *[2]
	States	1944 *[2]	34,456 *[3]	359 *[2]	-----
State,	Federal District	-----	4,255 *[3]	-----	928 Total *[2]
Pemex, Sedena, Marine, DIF	States	-----	7,340 *[3]	-----	-----
Red Cross	Federal District	1	85 *[3]	-----	20 *[2]
	States	-----	1,831 *[3]	-----	
Total		**2,271**	**45,313** **114,704** **160,017**	**3,887**	**10,781**

*[1] Administrative Branch; Construction, Maintenance and Equipment Directorate; Regulatory and Technological Innovation Division; Technological Innovation and Adaptation. IMSS. 1999.
*[2] Ssa page: http://www.ssa.gob.mx/dgei/ Nov-99.
*[3] INE page: http://www.ine.gob.mx/dgrmar Jan-99.
+ Statistical Yearbook 1998, Finance Division, ISSSTE.
++ Private dentists, Mexican Dental Association, 1999.
Note: Data in process of validation.

Consumption calculation:

Of a total of 10,781 practising dental professionals, 70% (7,547) are using mortar and pestle, generating approximate emissions of 200 g/year per professional.
Total mercury emissions = 1.51 ton (Appendix 1).

1.3.3.4. Thermostats

Consumption calculation:

The thermostats are used in the country to regulate air conditioners. According to industry sources, some 36,000–40,000 units are sold in Mexico annually. Each thermostat contains one or two 3-g capsules of mercury, approximately. Assuming a per-unit average of 4 g of mercury, the estimated average consumption in order to build this equipment is 152 kg (Appendix 1).

1.3.3.5. Fluorescent Light Bulbs

There are various kinds of mercury-containing bulbs on the market: fluorescent, metal halide, high-pressure sodium and neon bulbs. All fluorescent light bulbs contain elemental mercury, with the approximate content of a 120 cm tube being 15–25 mg (Tables 1.8 and 1.9). There are three main manufacturers in Mexico (General Electric, Osram, Phillips). To date, no program has been established to collect and recycle this mercury in the country.

Table 1.8. Mercury content of light bulbs

Year	Type of bulb	Production	Hg content/unit	Total Hg content	National production (%)
1996	Fluorescent	22 million	40 mg	880 kg	100%
	Compact (112/T8)	4 million	10 mg	40 kg	20%
1997	Fluorescent	25 million	40 mg	1000 kg	95%
	Compact (112/T8)	5 million	10 mg	50 kg	20%
1998	Fluorescent	27 million	35 mg	945 kg	80%
	Compact (112/T8)	6 million	10 mg	60 kg	20%
1999	Fluorescent	30 million	30 mg	900 kg	75%
	Compact (112/T8)	7 million	5 mg	35 kg	20%

Source: Information provided by Caname on February 7, 2000.

Table 1.9. Mercury consumption for light bulb production (1996–99)

Year	**Production** (million)	**Total Hg content** (kg)
1996	26	920
1997	30	1,050
1998	33	1,005
1999	37	935

Source: Information provided by Caname on February 7, 2000.

Consumption calculation:

Approximately 1 ton of mercury per year is used in the production of light bulbs (Appendix 1).

1.3.3.6. Small-Scale Uses

Largely on the informal market, craft products containing encapsulated liquid mercury (up to 0.8–4.5 g of mercury mixed with water or glycerine) are sold; e.g., glass charm bracelets or necklaces. These may occur with or without ornaments of stone or *chaquira* (painted glass beads). They are found in four different models.

Consumption calculation:

In a survey conducted in Mexico City in three markets where these bracelets or necklaces were being sold wholesale, a monthly sale of approximately 3,000 pieces per market was found, i.e. 9,000 per month. Assuming that each piece contains an average of 2.65 g, mercury consumption is calculated at 23.85 kg.

Besides Mexico City, other cities such as Querétaro and Zacatecas are also significant distributors, leading to a conservative estimate of mercury consumption in Mexico for this item of 75 kg/month or 900 kg/year (Appendix 1).

The INE has made contact with the competent authorities to eliminate mercury consumption for this non-essential use.

1.3.3.7. Cultural/Religious Uses

In a survey conducted by the INE at the Sonora plant market in the Federal District, 35 stands were found to be distributing liquid mercury in small glass or plastic containers, with volumes ranging from 7–15 g. Daily average sale according to the survey is one container per stand (35 containers total), with an average content of 12.5 g, amounting to approximate monthly consumption of 9.375 kg (112.5 kg/year) (Appendix 1).

It should be noted that due to the belief that mercury brings good luck, this substance is sprinkled on the floors of homes and businesses. To date, the risks due to environmental exposure to mercury in this way have not been assessed; however, in the last four years, five intoxications by elemental mercury attributed to this non-essential use have been recorded.

1.3.3.8. Coal and Coke Production Processes

In Mexico, there exist two main types of coal; thermal (Table 1.10) for direct combustion in coal-fired power plants, and coking (Table 1.11), for metallurgical use. The mercury content of coal in Mexico has not been analyzed.

Table 1.10. Coal production and estimated mercury emissions, 1994–98

Year	Coal production (ton/year)	Estimated emissions (kg Hg/year)

1994	11,432,222.00	1,557.07
1995	11,800,258.00	1,607.20
1996	13,745,528.00	1,872.14
1997	12,707,443.30	1,730.75
1998	12,378,788.40	1,685.99
Total	62,064,239.70	8,453.15

Source: *Anuario Estadístico de la Minería Mexicana*, 1998. 1999 edition. Council of Mineral Resources. Secofi.

Table 1.11. Coking coal, 1994–99

Year	Coke production (ton/year)	Estimated emissions (kg Hg/year)
1994	1,984,730	54.1
1995	2,147,602	58.5
1996	2,184,364	59.5
1997	2,139,376	58.3
1998	2,202,558	60.0
1999	2,219,845	60.5
Total	12,878,475	350.9

Source: INEGI page, 2000. Mining industry.

Emissions calculation:

Coal production = 62,064,239.70 ton (period 1994–98).
Emission factor = 1.362 x 10^{-4} kg Hg/ton (EPA, 1997).
Total emissions = 8.45 ton (Appendix 2).

Coking coal = 12,878,475 ton (period 1994–98).
Emission factor = 2.724 x 10^{-5} kg Hg/ton (EPA, 1997).
Total emissions = 0.351 ton (Appendix 2).

1.3.3.9. Coal-Fired Power Plants

All available technologies are used to generate electrical power in Mexico. In late 1994, the Federal Electricity Commission had a productive capacity of more than 31,600 MW, of which 28.8% corresponded to hydroelectric plants, 6% to coal-fired plants, 2.38% to geothermal plants, 54.02% to hydrocarbon-based thermal plants, 6.64% to combined cycle plants, 2.13% to nuclear plants and 0.01% to wind plants.

At the present time, only 6% of the electricity in Mexico is generated by the two coal-fired plants, both located in the state of Coahuila (Table 1.12).

Table 1.12. Coal-fired power plants in Coahuila, Mexico

Plant
Río Escondido (President José López Portillo) plant

24 km south of Piedras Negras. 4 units, 300 MW capacity each. Total production capacity: 1,200 MW. Annual coal consumption: 4.2 million tons.
Carbón II plant. 24 km south of Piedras Negras. 4 units, 350 MW capacity each. Total production capacity: 1,400 MW. Annual coal consumption: 6.3 million tons.

Source: CFE, Carbón II. Information bulletin. Undated.

At mid-year 2000, in Petacalco, Guerrero, the CFE will begin converting a petroleum-based thermal plant to coal. The new plant will have six units with 350 MW capacity each for a total production capacity of 2,100 MW. Annual coal consumption is estimated at approximately 8 million tons. The mercury content of coal mined in Mexico has not been analyzed.

Emissions calculation:

Annual coal consumption = 10,500,000 ton.
Emission factor = 0.25 g/ton (Parcom-Atmos, 1992).
Total emissions = 2.625 ton (average for 1997 and 1998) (Appendix 2).

1.3.3.10. Smelting

The smelting industry in Mexico is under the umbrella of the industry association Sociedad Mexicana de Fundidores. In 1999, according to its national directory, there were 482 foundries for both primary and recycled (secondary) metals, of which two are micro-businesses with monthly capacity less than 200 tons; 194 are small businesses, 200–500 tons; 193 are mid-sized businesses, 500–1000 tons, and 93 are large businesses producing more than 1000 tons monthly.

Many of these companies are producing more than one metal. The data obtained shows that the small companies are more diversified in their activities: some of them produce up to five different metals. The large companies are more specialized and concentrate on one or two metals.

No study has yet been done on the type of technology and fuel they use; no accurate production data is available (Table 1.13), nor is it known whether their production is primary or secondary, nor the magnitude of their mercury emissions.

Table 1.13. Total mining production in Mexico (ton/year)

	1995	1996	1997	1998	1999	Total
Silver	2,495,522	2,536,465	2,701,329	2,868,099	2,337,554	24,581,545
Gold	20,902	24,083	26,032	25,983	22,285	172,945
Copper	339,347	327,976	338,932	344,753	321,041	3,143,436

Lead	179,741	167,115	180,349	171,611	125,956	1,680,597
Zinc	354,673	348,329	377,861	371,899	321,205	3,411,664

Source: *Anuario Estadístico de la Minería Mexicana*, 1998. 1999 edition. Council of Mineral Resources. Secofi. INEGI mining industry Web page, 1999.

Emissions calculation:

Three metals possibly involving mercury in their production processes were considered. The values for gold and silver were not estimated since the emissions factors were not available; for these, only production data are presented (Table 1.14). It should also be clarified that the calculation for the other three metals was performed with gross mining production data, with no accounting for the technology used nor the mercury content of the minerals.

Table 1.14. Emission factor by metal and total mercury emissions (kg)

	Emission factor*	**1995**	**1996**	**1997**	**1998**	**1999**	**Total emissions**
Copper	0.1 g/ton	33,9	32,8	33.9	34.5	32.1	167.2
Lead	3 g/ton	539,2	501,3	541.1	514.8	377.9	2,474.3
Zinc	20 g/ton	7,093.5	6,966.6	7,557.2	7,438.0	6,424.1	35,479.4
Total		7,666.6	7,500.7	8,132.2	7,987.3	6,834.1	38,120.9

* (Parcom-Atmos, 1992). (Appendix 3).

1.3.3.11. Cement Production

In Mexico, there are three large companies with a total of 29 cement kilns (Figure 1.1), of which 24 are authorized to use alternate fuels while the remaining ones use heavy fuel oil. Cemex has a total of 16 plants, Cementos Apasco has six and Cooperativa La Cruz Azul has three.

Figure 1.1. Distribution of cement kilns

Source: National Association of Cement Producers (Canacem).

NOTE: *The data and quantities presented in this draft have been obtained from official and unofficial sources, both national and international. This data is under review to determine whether more accurate data is required.*

Emissions calculation:

Cement production = 30,000,000.00 ton (INEGI).
Emission factor = 0.087 g/ton (EPA).
Total emissions = 2.61 ton (Appendix 2).

1.3.3.12. Incineration of Biological/Infectious and Industrial Waste

In Mexico, there are 24 authorized incinerators of biological/infectious waste (Table 1.15). Under NOM 098, they are required to report emissions of lead, total suspended particles, dioxins, furans and mercury, among others. The incineration temperature at these facilities does not exceed 300 °C.

Table 1.15. Biological/infectious waste incinerators in Mexico

Company	State	Capacity (kg/h)
Tradem	Federal District	1000
Control de Desechos Ind. y Monit. Amb.	Coahuila	200
Tradem	Mexico	500
Sterimed	Mexico	109
Soluciones Ecológicas Integrales	Mexico	1400
Protección Integral del Medio Ambiente	Mexico	45
Desechos Biológicos	Mexico	250
Proterm-JV de México	Mexico	350
Proterm-JV de México	Mexico	200
Tecnología Especializada en Reciclaje	Hidalgo	1000
Alicia Chávez González	Jalisco	360
Ciba Especialidades Químicas México	Jalisco	588
Servicios de Tecnología Ambiental	Nuevo León	350
Bio-System Technology	Nuevo León	270
Ecotérmica de Oriente	Puebla	350
Marepel	Sinaloa	200
Secam	Tamaulipas	220
Ecología del Mayab	Yucatán	270
Incineradores, Mantenimiento y Equipo	Jalisco	420
Centro Ambiental	San Luis Potosí	90
Bio-Tratamientos	Mexico	340
Ameq de México	Coahuila	112.5
Técnicas Especiales Reducción de Altamirano	Tamaulipas	250

Control Ambiental del Bajío	Guanajuato	83
Total companies: 24		8,957.5

Source: National Institute of Ecology. High Risk Materials, Wastes and Activities Branch. Internal Report. March 2000.

The installed capacity for biological/infectious waste incineration in Mexico as of December 1999 was 18,632 ton/year, assuming 260 days of operation at 8 hours per day. If it is considered that the application of the regulations takes approximately three years, it can be estimated that operations are at 40% of capacity, so that the volume of incineration should now be 7,453 ton/year. Applying an emission factor of 0.96 g/ton, we obtain an approximate figure of 7.15 ton/year of mercury emissions.

Emissions calculation:

Average annual incineration for 1997–1999 = 7,453 ton.
Emission factor = 0.96 g/ton (Parcom-Atmos, 1992).
Estimated annual emissions (1997–1999) = 7.15 ton (Appendix 2).

For hazardous industrial waste, there are 11 incinerators in Mexico with an installed capacity of 65,400 tons per year, 10% of which is currently in use. Among the wastes incinerated are oils and greases, solvent-soaked rags and pharmaceutical industry waste.

Table 1.16. Companies authorized to incinerate hazardous industrial waste (ton/year)

Company	Hazardous wastes	Installed capacity
Tecnología Especializada en Reciclaje, Tepeji del Río, Hidalgo	Industrial and biological/infectious waste.	7,500
Ciba Geigy Mexicana, Atotonilco, Jal.	Industrial and pharmaceutical waste.	2,075
Kodak de México, Zapopan, Jalisco	Waste from production of photographic film, filter paper, activated sludge, foundry slag and silver recovery process sludge.	613
Bayer de México, Ecatepec, State of Mexico	Incineration of hazardous waste generated by the company.	1,752
Aceros Nacionales, Tlalnepantla, State of Mexico	Incineration of oil and grease-soaked sawdust, rags, gloves and flash.	183
Siderúrgica Lázaro Cárdenas. Las Truchas, Lázaro Cárdenas, Michoacán	Incineration of solvent-, oil- and grease-soaked gloves and rags.	22
Laboratorios Julián de México, Jiutepec, Morelos	Incineration of hazardous waste generated by its facilities.	20,000

Sintex, Jiutepec, Morelos	Expired and substandard pharmaceutical products.	840
Hylsa, San Nicolás de Los Garza, Nuevo León.	Waste oil incineration.	246
Síntesis Orgánica, Xalostoc, Tlaxcala	Incineration of solid blocks of tar from phthalic anhydride distillation.	2,160
Pemex-Petroquímica, Coatzacoalcos, Veracruz	Operation of incinerator (Pajaritos Complex) for thermal treatment of effluents with heavy chlorinated hydrocarbons.	30,000
Total capacity of companies (2)		**65,391**
Total capacity of cement producers (1)		**1,227,414**
Total installed capacity		**1,292,805**
Estimated 10% of installed capacity used		**129,281**

Source: (1) Web pages of Cementos Apasco; Cemex; Cementos Cruz Azul, 1999.
(2) INE, DGMRAR, 2000

The INE has also authorized the incineration of hazardous waste for the majority of the cement plants operating in the country. The installed incineration capacity (1,227,414 ton) is greater than the hazardous waste actually incinerated, which amounts to 10% of this capacity; 90% of the energy consumed is generated by heavy fuel oil.

Emissions calculation.

In 1998–1999, 10% of total installed capacity for hazardous waste incineration was used.
Waste incinerated by companies = 6,539.1
Waste used as alternate fuel by cement plants = 122,741.4
Total incinerated = 129,280.5
Emission factor (Parcom-Atmos, 1992) = 3.0 g/ton
Total mercury emissions = 0.388 ton (Appendix 2).

1.3.3.13. Cremation

In the Federal District there are nine crematoria, with a total of 18 furnaces cremating between four and seven cadavers per day. A mid-sized crematorium cremates five cadavers daily, and it is reported that for the year to date, the number of cadavers cremated has been about 1,600. Cremation services are growing at an estimated 30% annually.

Assuming an average of five cremations per day for each of the eight crematoria in operation yields a total of 14,600 cremations per year in the Federal District. Applying the emission factor to this figure yields a result of 21.9 kg of emissions per year for this item.

Emissions calculation:

Estimated annual cremations = 14,600.
Emission factor = 1.5 x 10^{-3} kg/cremation (EPA, 1997).
Emissions = 21.9 kg (Appendix 2).

NOTE: The data and quantities presented in this draft have been obtained from official and unofficial sources, both national and international. This data is under review to determine whether more accurate data is required.

2 Regulatory Framework for Risk Management and Pollution Prevention

2.1 Federal Laws, Regulations and Standards

Mercury is not widely perceived as a risk in Mexico, and as yet no standards have been developed to govern the management of specific products; however, the laws deriving from the Political Constitution of the United Mexican States contain provisions that serve to regulate this pollutant (Table 2.1).

Table 2.1 Legal framework for mercury in Mexico

Law	Regulation	Mexican Official Standards	Responsible entity
General law on Ecological Balance and Environmental Protection (LGEEPA)	Hazardous Waste Regulation	NOM-052-ECOL-1993 NOM-053-ECOL-1993	Semarnap, INE, Profepa
National Water Law	National Water Regulation	NOM-031-ECOL-1993 NOM-071-ECOL-1994	Semarnap, INE, Profepa
General Health Law	Regulation on Sanitary Control of Activities, Establishments, Products and Services	NOM-071-ECOL-1994 NOM-118-SSA1-1994	Ssa
Federal Labour Law	Regulation on Work Safety, Hygiene and Environment	NOM-010-STPS-1994	STPS
Federal Animal Health Law		NOM-016-ZOO-1994	Sagar
Federal Roads, Bridges and Vehicle Transportation Law	Regulation on Ground Transportation of Hazardous Materials and Wastes	NOM-002-SCT2/1994	STC
Federal Firearms and Explosives Law	Firearms and Explosives Regulation	There is no Mexican Official Standard. However, Art. 41 indicates that mercury fulminate is subject to the regulations of the	Sedena

		Ministry of National Defense.	
Mining Industries Law	Regulation on Mining Activities	There is no Mexican Official Standard. However, Art. 41 indicates that mercury fulminate is subject to the regulations of the Ministry of National Defense.	Secofi

The Mexican Official Standards (NOM) deriving from the laws and regulations are federally enforced. They were drafted with the participation of various government, academic and industry sectors and submitted for public consultation before final publication. Table 2.2 lists the mercury-related standards published to date.

The agency in charge of enforcing compliance with these standards is the Office of the Federal Attorney for Environmental Protection (Profepa); its head offices are in Mexico City and it has branch offices in every state of the republic.

Table 2.2 Mexican Official Standards governing the use of mercury

Standard	Type of regulation
NOM-052-ECOL-93	Establishing the characteristics of hazardous wastes, the list thereof and the threshold above which a waste is considered hazardous due to its toxicity in the environment.
NOM-053-ECOL-93	Establishing the testing procedure for determining the components identifying a waste as hazardous due to its toxicity in the environment.
NOM-001-ECOL-1996	Establishing the maximum allowable limits for pollutants in wastewater discharges into national bodies of water and property.
NOM-002-ECOL-1996	Establishing the maximum allowable limits for pollutants in wastewater discharges into urban or municipal sewer systems.
NOM-117-SSA1-1994	Goods and services. Testing method for the determination of cadmium, arsenic, lead, tin, copper, iron, zinc and mercury in food, potable water and purified water by atomic absorption spectroscopy.
NOM-048-SSA1-1993	Establishing the standard method for assessing risk to health as a consequence of environmental agents.
NOM-118-SSA1-1994	Goods and services. Raw materials for food, perfume and beauty products. Inorganic dyes and pigments. Sanitary specifications.

__NOTE:__ The data and quantities presented in this draft have been obtained from official and unofficial sources, both national and international. This data is under review to determine whether more accurate data is required.

Standard	Type of regulation
NOM-016-ZOO-1994	Analysis of mercury in liver, muscle and kidney of bovines, equines, porcines, ovines and birds by atomic absorption spectroscopy.
NOM-010-STPS-1994	Concerning safety and hygiene conditions in work centres producing, storing or managing chemicals capable of causing pollution in the working environment.
NOM-002-SCT2/1994	List of hazardous substances and materials most commonly transported.

Draft standard NOM-098-ECOL/99, in process of approval, governs and establishes the requirements and specifications for the adequate operation of incinerators, and the maximum allowable limits for air emissions, wastewater discharges and solid waste management produced by the incineration of urban solid waste, hazardous waste, non-hazardous industrial waste and biological/infectious waste, so as to reduce their risks to heath and the environment. This standard, which establishes the mercury emission limit at 0.07 mg/m^3, also indicates that the sampling time is 1 hour with an average of 3 samples in an 8-hour period.

2.1.1 Environmental Policy

The General Law on Ecological Balance and Environmental Protection (*Ley General del Equilibrio Ecológico y la Protección al Ambiente*—LGEEPA) was amended by the Congress of the Union and its reformed version was published in the Official Gazette of the Federation (*Diario Oficial de la Federación*) on December 13, 1996. The fundamental purpose of these reforms was to make into law the orientations and principles of a new environmental policy founded on the principle of sustainable development (INE-Semarnap, 1999).

The Semarnap has a wide range of environmental regulatory instruments arising from the law and its internal regulation, which establishes the powers of the bodies making up this ministry. The modernization of the procedures for the licensing of industrial establishments and for emissions reporting helped to strengthen the application, scope and effectiveness of the Comprehensive Environmental License (*Licencia Ambiental Única*—LAU) and to promote the use of the Annual Certificate of Operation (*Cédula de Operación Anual*—COA).

Characteristics of the LAU:

- One per industrial establishment. Comprised of the following elements:
    - Environmental impact assessment
    - Risk assessment
    - Air emissions

  - Hazardous wastes
  - Wastewater discharges
- Applies to new establishments or those that are required to regularize their situation
- Also, those establishments so desiring may participate by renewing their license.

Characteristics of the COA:

- Generates annual up-to-date information on pollutant emissions, management and transfer
- Monitors the operation of the establishment
- Supports decision-making on environmental protection matters
- Contributes to the formulation of environmental criteria and policies.

The Pollutant Release and Transfer Registry (PRTR) is a component of the SNIA, which contains information on air, water and soil pollutant emissions obtained by use of GIS techniques and by methods for estimating air emissions, wastewater discharges and hazardous waste production.

The PRTR makes it possible to ascertain, through information reported by all municipalities and states, the emissions and transfers of 105 pollutants, listed by industry, by means of:

- Annual air, water and soil emissions data, and data on transfers of hazardous waste for treatment and/or containment, broken down by chemical species and by establishment type, industry and geographical area.

- Geographical location, general data, operational characteristics and pollution prevention and control characteristics for the emission sources, as well as data on non-point sources, such as agricultural or transportation operations.

With this inventory, it is hoped to achieve the following objectives:

- Obtain a reliable, up-to-date database on emissions and transfers of toxic substances.
- Simplify and rationalize data collection.
- Help companies make environmental decisions.
- Monitor and quantify advances in emission and discharge reductions.
- Provide information on chemical substances representing a risk to health and the environment.
- Create an emission and transfer information system for the production of reports containing information available to the general public
- Generate an instrument to serve as a basis for Mexico's fulfilment of its international environmental information obligations.

The formulation and implementation of a notification procedure for pollutant emissions and the development of a PRTR in Mexico grow out of the principles contained in the "Environment Program 1995–2000" and the powers invested in the Semarnap by the LGEEPA (INE-Semarnap, 1999).

3 Rehabilitation Activities

3.1 Contaminated Sites

According to data obtained by the Profepa state office in Zacatecas in December 1996, at the Zacatecana Lagoon, covering approximately 120 hectares and located about 10 km from the city of Zacatecas, there are 4 plants located downstream from the lagoon (Jales de Zacatecas, S.A. de C.V., Beneficiadora de Jales de Zacatecas, S.A. de C.V., Jales del Centro, S.A. de C.V. and Mercurio del Bordo, S.A. de C.V.) that are processing tailings by leaching with sodium hyposulfite. The valuable metals (mainly gold and silver as products and mercury as a sub-product) are separated by means of a thermal process in which the mercury is condensed. It should be noted that the tailings processed by these plants and the tailings dumped in the lagoon are of the same origin, that is, the District of Zacatecas. The product of the 3 main groups of lodes, Veta Grande, San Bernabé and La Cantera, was processed at 48 processing facilities located in the Zacatecas mountains. These facilities, which operated for 300 years until the turn of the century, habitually dumped their waste into the streambeds, whence it was carried down into the valleys by the rains, forming very large deposits. In the case of the Pedernalillo lagoon, some 5 million tons of mineralized material built up, with an average of 60 g of silver and 180 g of mercury per ton, for an approximate total of 300 tons of silver and 900 tons of mercury.

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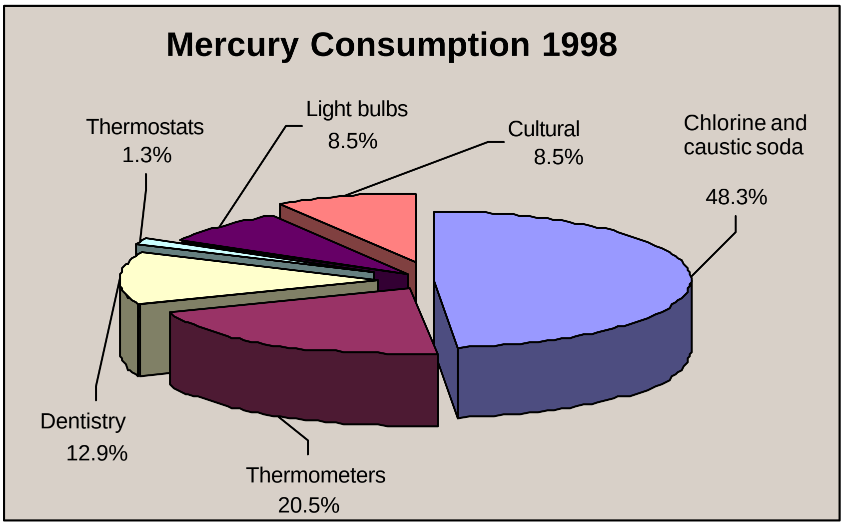
NOTE: *The data and quantities presented in this draft have been obtained from official and unofficial sources, both national and international. This data is under review to determine whether more accurate data is required.*

Appendix 1. Consumption

Table A1.1. Mercury consumption in Mexico, 1998

Product	Hg quantity (ton/year)
Chlorine and caustic soda	5.658
Thermometers and sphygmomanometers	2.4
Dentistry	1.51
Thermostat	0.152
Fluorescent light bulbs	1.0
Cultural uses	1.0
Total	**11.72**

Figure A1.1. Mercury consumption in Mexico, 1998



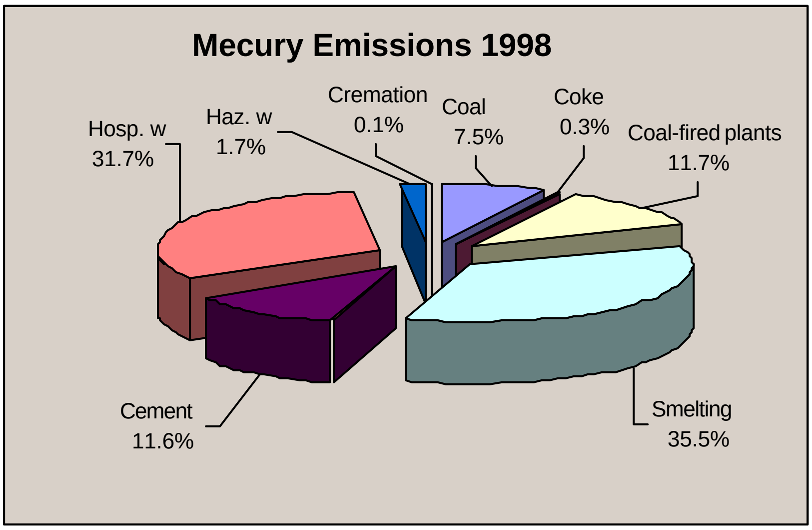
NOTE: *The data and quantities presented in this draft have been obtained from official and unofficial sources, both national and international. This data is under review to determine whether more accurate data is required.*

Appendix 2. Emissions

Table A2.1. Estimated mercury emissions in Mexico (ton/year)

Source	1994	1995	1996	1997	1998	1999
Coal production	1.557	1.607	1.872	1.731	1.686	
Coke production	0.054	0.059	0.060	0.058	0.060	0.061
Coal-fired power plants				2.625	2.625	
Smelting (copper, lead and zinc)		7.667	7.501	8.132	7.987	6.834
Cement production				2.61	2.61	
Hospital waste				7.15	7.15	7.15
Hazardous waste				0.390	0.390	0.390
Cremation				0.022	0.022	0.022
Total				22.718	22.53	

Figure A2.1. Estimated mercury emissions in Mexico, 1998



NOTE: *The data and quantities presented in this draft have been obtained from official and unofficial sources, both national and international. This data is under review to determine whether more accurate data is required.*

Appendix 3. Emission Factors

Table A3.1. Mercury emission factors

Product	**Parcom-Atmos (g/Mg)**	**Emission factor (Hg) (EPA)**
Sinter plants	0.02	
Pelletizing plants	Page missing	
MP in powders for blast furnaces	0.02	
MP in powders for basic converters	0.003	
MP in electric arc furnaces (steel, steel for construction and stainless steel)	0.15	
Coke production		6×10^{-5} lb/ton 2.724×10^{-5} kg/ton
Coke furnaces	0.03	6×10^{-5} lb/ton (2.724×10^{-5} kg/ton)
Primary **copper** production	0.1	0.1 g/ton
Primary **lead** production	3.0	3 g/ton
Primary **zinc** production	20.0	20 g/ton
Secondary **zinc** production	0.02	0.02
Black coal manufacturing		3×10^{-4} lb/ton 1.362×10^{-4} kg/ton
Coal-fired power plants	0.25, 0.18	0.15 g/Mg (3×10^{-4} lb/ton, 1.362×10^{-4} kg/ton)
MP from lignite combustion	0.06	
Natural gas	5 µg/m^3	
Firewood combustion	0-0.2	
Percentage in dust for waste incineration	0.6	
Hazardous industrial waste	3.0	
Biological/infectious waste	0.96	
MP from incineration of sewage sludge	1.0	
Chlorine and caustic soda industry	3.1	41.2 g/ton (Méx) 4.071 g/ton (USA)
Portland cement manufacturing		1.3×10^{-4} lb/ton 5.902×10^{-5} kg/ton

Cement production	0.275	0.087 g/ton (8.7 x 10^{-5} kg/ton) 6.5 x 10^{-5} kg/Mg (1.3 x 10^{-4} lb/ton, 5.902 x 10^{-5} kg/ton)
Glass production (NA)	0.05	
Batteries	-----	
Cremation	1.0 Hg/cadaver (Switzerland)	3.3 x 10^{-3} lb/cremation (1.5 x 10^{-3} kg/cremation)
Dentistry	0.6 g/dental filling (United Kingdom)	40 lb/ton 20 kg/ton

Source:

Emission Factors Manual Parcom-Atmos Emission factors for air pollutants. Netherlands, 1992.

Locating and Estimating Air Emissions from Sources of Mercury and Mercury Compounds. EPA, 1997

Appendix 4. Chlorine and Caustic Soda Industry in North America and Western Europe

Table A4.1. Chlorine production with mercury cell technology (MT/year)

	Installed capacity (IC) (MT Chlorine)	% of IC/Total Capacity	% of US IC
Mexico	147,000	33	8.2
Canada	37,700	2.8	2.1
United States	1,800,000	14	---
Western Europe	6,300,000	70	350

Source: Information provided by ANIQ. 2000.