Preliminary Atmospheric Emissions Inventory of Mercury in Mexico

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ABSTRACT

A preliminary inventory of atmospheric emissions of mercury (Hg) from stationary sources in Mexico was prepared for the year of 1999. Atmospheric emissions of mercury from the sources of interest in Mexico were estimated through indirect approaches, based on annual process throughputs for these sources, using either commonly acceptable emission factors, available data on mercury content in feedstock or product, best typical values of mercury concentration in oil and fuel oil, and by using similar operations as a surrogate to estimate potential atmospheric mercury emissions.

In Mexico there is very limited official information on atmospheric mercury emissions from the source categories of interest. Mercury emissions are regulated in Mexico only for incinerator facilities of hazardous waste and medical waste, and for cement plants burning waste combustibles, but only since 1998. No other sources are required to monitor their mercury emissions or to analyze mercury content in feedstock or wastes. Even the "*Registro de Emisiones y Transferencia de Contaminantes* (*RETC*)", Mexico's equivalent to the U.S. Toxic Release Inventory or the Pollutant Release and Transfer Register, contained practically no data on mercury emissions or mercury concentration in process feedstock or waste streams. This was the case even for gold mine operations that included mercury retorts and condensers in their process schematics or flow diagrams submitted to the National Institute of Ecology (*Instituto Nacional de Ecologia, INE*). Relevant information such as mercury content of smelters feedstock, heavy fuel oil, diesel fuel and carbon, required to estimate mercury emissions from potentially important sources was neither available. For these reasons, a fundamental objective of the project was to identify a comprehensive list of potential stationary sources of atmospheric mercury emissions in Mexico, to provide annual process throughputs for these sources and to estimate mercury emissions using indirect approaches.

This preliminary inventory of atmospheric emissions of mercury from stationary sources in Mexico was prepared under contract for the North American Commission for Environmental Cooperation.

INTRODUCTION

A preliminary inventory of atmospheric emissions of mercury (Hg) from stationary sources in Mexico was prepared for the year of 1999. This inventory was build upon two previous studies of mercury air emissions in Mexico: the 1997 Electric Pacific Research Institute (EPRI) study for the North Border States, coordinated by Bill Powers of Powers Engineering and the May 2000 draft study coordinated by the *Dirección de Materiales Tóxicos* (Toxic Materials Directorate) of the *Instituto Nacional de Ecología*, *INE* (National Institute of Ecology).

The EPRI-funded study identified the lack of information on airborne Hg emissions from the processing of ores at Mexican gold and silver mines as the major unknown in developing the inventory. Lack of data on Hg concentration in smelters feedstock was a second major unknown for a more precise estimation of Hg emissions from these sources. Lack of accurate data on Hg concentration in heavy crude oil and refined heavy fuel oil (*combustóleo*) was identified as the third major unknown in assessing with some degree of accuracy the Hg emissions associated with oil combustion in Mexico. Preliminary Hg emission ranges for these source types were estimated in the EPRI study by: 1) evaluating Hg production rates and capture efficiencies of Hg control systems at large U.S. gold and silver mines to develop a range of Hg control efficiencies for Mexican gold and silver mining operations; 2) by using U.S. EPA's emission factors for primary and secondary smelters and, 3) by identifying the maximum concentration of Hg in heavy crude oil based on available oil assay laboratory data.

The *INE*-conducted study identified secondary mercury production from silver tailings and chlor-alkali operations as the major sources of mercury atmospheric emissions of mercury. The *INE* study estimated emissions from these two sources based on mercury recovery/usage rates reported for the year of interest.

There is very limited official information on atmospheric mercury emissions from the source categories of interest in Mexico. Since 1998, mercury emissions have been regulated only for incinerator facilities of hazardous waste and medical waste, and for cement plants burning waste combustibles. No other sources are required to monitor their mercury emissions or to analyze mercury content in feedstock or wastes. Only emissions of Particles and of Combustion Gases are regulated and as such must be measured and reported annually. Project members reviewed files of the "*Registro de Emisiones y Transferencia de Contaminantes* (*RETC*)", Mexico's equivalent to the U.S. Toxic Release Inventory or the Pollutant Release and Transfer Register, submitted by several facilities of the source type of concern in Mexico, and found practically no data on Hg emissions nor Hg concentration in process feedstock or waste streams. This was the case even for gold mine operations that included mercury retorts and condensers in their process schematics or flow diagrams submitted to *INE*. Information regarding annual process throughputs were neither available for some of the sources of interest, since most of these data are considered confidential and protected by law.

The following table summarizes atmospheric mercury emission estimates for the major stationary sources categories identified in Mexico. Emissions were estimated using indirect approaches.

Table 1.- Summary of Atmospheric Mercury Emissions in Mexico: 1999

Source category	**Mg/yr**	**%**
Gold/Hg mining and refining	20.936	66.9
Chlor-alkali plants	4.902	15.7
Combustion processes	2.189	7.0
Ferrous and Non-ferrous smelters	1.892	6.0
Oil refining	0.680	2.2
Other manufacturing	0.667	2.1
HW/MW incinerators	.027	0.1
Total Hg Emissions Estimated	**31.293**	**100.0**

Following, a brief description of the characteristics of each of the main source types of mercury emissions in Mexico is presented, including the approach used to estimate these emissions. The complete report will be uploaded shortly into the Commission for Environmental Cooperation web page *www.cec.org* and may be obtained upon request to the authors.

MAJOR ANTHROPOGENIC SOURCES OF MERCURY EMISSIONS IN MEXICO

Atmospheric emissions of mercury from the sources of interest in Mexico were estimated through indirect approaches, based on annual process throughputs for these sources, using either commonly acceptable emission factors, available data on mercury content in feedstock or product, best typical values of mercury concentration in oil and fuel oil, and by using similar operations as a surrogate to estimate potential atmospheric mercury emissions.

Gold Mining and Refining:

Mexico is a major producer of copper, silver, lead, zinc, gold and has important deposits of mercury. These metals are often found together in various concentrations as reduced sulfur compounds, such as CuS, PbS, ZnS and HgS (cinnabar). Mercury is particularly associated with gold, and is apparently found within the crystal structure of gold in many gold deposits. In the U.S., gold mining operations are the major domestic producer of mercury.

Mercury has a low boiling point relative to gold and silver. For this reason, mercury is typically evaporated during the initial refining of these metals. In the U.S., in cases where the mercury concentration in the ore is sufficiently high to make recovery economically attractive, mercury retort furnaces are used to evaporate mercury from the ore. Condensers are used to condense and recover the mercury *(1)*. Another factor that encourages gold mine operators to remove the mercury from the gold ore during initial refining is the economic penalty imposed by gold refiners for gold/silver concentrate, known as “dore,” that contains more than 1,000 mg/kg of mercury.

There is no documented Hg recovery from gold mining operations in Mexico. The project team reviewed air emissions inventories and semi-annual report of hazardous waste generated from four major gold producers in the State of Sonora for 1998 and 1999 years. No Hg emissions and no Hg-containing by-product or waste were reported by any of the mines reviewed. Two of these mines included Hg condensers and Hg “washing towers” in their flow diagram schematics and on their list of equipment. According to the *Dirección General de Minas* (General Directorate on Mines) of the Secretary of Commerce and Industrial Development (*SECOFI*), mercury has not been produced from mining operations in Mexico since 1995 (*2*). The project team concluded that either all mercury in gold/silver ore is evaporated during the roasting and smelting operations to produce dore or mercury recovered and mercury-containing sludge is recycled -to recover precious metals- or disposed on site. Three of the four mines analyzed are in the *SECOFI's* top ten list of gold producers in Mexico *(3)*.

There are a large number of *pequeños mineros* (small miners) operating gold/silver mining operations in Mexico states of Sonora, Chihuahua, Durango, Zacatecas, Queretaro and Guerrero. These operations are essentially unregulated by the state or federal government. However, small miners usually do not have thermal processes in their mining operations, but send their concentrates to anyone of the three gold/silver smelters operating in the country *(4, 5)*. As a default, it is assumed that roasting/smelting take place in gold mining operations processing more than 500,000 metric tons of ore per year, or producing more than 400 Kilograms of gold per year. Gold mines meeting the above criteria were identified, most of which are in the 1999 *SECOFI's* top ten gold producers in Mexico. Annual ore processed for each of these mines was provided either from available records or by extrapolation from annual gold production rates, resulting in 11,679,723 metric tons of ore processed by these gold mines in 1999.

Nevada is the leading gold producer in the U.S. with two operating gold mines: Jarret Canyon-Anglo Gold and Barrick Gold. Jarret Canyon processes 2,190,000 tons/year of ore that is high in sulfur material and for this reason it must be roasted. Jarret Canyon emits 7,000 lb/yr of mercury at the roaster, although roasters are equipped with spray tower/scrubbers. Barrick Gold processes about 7,500,000 tons/year of ore and emits about 5,000 lb/year of mercury *(Powers Engineering, 2001)*. Using these Nevada mines as a surrogate to determine the potential atmospheric mercury emissions from gold/silver mining operations in Mexico based on the total ore processing rate, mercury is being emitted at a rate of 0.965 g/Mg of ore. Applying this factor to the above annual ore processed estimate, mercury emissions from gold mining operation in Mexico were estimated as <u>11.270 Mg/year</u>.

Mercury Secondary Production

Mercury is extracted from silver mine tailings in Zacatecas at the municipalities of Guadalupe and Veta Grande. According to *SECOFI* these are the only mercury producer operations in Mexico. A total of 60.63 metric tons were reported as recovered during 1998 *(6)*. This is almost twice the secondary production of mercury of 33.2 ton/yr reported by *INE* in 1996 *(7)*. In 1999 only 29 metric tons of mercury were reported as recovered from these tailings *(8)*. Processing of these tailings largely depends on the market price of silver.

Mercury retort furnaces are used to evaporate the mercury from the silver/mercury concentrate produced in the initial refining steps. Mercury recovery rate was estimated by mass balance using average Hg content in tailings and in recovered bottom waste (*9*), tons of tailings processed and tons of mercury recovered (*8*). For a mercury secondary production of 29 metric tons as reported for 1999 and an estimated average condensation efficiency of 75 % in the mercury condenser after the retort/kiln used to separate gold/silver from mercury, emissions from these "*Plantas de Beneficio*", were estimated to be 9.666 Mg/yr of mercury.

Chlor-Alkali Plants

There are five chlor-alkali plants in Mexico with a combined production of 447,000 metric tons per year of chlorine gas. 147,000 metric tons of chlorine per year are produced with the mercury cathode technology in three of these plants that utilize the mercury cell production process (*10*). In 1999 these plants purchased 5.767 metric tons of mercury to replace losses in their processes.

Mercury emissions from Mexican chlor-alkali industry in 1998 were estimated by INE as 5.658 metric tons equal to the yearly amount of mercury purchased by chlor-alkali plants based on estimates by the National Association of Chemical Industry (*7*). This estimate results in an emission factor of 41.2 grams of mercury per ton of chlorine produced, considerably much higher than the 1994 emission factor of 3.5 g/ton estimated by EPA for U.S. chlor-alkali plants (*11*). However, USGS estimates that about 74 percent of mercury used by chlor-alkali plants is "unaccounted", calling this amount, the "missing" mercury, addressing EPA concern about this unaccounted mercury (*12*).

USGS estimates that 14 % of mercury replaced in a chlor-alkali plant is transferred to landfills in the sludge from wastewater treatment, 5 % is internally recycled and 1 % is lost with NaOH product (*12*). With these USGS figures and 5.767 metric tons of mercury replaced, estimated mercury emissions in Mexican chlor-alkali plant were 4.902 metric tons in 1999.

Combustion Processes

Major sources of atmospheric mercury emissions from the combustion of fossil fuels identified, include power generation plants, both thermoelectric and carboelectric, industrial and commercial boilers, residential wood combustion and cement and lime plants.

Electric Power Generating Plants

By the end of year 2000 there were 172 electric power generating plants in operation in Mexico with five more scheduled for construction by 2005 *(13)*. 67 % of Mexico's total capacity to generate electricity is based on fossil fuel combustion processes.

The principal crude oil used by Mexican refineries as the feedstock to produce heavy oil, known as "*combustóleo*," and various diesel fuel grades used in thermal power plants and industrial/ commercial boilers, is Maya crude oil. It is a heavy crude high in sulfur and trace metals. *PEMEX*, Mexico's State-owned Petrolleum Company, does not perform Hg analyses on this crude, nor on refined products such as *combustóleo* or diesel. The Mexican Federal Electricity Commission (*Comision Federal de Electricidad, CFE*), performs analytical test of *PEMEX* fuel oil samples used by their power generating facilities. Mercury is not tested for in the fuel and it is not routinely analyzed in the slag or ash from their steam boilers.

A laboratory that specializes in crude oil assays in the Houston area, ITS Caleb-Brett performed Hg analysis of four Maya crude oil samples supplied by *PEMEX* customers. Mercury content in heavy fuel oil and diesel samples analyzed were lower than this laboratory detection limit: 10 ppbwt.

No comprehensive oil characterization studies have been done, but data in the literature report mercury concentrations in crude oil ranging from 0.023 to 30 ppmwt, while the range of concentration in residual oil (*combustoleo*) has ranged from 0.007 to 0.17 ppmwt. *(14).* For diesel, EPA reported only one test with less than 12 ppb of mercury. Mercury emissions from power plants in Mexico was then calculated based on U.S. EPA's best typical value determined for heavy fuel oil, 0.004 ppmwt of mercury *(11)* and <10ppb for diesel as determined by ITS Caleb-Bret. An emission factor of 5 ug of mercury per cubic meter of Natural Gas will also used *(11).* Fuel consumption figures by type of fuel were taken from the National Institute of Statistics, Geography and Information (*Instituto Nacional de Estadistica, Geografia e Informatica, INEGI)* for 1999. Using these fuel consumption figures, mercury emissions from electric power generating plants in Mexico were estimated to be <u>0.1263 Mg/yr</u>.

Carboelectric Plants

The issue of Hg emissions from coal-fired power plants is limited to the Rio Escondido (1,200 Mwatt), also known as Carbon I or Jose Lopez Portillo, and Carbon II (1,400 Mwatt) facilities in Coahuila and perhaps to the Petacalco unit in Guerrero which was scheduled to begin burning coal in 2001 *(15)*. The Carbon I and II plants are located in the U.S.-Mexico border region, and thus, have been a focus of concern regarding SO_2 emissions. For this reason, increasing amount of mined coal are cleaned in Mexican washing plants prior to combustion *(16)* and low sulfur coal is being imported from Colorado *(El Universal, September 5, 2000)*. Coal that is utilized by the carbon power plants include approximately 1.5 million metric tons of imported coal from Fideil Creek, Colorado mine. This coal is being utilized because it is much lower in sulfur than Coahuila coal *(17)*.

The same considerations made regarding characterization of fuel oil apply to analysis of mercury in coal. Mercury emissions from coal combustion in power plants in Mexico were calculated based on best typical value for mercury in bituminous coal: 0.105 ppmwt *(18)*.

Coal consumption by *CFE* in 1999 was 9,468,000 metric tons *(24)*. Since both Carbon plants have only electrostatic precipitators to control particles, no significant reduction in mercury emission is expected in these pollution control devices *(11)*. It was assumed a reduction of 21% in mercury content by the washing process *(11)*. Then, mercury emissions from Carbon I and II were estimated as <u>0.7855 Mg/yr</u>.

Industrial/Commercial Boilers

The EPA's <u>Mercury Study Report to Congress</u> *(11)* identifies mercury emissions from industrial/commercial boilers as a major source of mercury emissions in the U.S. Approximately half of these mercury emissions are associated with coal-fired industrial boilers. No coal use is reported in industrial/commercial boilers in Mexico *(13)*. Heavy oil and diesel fuel appear to be the principal fuel used in industrial/commercial boilers, with natural gas use also common in Mexican cities located on or near the U.S. border.

Mercury emissions from industrial and commercial boilers were estimated based on *INEGI's* published data on total heavy oil and diesel fuel used by the commercial and industrial sectors nationwide *(13)*. Diesel used for transportation is not included in these statistics. According to *INEGI's* statistics, wood is not used as a fuel by industry in Mexico. Assuming that industrial and commercial boilers have not installed any type of pollution control device, mercury emissions from the combustion of fossil fuels in these type of boilers were estimated as 0.0954 Mg/yr.

Residential Wood Combustion

According to *INEGI*, in 1998 Mexico consumed a total of 243.913×10^{15} Joules from wood (Since there was no information available regarding wood used as fuel in Mexico in 1999, figures for 1998 were used to estimate mercury emissions from this type of source). Assuming an average heating value for wood of 8, 989 Btu/lb *(19)*, Mexico consumed 11, 679,000 metric tons of wood in residential combustion processes. Using an emission factor of 0.1 grams of mercury per ton of wood burned, which is the average of the range assumed by Parcom-Atmos *(20)*, atmospheric emissions of mercury from residential wood combustion in Mexico were estimated as 1.168 Mg/yr.

Cement Plants

There are 31 cement plants in Mexico, 28 of which are operated by three cement manufacturing group: Cementos Apasco, Cementos Mexicanos and Cementos Cruz Azul. 25 of the Mexican cement plants are authorized to burn "alternate" fuels, including hazardous waste equaling from 5 percent up to 30 percent of the total heat input required by the process *(21)*. A number of the cement plants located in Mexico have taken advantage of this authorization, burning both waste combustible liquid and solid hazardous waste.

The project team had access to the annual emission inventory reports of 17 of the cement plants operating in 1999 *(22)*. These reports include cement production and fuel used by type of fuel. Total cement production for these 17 plants in 1999 was 19,330,136 metric tons with a consumption of 989, 320 m^3 of heavy fuel oil, 4,930 m^3 of Diesel and 221,160 metric tons of a variety of alternate fuel. These figures were used to extrapolate fuel consumption for the other 14 plants based on rated production capacity, resulting in mercury emissions of 0.0105 Mg/yr. Since actual cement production often is lower than installed capacity, this assumption may over estimate mercury emissions for this source.

Lime Plants

There are 80 registered lime plants in Mexico with a total rated capacity of 5,102,323 metric tons of hydrated lime and one plant with 140,000 metric tons of quick lime *(22, 57)*. The majority of these plants operate vertical or shaft kilns. Only a few utilize a rotary kiln for intermediary quick lime production. Only Mexicana de Cobre lime plant in Agua Prieta in the state of Sonora produces quick lime as its final product. All others commercialize hydrated lime.

The project team had access to records of 22 of the lime plants operating in Mexico and obtained data on lime production and fuel consumption for each *(22, 24)*. Emissions inventory for these 20 plants reviewed contained data only on gases of combustion and some on particles, but none on heavy metals.

Total lime production for these 22 plants in 1999 was 801,117 metric tons of hydrated lime with a consumption of 68,084 m^3 of heavy fuel oil, 723 m^3 of Diesel and 21,769,070 m^3 of natural gas and 119,300 metric tons of quick lime consuming 30,667 m^3 of heavy fuel oil 3.5 m^3 of Diesel and 33,979,895 m^3 of natural gas. No alternate fuel usage was reported. These figures were used to extrapolate fuel consumption for the other 58 plants based on rated production capacity. Using this approach, mercury emissions from lime plants were estimated as 0.003 Mg/yr. Since actual lime production often is lower than installed capacity, this assumption may over estimate mercury emissions for this source

Ferrous and Non-Ferrous Smelters

Primary Copper Smelters

Mexico is a major producer of copper, processing approximately 1,100,000 metric tons per year of copper concentrate at the Mexicana de Cobre copper smelter in Esqueda, Sonora and approximately 22,000 metric tons of copper in the Industrial Minera Mexico (IMMSA) plant in San Luis Potosi (*24*). The mercury concentration in this concentrate can range from less than 1 ppm to as much as 1,000 ppm, depending on the ore deposit being worked *(23)*. Copper concentrates processed by IMMSA contains 1.4 ppm of mercury as an average *(25)*. The Esqueda smelter is equipped with a state-of-the-art sulfuric acid plant to control and convert SO_2 emissions from the smelter furnaces and converters to sulfuric acid, while the San Luis plant operates with no control in place.

The acid plant at Esqueda is equipped with high efficiency wet electrostatic precipitators to protect the SO_2 catalysts from exhaust gas particulate. Virtually all mercury entrained in these exhaust gases is condensed and captured in this control system. A lead-, arsenic-, and mercury-laden sludge is produced by the acid plant particulate control system and diverted to holding ponds at the smelter. This sludge is eventually sent to the IMMSA copper smelter in San Luis Potosi for reprocessing *(23)*. It is likely that the mercury contained in the sludge would be emitted to atmosphere during the copper smelting process. Mexicana de Cobre performs routine analysis of mercury to its concentrates and sludge, as well as do test mercury in the exhaust gas from the acid plant, but do not report results to *INE*. IMMSA historically has not analyzed mercury in its process streams. Very recently they characterize feedstock and air emissions at the San Luis plant.

Figures of concentrate processed in 1999 *(22,24,26)* and data on mercury concentration obtained from personal communications (*25*) were used to estimate emissions of mercury from these sources to the atmosphere Assuming 98% efficiency in the pollution control system of the acid plant of Mexicana de Cobre smelter and knowing there is no emissions control in IMMSA plant, mercury emissions were estimated as of **1.543 Mg/yr** from these primary copper smelters.

Primary Lead and Zinc Smelters

Mexico has a primary lead smelting capacity of 360,000 metric tons/yr and a primary zinc smelting capacity of 380,000 metric tons/yr (*24*). There is only one primary lead smelter in México, Met-Mex Peñoles in Torreon. This Torreon plant, along with Industrial Minera Mexico (IMMSA) in San Luis Potosi, are the only two primary zinc smelters in the country. Peñoles is in the process of expanding its primary zinc smelting capacity from 260,000 t/yr to 400,000 t/y (*5*). Both plants are equipped with sulfuric acid plant to control and convert SO_2 emissions from the smelter furnaces and converters to sulfuric acid. Figures of concentrate processed in 1999 *(22,24)* and data on mercury concentration (20-25 ppm in Pb concentrates and 5-10 ppm in Zn concentrates) obtained from personal communications (*25, 27*) are used to estimate emissions of mercury from these sources to the atmosphere. Assuming 98% efficiency in the pollution control system of the acid plants of both Peñoles and IMMSA smelters, mercury is emitted at a rate of 0.1893 Mg/yr from Peñoles and 0.0183 Mg/yr from IMMSA. These figures do not take into account fugitive emissions which at least in the case of Peñoles caused this plant to exceed ambient SO_2 maximum allowable limits, as reported by *PROFEPA*, the environmental enforcing agency in Mexico*(La Cronica, March 2, 2001)*.

Secondary Lead and Zinc Smelters

No attempt was made to estimate mercury emission from secondary lead and zinc smelters in México.

Ferrous Smelters

The iron and steel industry is comprised of five major producers and a group of smaller plants known under the generic name of "*acerías*" (steel foundries). Total combined steel production in Mexico was of 14,213,000 metric tons in 1998.

Mercury emissions from ferrous smelters in Mexico were estimated assuming that mercury is emitted only from the combustion processes during production of primary iron ("arrabio"). Fuel consumption in this process, including coke usage, was taken from I*NEGI's* published data *(24)*. Using EPA's coke emission factor of 2.724×10^{-5} (*11*), mercury emissions from ferrous smelters in Mexico were estimated to be 0.086 Mg/yr.

Oil Refining

There are six *PEMEX's* oil refineries in Mexico which processed 1,228,000 barrels of crude oil per day in 1999. These are generally basic refineries that produce a fairly high percentage of heavy oil. It is likely that the majority of the Hg present in the crude oil processed by these refineries is concentrated in the heavy oil, due to the relatively high boiling point of Hg, ~670 ^{o}F, though significant fractions of the total Hg present in the feedstock could also be present in the distillate oil fraction (diesel), as well as the refinery fuel gas produced in the atmospheric fractionation tower. As a result, any Hg present in the feedstock crude oil that does not remain in the heavy oil or distillate product would probably be emitted in the exhaust gases produced by refinery heaters and boilers.

No estimate of mercury emissions from petroleum refining was made in the EPA's Mercury Study Report to Congress. The EPA cited insufficient data on Hg concentrations in the crude oil feedstock and refined products to develop a credible emission factor. The EPA has recommended that more analyses of oils and refinery stack emissions are needed to determine the significance of petroleum refineries as a source of Hg emissions, but considered 3.5 ppb as the best typical value so far for mercury in crude oil *(14)*. However, for the purpose of estimating mercury emissions from oil refineries, the project team will use the average value of 13.5 ppbwt of Hg content in crude oil as determined by ITS Caleb-Bret laboratory.

By assuming that mercury that does not remain in the heavy oil (446,000 barrels/day) *(28)* or distillate product (290,000 barrels/day) is emitted in the exhaust gases produced, mercury emissions from crude oil refineries were estimated as 0.680 Mg/yr.

Hazardous Waste Incinerators

In Mexico there are no incinerators of municipal solid waste. Except for two incinerators of expired pharmaceutical products authorized since 1993 and 1995, most incinerators of hazardous (HW) in Mexico started operation very recently. The number of operating incineration facilities in Mexico is changing constantly: there were 11 HW incinerators authorized in 1999 with a combined incineration capacity of 65,391 metric tons per year of hazardous waste; 17 in 2000 and the most recent list includes 14 of these plants operating with a total incineration capacity of 103,000 metric tons of hazardous waste per year *(21)*.

Since no data is available regarding actual amount of hazardous waste incinerated, mercury content in feedstock to incinerators as well as results of emission tests, no attempts were made to estimate mercury emissions from this source. In the *INE's Diagnóstico del Mercurio en México, 2000* *(7)*, it was assumed that actual amount of hazardous waste incinerated was only 10% of total incineration capacity and used a mercury emission factor of 3.0 g/Mg. Using these assumptions resulted in an estimated mercury emission of 0.020 Mg/yr, not including in this estimate hazardous waste burnt in cement plants as alternate fuel.

Medical Waste Incinerators

Of the 27 incinerators of medical waste (MW) authorized in Mexico, 24 are actually operating with a combined incineration capacity of almost 9 metric ton per day of medical waste. With few exceptions, most started operations in 1997 and 1998. The project team reviewed mercury emission records of 21 of these MW incineration facilities *(22)*. Most data reported combined emissions of cadmium and mercury as one single figure, since *INE* established a maximum emission limit of 0.2 mg/m^3 of Cadmium and Hg together. A new proposed standard for medical waste incinerators (NOM-ECOL-098/99) sets a maximum emission limit of 0.07 mg/m^3 of mercury.

In the *INE's Diagnóstico del Mercurio en México, 2000* *(7)*, it was assumed that actual amount of medical waste incinerated was 40% of total incineration capacity and used a mercury emission factor of 0.96 g/ton. Using these assumptions resulted in an estimated mercury emission of 0.007 Mg/yr.

Other Industrial Sources of Mercury Emissions

Mercury is used in several industrial applications including the manufacturing of a diverse range of instruments and devices such as batteries, thermometers, sphygmomanometers, electrical switches, thermal and electrical sensors, fluorescent lamps and dental amalgams, among others. Mercury has applications in polyvinyl chloride, acetate, and acetaldehyde production, explosives production, pharmaceutical industries and also in religious and cultural practices. Until very recently it was used in paints, pesticides, slimicides (in pulp and paper plants), and cosmetic creams. INE estimated a mercury consumption in Mexico over 13 tons in 1998 *(23)*. Fluorescent lamps and dental amalgams have been identified as the two major sources of atmospheric mercury emissions from manufacturing operations in Mexico. Both are described below.

Fluorescent Lamps

The EPA's Mercury Study Report to Congress *(11)* did not identify mercury emissions from fluorescent lamp manufacturing facilities, but included only emissions from lamp recycling. No attempts were made either to account for mercury emitted by lamp breakage. In Mexico, there is no recycling of fluorescent lamps or of any other mercury containing electric device.

INE estimated that 25 % of the mercury contained in a tube lamp is emitted to air at the time a lamp breaks and that about 98 % of all lamps in used breaks during one year *(7)*. Using these figures, it was estimated that mercury atmospheric emissions from fluorescent lamp breakage in Mexico were 0.229 Mg/yr. Mercury emissions estimated this way, may be underestimated because no consideration is given to emissions generated during the lamp manufacturing itself.

Dental Amalgams

Mercury is emitted from dental amalgam during amalgam formulation operations and from spills and scrap in the dentist offices during dental preparation. No information has been compiled regarding amount of dental amalgam formulated in Mexico. Amalgam is prepared by several private laboratories *(www.cosmos.com.mx)* as well as in dentist offices. According to the Mexican Dental Association, 70 % of dentists still formulate their own amalgam *(29)*. Typical amalgam formulation has the following composition: 34.65 % Silver, 8.95 % Tin; 5.90 % Copper; 0.5 % Zinc and 50.0% of Mercury *(www.dentsply.com.mx)*.

According to USGS estimates, 90 % of mercury used in dental applications is formulated in amalgams. From this, additionally 8 % is lost in the dental office during the first year, assuming a life time of 10 years for amalgams. *INE* estimated that in Mexico 1.51 metric tons of mercury are discarded from dental amalgam each year *(7)* and EPA reported that 2 percent of mercury used in dental amalgam is emitted into the atmosphere *(11)*. Using these figures, it was estimated that mercury emissions from amalgam during dental preparation/removal were 0.378 Mg/yr.

Other minor sources of atmospheric mercury emissions in Mexico estimated includes carbon black plants, pulp and paper plants, coke manufacturing, thermometers and crematories with a total combined emissions of mercury of 0.1153 Mg/yr. Sewage sludge incineration facilities were not included as potential sources of mercury emissions, since there are no such type of facility known to be operating in Mexico at this time *(21)*.

SUMMARY OF ESTIMATES OF ATMOSPHERIC MERCURY EMISSIONS IN MEXICO

Table 2. Estimated Emissions of Mercury in Mexico (1999)

Source of emission	Hg: Mg/yr
Gold mining and refining	11.270
Mercury mining/refining	9.666
Chlor-alkaly plants	4.902
Copper smelters	1.543
Residential Wood Combustion	1.168
Carboelectric plants	0.7855
Oil refineries	0.680
Amalgams	0.378
Fluorescent lamp	0.229
Primary Lead and Zinc smelters	0.208
Thermoelectric plants	0.1263
Industrial commercial boilers	0.0954
Ferrous smelters	0.086
Coke manufacturing	0.055
Pulp and paper plants	0.024
Hazardous waste incinerators	0.020
Carbon black plants	0.0183
Thermometers	0.018
Cement plants	0.0105
Medical waste incinerators	0.007
Lime plants	0.003
Secondary Lead and Zinc smelters	---
Crematories (not determined)	---
Total Hg Emissions Estimated	**31.293**

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