

**Inventories of Mercury, Mercury Compounds
And Mercury-containing Product Uses and
Releases and Development of Associated
Mercury Action Plan**

DENR-EMB/UNEP

OUTLINE

I. Introduction

II. Mercury Inventory Toolkit (UNEP)

II. Assessment of Sources of Mercury

III. Project Framework

Mercury, Hg

- the only metal that is liquid at room temperature
- has the highest solubility of any metal in water
- vaporizes readily into the atmosphere

Forms of Mercury

- Elemental Mercury – mercury in its purest form; exposure to this form of mercury usually comes through breathing mercury vapor, Hg^0
- Methylmercury – the primary form of mercury to which people are exposed. It is an organic compound (contains carbon) which can be bioaccumulated in the food chain, CH_3Hg
- Other mercury compounds (organic and inorganic) – exposure through ingestion of these compounds

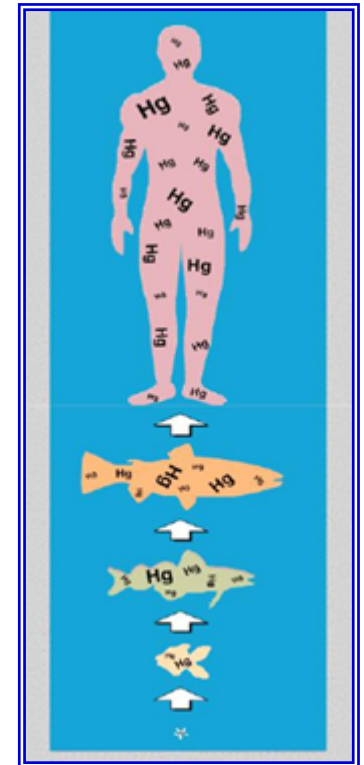
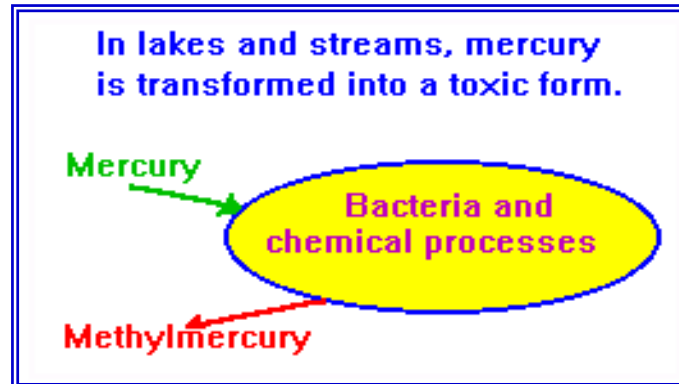
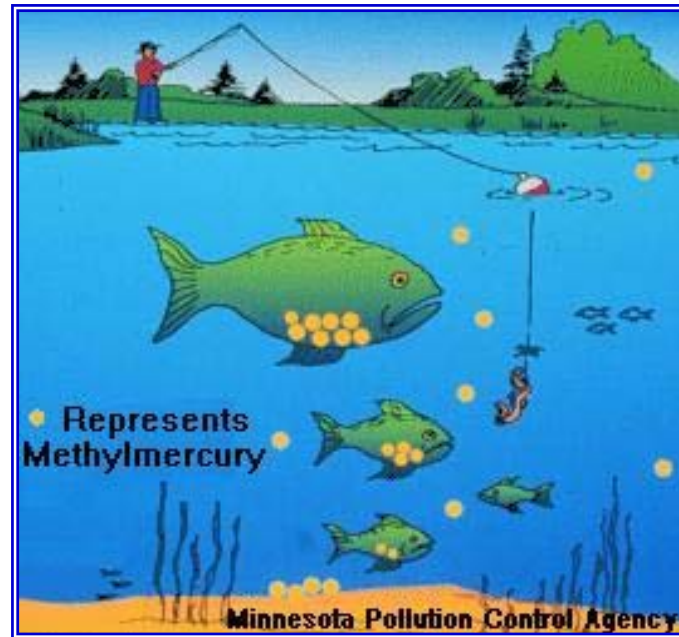
Unfortunate Characteristics of Mercury

- Bioaccumulation
- Local deposition
- High toxicity
- Teratogenic effects, i.e., affects fetus
- Persistent organic pollutants

Mercury uptake thru Fish Consumption

Metabolic conversion and bio-accumulation through “food-chain”

- Hg in sediments converts into methylmercury (MeHg)
- MeHg enters the aquatic food chain: fish, marine and freshwater
- MeHg uptake by humans through fish consumption



General Source or Emission Pathway of Mercury

- Natural occurrence
- Anthropogenic (associated with human activities)

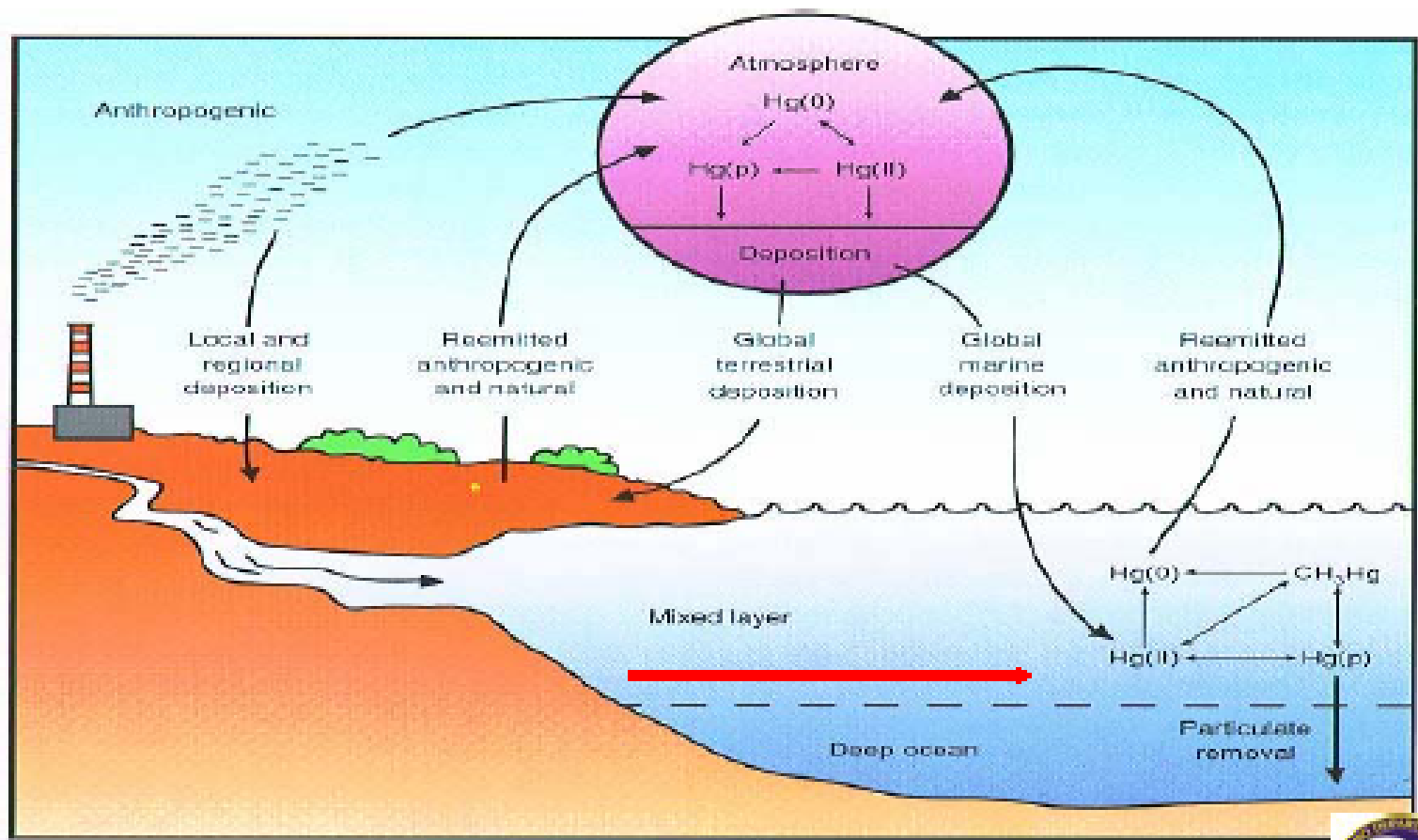
5,500 metric tons of mercury is released into Earth's atmosphere each year ^[1]

- 30% is result of natural emissions from sources like volcanoes
- 70% is manmade

[1] Trasande L, Landrigan PJ, Schecter C. Public health and economic consequences of methyl mercury toxicity to the developing brain. *Environmental Health Perspectives*. 2005;113:590-596.

Where Does Anthropogenic Mercury Come From?

The Geochemical Cycle of Mercury



Adapted from US Dept. of Interior's Report on Hg in the Florida Everglades



UNEP Global Mercury Inventory and Assessment

- Initiated by UNEP Governing Council at its 21st session in February 2001

Objectives

- Identification and quantification of mercury emissions in a given country
- Identification and evaluation of the population at risk
- finding potential pollution prevention measures to reduce mercury emissions and releases

UNEP Mercury Inventory Toolkit

- lists all the possible source categories of mercury emissions and the possible release pathways for each category.
- Accompanied by an excel file to calculate the emissions in different pathways of release- land, air water and general wastes
- Standardized format to be followed by the participating countries
- The basic formula is

Hg emission = Activity rate x input factor x distribution factor

A = activity rate, ton/year

i = input factor or the amount of mercury in a given category, kg Hg/ton

f = distribution factor

Hg emission = kg Hg/year

Assessment of Mercury Inventory

Based on the UNEP Toolkit, the following categories and subcategories are the sources of mercury releases to the global environment.

1. Natural Sources
2. Current Anthropogenic releases from the mobilization of mercury impurities in raw materials
 - coal fired power plants
 - Cement production
 - Mining and other metallurgical activities

3. Current Anthropogenic releases resulting from mercury used intentionally in products and processes

- mercury mining
- small scale gold and silver mining
- chlor-alkali production
- fluorescent lamps, manometers, thermometers
- dental amalgam fillings
- manufacturing of products containing mercury
- waste treatments and incineration
- cremation

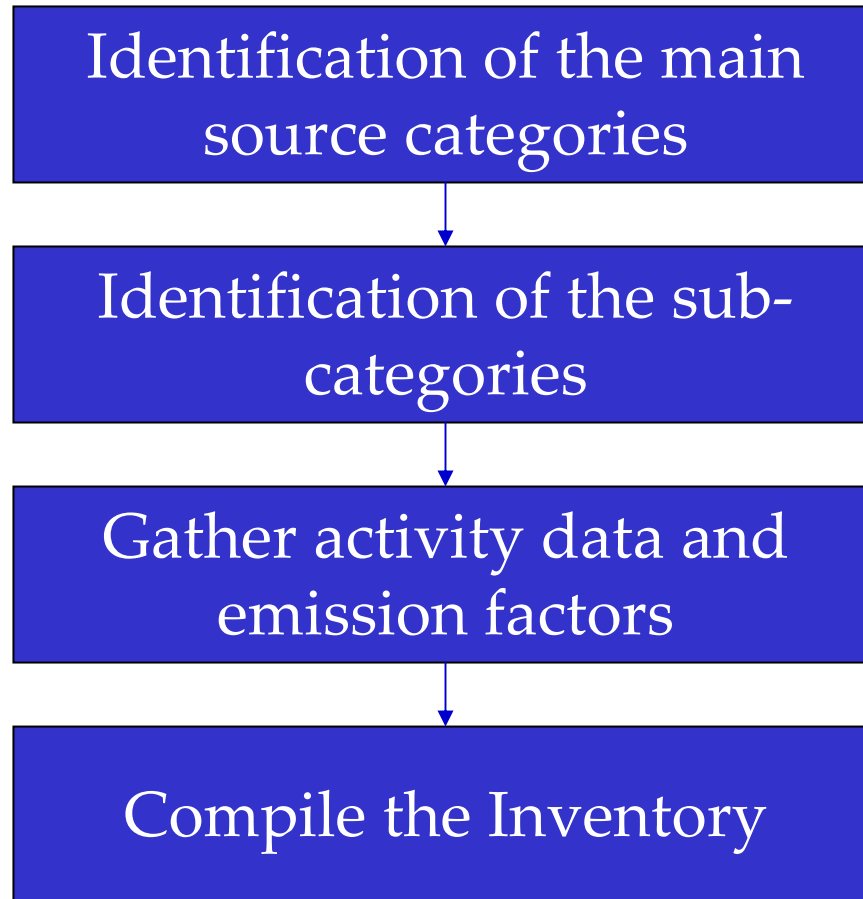
4. Re-mobilization of historic anthropogenic mercury releases previously deposited in soils sediments, water bodies, landfills and waste/tailings piles.

Mercury Inventory in the Philippines

Major Sources of Mercury Emissions in the Philippines

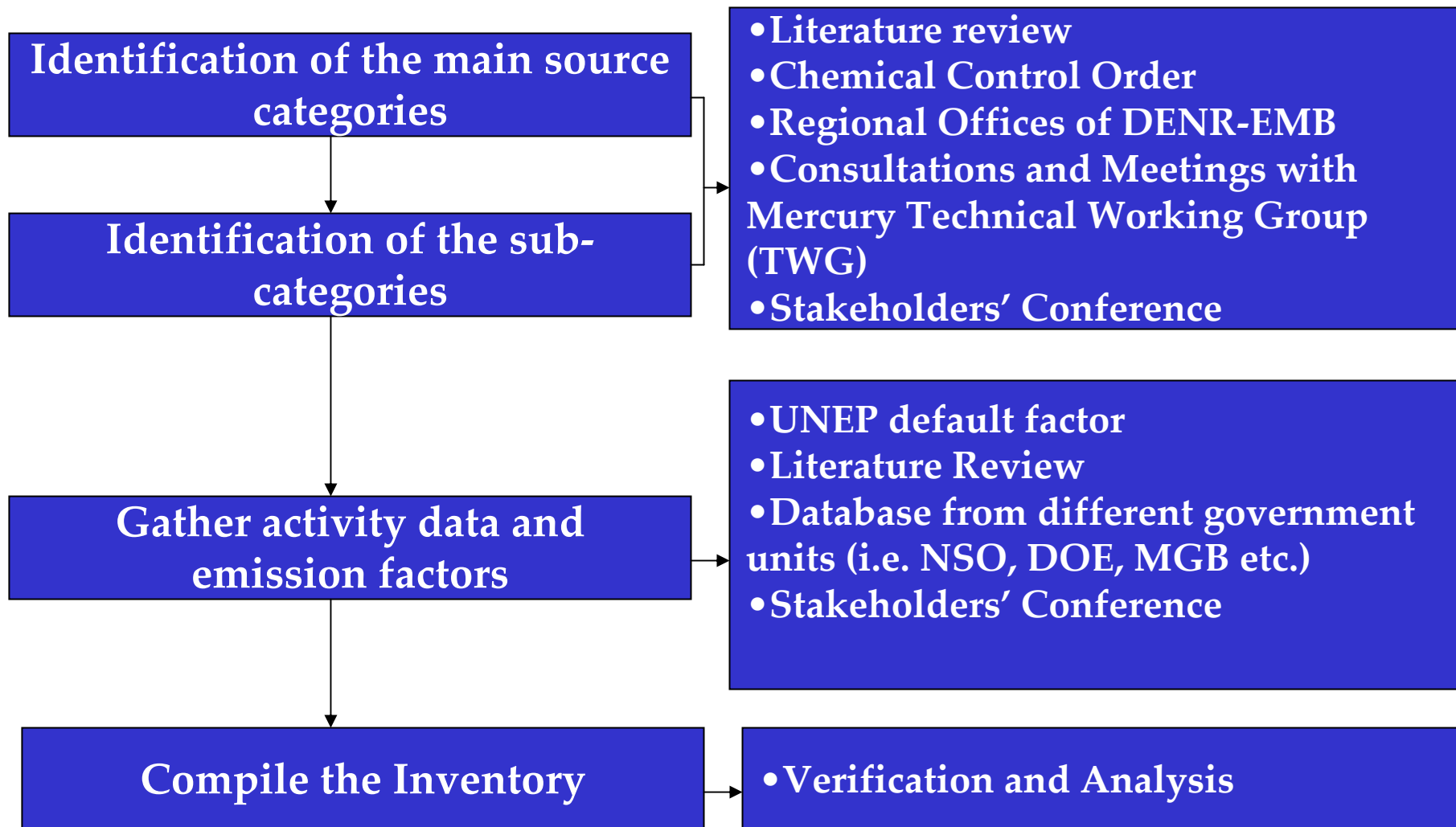
- Coal Combustion
- Gold and Silver Mining
- Refuse Burning
- Intentional use of Mercury in industrial processes
- Thermometers, Manometers
- Electric and Electronic Switches and Lamps

Project Framework



Activity

Methodology



Expected Outcomes from the Inventory

- A baseline data for the possible mercury emissions in the country
- Increased public awareness on the health and environmental effects of mercury
- An associated mercury action plan for the sound management of mercury compounds and mercury containing products
- Review of the UNEP Inventory Toolkit

Preliminary Data for the Mercury Inventory in the Philippines

Assumptions:

- Estimation on the emissions of mercury were based on the maximum default input factor of UNEP
- Statistical data were based from secondary data (i.e. DOE, USGS, DOH, CEMAP)

Initial Mercury Inventory-Philippines*

Category	kg Hg/year	%
Extraction and Use of Fuel and Energy Resources	47,862	13.08
Primary Virgin Metal Production	128,735	35.19
Production of other minerals with mercury impurities	2,415	0.66
Intentional use of mercury in industrial processes	8,400	2.30
Consumer products with intentional use of mercury	48,123	13.15
Other intentional use-thermometer etc	99,071	27.08
Wastewater	29,685	8.11
Crematoria	1,530	0.42

*Using the maximum default input factor

Extraction and Use of Fuels/energy sources

- Coal Combustion in large power plants
- Other Coal Use
- Extraction, refining and use of mineral oil
- Natural gas extraction
- Geothermal power production

Coal combustion in large power plants:

Activity rate: 10. 103 million tons per year

Reference: Philippine Energy Data 2005

Assumption: All coal consumption of the country is for the coal-fired power plants

Default input factor: 0.5 g Hg/ton

Emission pathway: 90% air and 10% general waste

Extraction, refining and use of mineral oil:

Activity rate: 372 333 ton/year

Data for calculation:

Power generation: 4,152 GWh (DOE, 2006)

Gross Calorific Value for diesel: 45.66 GJ/ton (IEA)

Conversion factor:

$$1\text{TJ} = 0.2778 \text{ GWh}$$

Default input factor: 100 mg Hg/ton

Emission pathway: 90% air and 10% general waste

Natural gas use:

Activity rate: 2.89 billion normal cubic meters per year

Assumption: all the consumption of natural gas is from raw or pre-cleaned gas

Reference: Philippine Energy Profile EIA

Default input factor: 200 $\mu\text{g Hg/Nm}^3$

Emission pathway: 100% air

Geothermal production:

Activity rate: 10 465 GWh/year

Reference: DOE 2006 Power Generation by Source

Input factor: 4 g Hg/MWh (Bacci et.al)

Emission pathway: 100% air

Data gaps:

- Other coal use such as power plants < 300MW were not considered
- Coke production exists in the Philippines but no data for the activity rate
- Data on other uses of crude oil such as in the polymerization process or in the manufacture of plastic products
- Biomass fired power and heat production were not considered. Heating and cooking in residential households using biomass is a common practice in rural areas

Primary Virgin Metal Production

- Gold and silver extraction with mercury amalgamation process
- Copper extraction
- Lead extraction

Gold and Silver Production:

Activity rate: 37 830 kg gold and silver/year

Reference: 18 680 kg annual gold production
(Makati Business Club)

19 150 kg silver mine output
(USGS Minerals Yearbook 2005, Volume III)

Input factor: 3 kg Hg/kg gold and silver

Emission pathway: 60% air, 20% water, 20% land

Copper Production:

Activity rate: 16 320 ton concentrate/year

Reference: USGS Minerals Yearbook, Volume III

Input factor: 15 g Hg/t

Emission pathway: 20% air, 40% water, 40% land

Lead Production :

Activity rate: 75 000 ton lead concentrate per year

Source Data:

30 000 ton /year production rate
(USGS Minerals Yearbook 2005, Volume III)

Lead ore in the Philippines is approximately
50% lead content

Assuming 80% plant efficiency

Input factor: 200 g Hg/ton

Emission pathway: 10% air, 30% land, 30% water, 30% sector
specific

Production of other minerals and materials with mercury impurities

- Cement production
- Pulp and paper production
- Production of lime

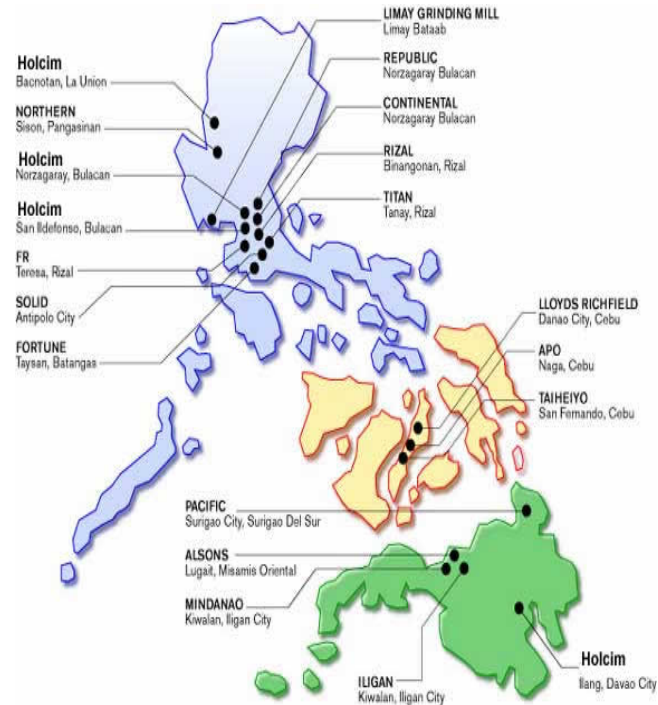
Cement Production :

Activity rate: 12 033 kilo ton cement/year

Source Data: CEMAP 2007

Input factor: 0.1 g Hg/t cement

Emission pathway: 100% air



Pulp and paper production :

Activity rate: 308, 542 ton pulp and paper/ year

Source Data:

Company	Production, tons
Trust International Paper Corporation	230 ⁺
National Tobacco Administration	3,000 ⁺⁺
Fiber Industry Development Authority	30,312 ⁺⁺⁺
Bataan 2020	80,000 [*]
United Pulp and Paper Co., Inc.	195,000 [*]

Input factor: 1.95×10^{-5} kg Hg/ton pulp and paper

Emission pathway: 100% air

Lime Production :

Activity rate: 47,957 ton lime/ year

Source Data:

Company/Location	Production, tons
Guimaras	5,000*
Negros Integrated Industries Corporation	36,000**
Quezon	6,957***

Input factor: 5.5×10^{-5} kg Hg/ton lime

Emission pathway: 100% air

Intentional Use of Mercury in Industrial processes

- Chlor-alkali production with mercury technology

Activity rate: 21,000 ton Cl₂/ year

Source Data:

Mabuhay Vinyl Corporation plant capacity

Input factor: 400 g Hg/t Cl₂ per year

Consumer Products with intentional use of Mercury

- Thermometers with mercury
- Electrical Switches
- Light Sources with mercury
- Batteries with mercury production
- Paints with mercury
- Cosmetics and other related products

Thermometers :

Activity rate: 131,765 thermometers

Source data and assumptions:

- breakage rate of 5 %
- number of nursing students and other medical courses
- bed capacity of hospitals

Input factor: 1.5 g Hg/item

Emission pathway: distributed in land, water and air

Electrical switches:

Activity rate: 88.7 M inhabitants

Source Data: National Statistics Office

Input factor: 0.25 g Hg/per year/inhabitant

Emission pathway: distributed in air, land and general waste

Light sources with mercury:

Activity rate: 588.5 million units of double end
147.1 million units

Source Data: need further verification on the
assumptions used in the report

Input factor: 40 mg Hg/unit

Other intentional product/process use

- Dental Mercury-Amalgam Fillings
- Manometers and gauges with mercury
- Laboratory chemicals and equipment with mercury
- Miscellaneous product uses, mercury Metal uses and other source

Dental mercury amalgam fillings:

Activity rate: 88.7 million inhabitants

Source Data: National Statistics Office

Input factor: 0.20 g Hg/inhabitant

Manometers and gauges with mercury:

Activity rate: 173 barometers

Source Data: NEDA, PAG-ASA

Assumptions: Only the barometers in airports and weather stations were considered and a 1:1 ratio was used

Input factor: 600 g Hg/unit

Laboratory chemicals and Equipment with mercury:

Activity rate: 10 920 463 units

Source Data: need further verification on the assumptions used in the report

Input factor: 6 g Hg/unit

Miscellaneous products Uses, Mercury Metal Uses and Other Sources

Activity rate: 57 lighthouses

Source Data: Stockinger's report

Input factor: 600 kg Hg/lighthouse

Waste deposition/landfilling and wastewater treatment:

Activity rate: 457 718 metric tons waste disposal
1 961 500 000 cubic meters wastewater

Source Data: USAID, 2008

Input factor: 10 mg Hg/cubic meter
15 g Hg/ton waste

Crematoria and cemeteries

Activity rate: 382 418 corpses (excluding infant death)

Source Data: NSO

Assumptions: 1% of the total death were cremated

Input factor: 4 g Hg/corpse

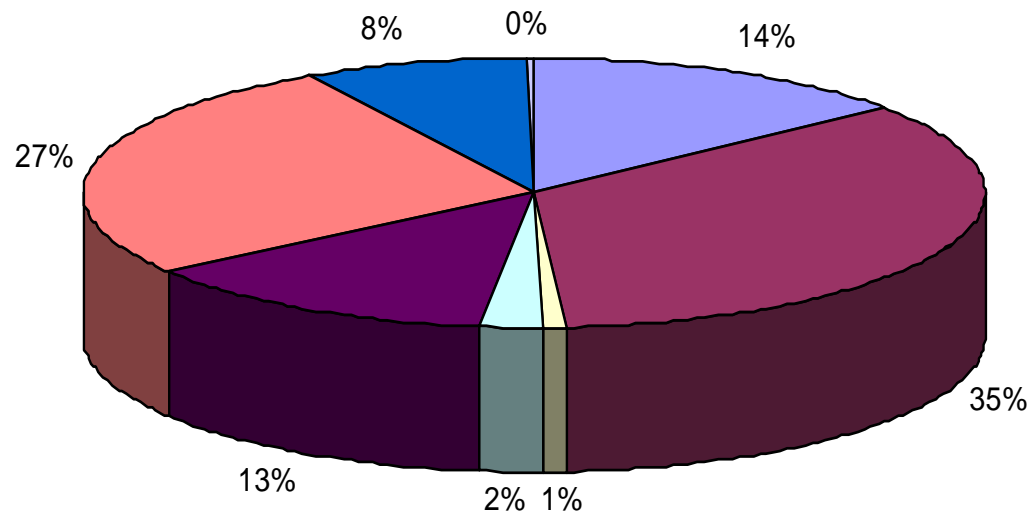
Data gaps:

- Incineration was not considered in the inventory because of the “incineration ban” but some hospitals were given permit for medical wastes incineration
- Mercury in batteries were also not considered in the calculation
- Mercury in paint was also not considered in the calculation

Potential Hot-spots:

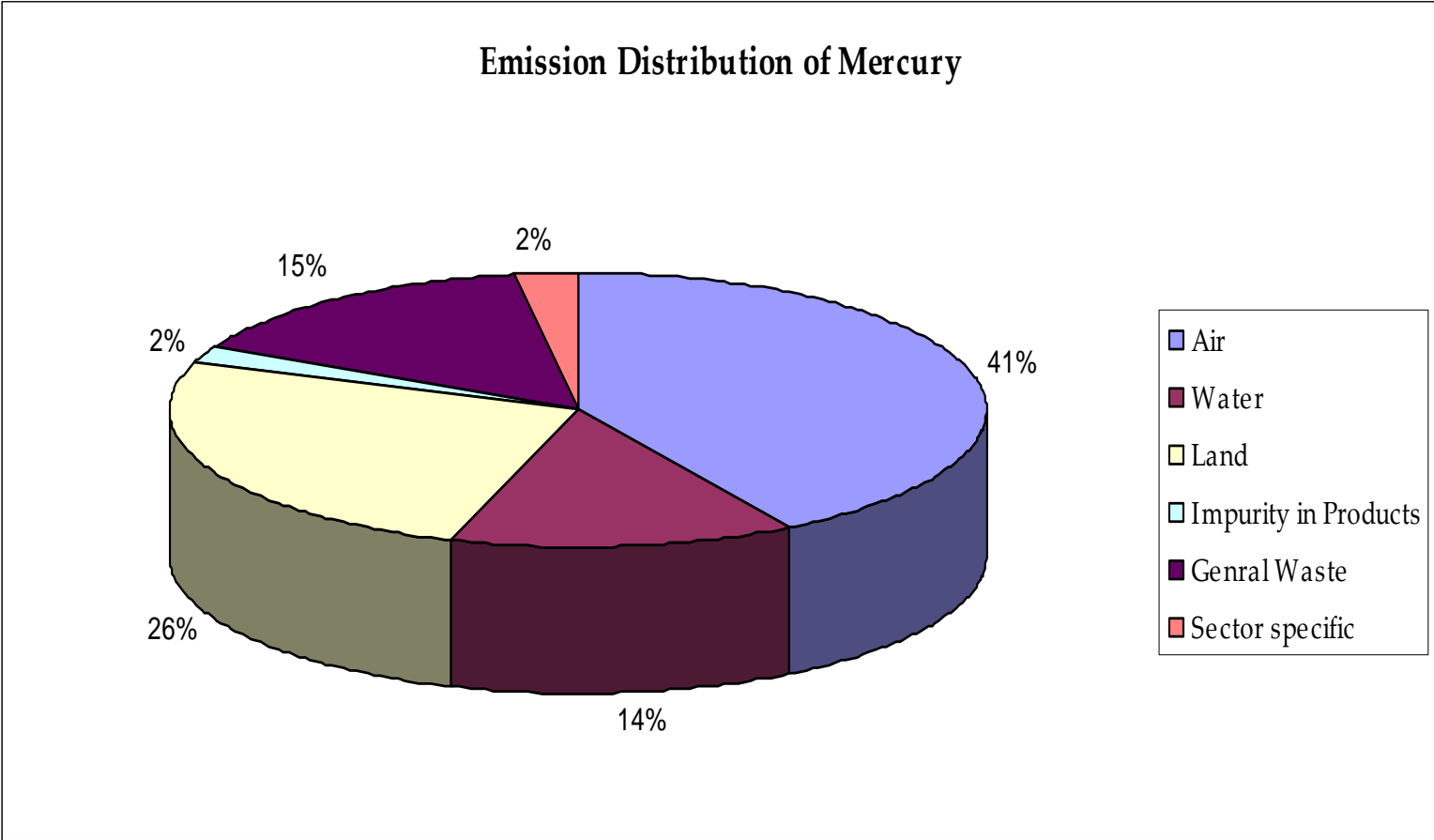
- Other sites of former chemical production where mercury compounds are/were produced (pesticides, biocides, pigments)
- Tailings/residue deposits from abandoned mining area
- Mercury spills in schools

Initial Mercury Inventory-Philippines



- Extraction and Use of Fuel and Energy Resources
- Primary Virgin Metal Production
- Production of other minerals with mercury impurities
- Intentional use of mercury in industrial processes
- Consumer products with intentional use of mercury
- Other intentional use-thermometer etc
- Wastewater
- Crematoria

Emission Inventory of Mercury (mostly to air)





Thank you

