MERCURY
Its Properties, Sources and Health Effects

Prepared and annotated by

Jorge Emmanuel, PhD, DES, REP, PE, CHMM
Professor of Chemical Engineering & Chief Technical Advisor, UNDP GEF Project

Peter Orris, MD, MPH, FACP, FACOEM
Professor & Director, Global Toxics Policy Center, School of Public Health, University of Illinois at Chicago
MERCURY

Silver-colored, odorless, liquid metal at room temperature
MERCURY

Cinnabar (mercury ore)

Tomb of Mayan King Pakal was sprinkled with cinnabar 683 CE

Slave mines during the Roman era

Tomb of Mayan King Pakal was sprinkled with cinnabar 683 CE
The global air emissions of mercury from human activities is about 1930 tonnes per year.
• Levels of mercury in the environment have significantly increased since pre-industrial times

Global mercury emissions to air from human activities in 2005 by regions

- Asia, 66.5
- North America, 7.9
- Europe, 7.8
- Oceania, 2
- Russia, 3.9
- Africa, 5
- South America, 6.9
Properties of Mercury

- Properties of Mercury
  - Chemical forms
  - Volatilization
  - Persistence in the environment
  - The Mercury Cycle
- Bioaccumulation
- Toxicity
Chemical Forms of Mercury

• **Elemental**
  – Liquid metal

• **Inorganic**
  – Mercuric chloride
  – Mercuric sulfide (cinnabar)

• **Organic**
  – Methyl, ethyl, dimethyl
  – Phenyl organic groups
Volatilization of Mercury

Mercury droplets on a carpet

Mercury vapors from the carpet seen under UV light and a fluorescent screen

Bowling Green State University: http://wbgustream.bgsu.edu/bgsu/epa/index-fl.html
Persistence of Mercury in the Environment

- Mercury cycle
  - Emitted from human activities & natural sources
  - Circulates in the atmosphere from 6 months to 1½ years
  - Deposited back into land or bodies of water
  - Converted into insoluble forms, settling into sediment
  - Converted by bacteria into methyl mercury and enters the food chain
  - Released back into the atmosphere by volatilization

Source: New York State Department of Environmental Conservation
Biomagnification of Mercury

ppt = parts per trillion (mercury concentration)

Source: South Florida Restoration Science Forum
Health Effects of Mercury (Hg)

• Depend on the form of mercury, type of exposure (acute or chronic), route of exposure, dose

EXCEPTIONS:

• Acute exposure to high levels of elemental Hg
  – tremors, slowed motor nerve functions, memory loss
• Acute inhalation of high amounts of elemental Hg
  – chest pains, acute renal failure, shortness of breath
• Acute ingestion of inorganic Hg
  – nausea, vomiting, abdominal pains
• Chronic exposure to inorganic Hg
  – kidney damage
Chronic Exposure to Elemental Hg

• Classic triad of the “Mad Hatter” syndrome
  – Erethism
  – Tremor
  – Gingivitis
• Renal impairment
Chronic Exposure to Elemental and Inorganic Mercury

- Acrodynia (Pink disease)
- Affects children
- Toxic/Allergic syndrome
- Symptoms
  - Skin rashes
  - Hypertension
  - Fever
  - Pneumonia
  - Pink, peeling hands and feet
Health Effects of Organic Forms of Hg

• Organic
  – Methyl, ethyl, dimethyl, and phenyl organic groups

• Methyl mercury
  – Absorbed by the body six times more easily than inorganic mercury
  – Crosses the placenta and concentrates in the central nervous system

• Mercury dumped in Minamata Bay, Japan by Chisso Corporation from 1932 to 1968 resulting in Minamata disease
Chronic Exposure to High Levels of Methyl Mercury

- **Minamata disease**: 2,265 cases confirmed in Minamata, Japan as of March 2001
- **Effects**:
  - Constriction of visual fields
  - Irregular gait
  - Loss of muscular coordination
  - Loss of speech, hearing, and taste
  - Emotional disturbance
  - “Living wooden dolls”
- **Congenital Minamata disease** diagnosed in 1961

Photo: William Eugene Smith
16-year old child with congenital Minamata disease
Health Effects of Prenatal Exposure to Mercury: Faroe Islands Study

- Prospective cohort study of 700 mother-infant pairs
- Exposure to methylmercury from pilot whale meat indicated by mercury levels in umbilical cord blood and maternal hair
- **Mean mercury levels in mothers’ hair was 6.8 ppm (range 0.5-27 ppm)**
- Study controlled for PCB exposure from whale meat
Mercury: Effects of Low Dose Prenatal Exposure


Children with low prenatal mercury exposure

Children with high prenatal mercury exposure

μg/l

% Faroe Island Children with lowest scores at age 7 years

- Motor
- Attention
- Visuospatial
- Language
- Memory

< 15 µg/l

15-30 µg/l

30-50 µg/l

> 50 µg/l

Per cent of children with low test scores at age 7 years

0

10

20

30

40
Seychelles Study

- Fish have relatively low methylmercury concentrations (<0.3 ppm)
- Mean mercury levels in mothers hair 6.3 ppm (range 0.5-27 ppm)
- Adverse effects on development or IQ were not found in the Seychelles study to 9 years of age.

GJ Myers et al., Lancet, 361, 1686-1692, 2003
Long-chain polyunsaturated fatty acids and mercury

- Adverse associations were found between prenatal methyl mercury exposure and the Psychomotor Development Index of children at 30 months when long-chain polyunsaturated fatty acids were accounted for.

- Beneficial effects of long chain polyunsaturated fatty acids in fish mask the deleterious effects of fetal methyl mercury exposure.

PW Davidson, et al., NeuroToxicology, 29(5), 767-775, September 2008
Prenatal methyl mercury exposure sufficient to increase the mercury concentration in maternal hair at child birth by 1 micrograms per gram could decrease the child’s IQ by about 0.7 points.

Public Health and Economic Consequences of Methyl Mercury Toxicity to the Developing Brain

- Lost productivity due to methyl mercury toxicity amounts to $8.7 billion annually.
- Of this amount, $1.3 billion is attributable to mercury emissions from U.S. power plants.

Maternal Fish Consumption and Risk of Preterm Delivery

Compared with women delivering at term . . . women who delivered before 35 weeks’ gestation were more likely to have higher hair mercury levels.

F Xue, C Holzman, MH Rahbar, K Trosko and L Fischer, Environmental Health Perspectives, Vol. 115, No. 1, January 2007
# Summary of Health Effects of Methyl Mercury on Humans

<table>
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<th>Death</th>
<th>Acute</th>
<th>Intermediate</th>
<th>Chronic</th>
<th>Immunologic</th>
<th>Neurologic</th>
<th>Reproductive</th>
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- **Inhalation**
- **Oral**
- **Dermal**

*Existing Studies (ATSDR 1998)*
GREAT LAKES
FISH CONSUMPTION
ADVISORIES

The Public Health Benefits and Risks
Discussion Paper prepared by the Health Professionals Task Force for the International Joint Commission

January 2004
Hg Exposure Potential from Seafood

- Swordfish, shark $\geq 1$ ppm
- Tuna steak $\approx 0.3 - 0.5$ ppm
- Canned tuna $\approx 0.1 - 0.3$ ppm

- 1/month consumption of swordfish/shark = RfD
- $>2$ times/week of canned tuna $>\text{RfD}$

ppm = concentration in parts per million
RfD = Reference Dose
Mercury and Omega-3 Fatty Acids

- Additional data in 2003 raised interest in mercury as a cardiac toxin.

- Omega-3 fatty acids in fish are cited as a health benefit of fish and shellfish to help protect against heart disease.

- Substantial species-specific differences in the distribution of mercury and of omega-3s.
  - Species high in mercury ... not necessarily high in omega-3s
  - Species high in omega-3s ... not necessarily higher in mercury
Keep Mercury Out Of The Fish
Not Fish Out Of The Mother!
Mercury Sources

• **Major global sources include:**
  - Coal combustion
  - Gold mining, metal production
  - Waste incineration
  - Product-use

• **Major sources from the health sector:**
  - Medical waste incineration
  - Mercury-containing products
Environmental Mercury and Medical Waste Incinerators

- In the United States, medical waste incinerators accounted for 10% of the total mercury emissions from combustion sources in 1995 (before hospital incinerators started shutting down).

Source: US EPA
Healthcare Products Containing Mercury

- **Product**
  - Hg thermometers
  - Hg-based blood pressure monitoring devices
  - Esophageal devices, Cantor & Miller-Abbott tubes
  - Hg dental amalgams
  - Hg batteries
  - Lamps & lighting devices
  - Hg switches

- **Alternatives**
  - Digital, alcohol, galinstan
  - Aneroid, electronic (oscillometric)
  - Tungsten-filled dilators, products w/ tungsten tubing Anderson AN-20
  - Composite resin, porcelain
  - Lithium, zinc air, alkaline
  - Non-Hg lamps, LEDs
  - Non-Hg switches
Mercury-Free Alternatives

- Studies show that alternatives can be as accurate as mercury devices
- Mercury-free alternatives must meet existing standards
- Alternatives of unknown quality should be validated before use
- Like mercury sphygmomanometers, aneroid blood pressure devices should be periodically maintained and calibrated
Policy on Mercury in Health Care

**Short Term:** Develop and implement plans to reduce the use of mercury equipment and replace with mercury free alternatives. Address mercury clean up, waste handling and storage procedures.

**Medium Term:** Increase efforts to reduce use of unnecessary mercury equipment

**Long Term:** Support a ban of mercury containing devices and promote alternatives.

www.who.int/water_sanitation_health/medicalwaste/mercury/en/
THE GLOBAL MOVEMENT FOR MERCURY-FREE HEALTH CARE

How health care leaders around the world are substituting mercury-based medical devices with safer, environmentally sound alternatives.

www.mercuryfreehealthcare.org    www.noharm.org
Acknowledgements

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Source: Health Care Without Harm