Concerns over Mercury Pollution in Asia

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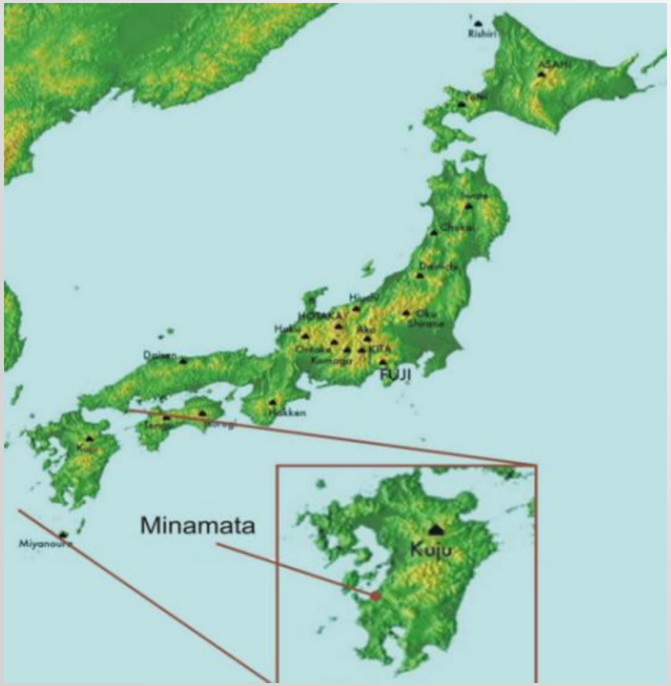
Minamata Disease and Hg Pollution

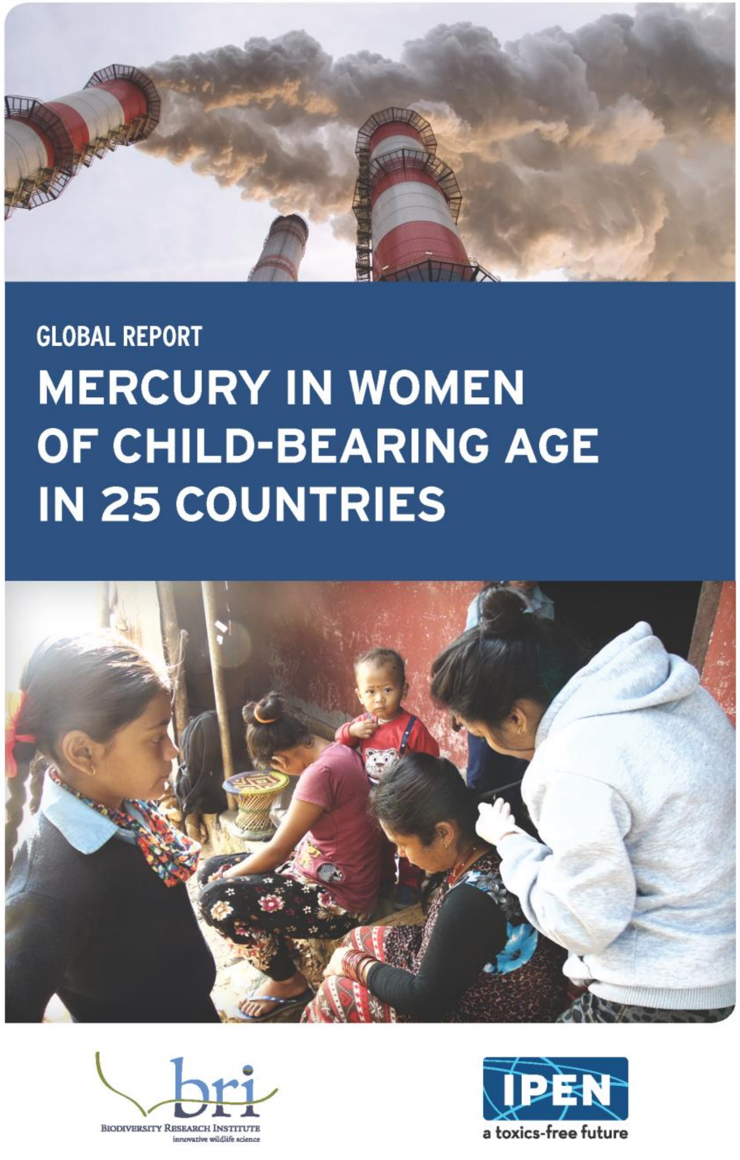
- Minamata disease, a neurological disease caused by severe Hg poisoning due to consumption of contaminated fish, was first discovered in Minamata, Japan in 1956.
- Hg-containing industrial wastewater discharge was the major Hg source to the fish in Minamata Bay.



(Time, 2010)

Why Is Mercury Still A Concern?

Global Hg Pollution



KEY FINDINGS

- 1044 women of child-bearing age from 25 countries participated in the study. 42% of them had mercury levels greater than 1 ppm – the level that approximately corresponds to the US EPA reference dose.* 55% of the women had mercury levels greater than 0.58 ppm mercury, a more recent, science-based threshold based on data indicating harmful effects at lower levels of exposure. Mercury is a health threat to women and the developing fetus.
- Women of the Pacific Islands have elevated mercury levels, likely due to a fish-rich diet. Distant air emissions of mercury from coal-fired power plants, cement kilns and other industries contaminate ocean fish that serve as a primary protein source for Pacific Islanders.
- Artisanal small-scale gold mining results in high mercury body burdens in women from Indonesia, Kenya, and Myanmar. Two likely mercury exposure sources are burning mercury amalgam and eating contaminated fish.
- Industrial mercury emissions contaminate local fish and elevate mercury levels in Thai women living nearby.
- Indigenous women in Alaska have mercury levels of concern due to their subsistence diet of sea mammals and fish. Consumption of seals may be a key source of mercury exposure.
- Women from locations in Albania, Chile, Nepal, Nigeria, Kazakhstan, and Ukraine have mercury levels of concern due to localised pollution of water-ways and suspected fish contamination.
- Women using mercury to gold plate statues in Nepal have elevated mercury levels.

* This is the daily exposure that US EPA considers "likely to be without an appreciable risk of deleterious effects during a lifetime."

Review

A Section 508–conformant HTML version of this article is available at https://doi.org/10.1289/EHP3904.

A State-of-the-Science Review of Mercury Biomarkers in Human Populations Worldwide between 2000 and 2018

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Background: The Minamata Convention on Mercury provided a mandate for action against global mercury pollution. However, our knowledge of mercury exposures is limited because there are many regions and subpopulations with little or no data.

Objective: We aimed to increase worldwide understanding of human exposures to mercury by collecting, collating, and analyzing mercury concentrations in biomarker samples reported in the published scientific literature.

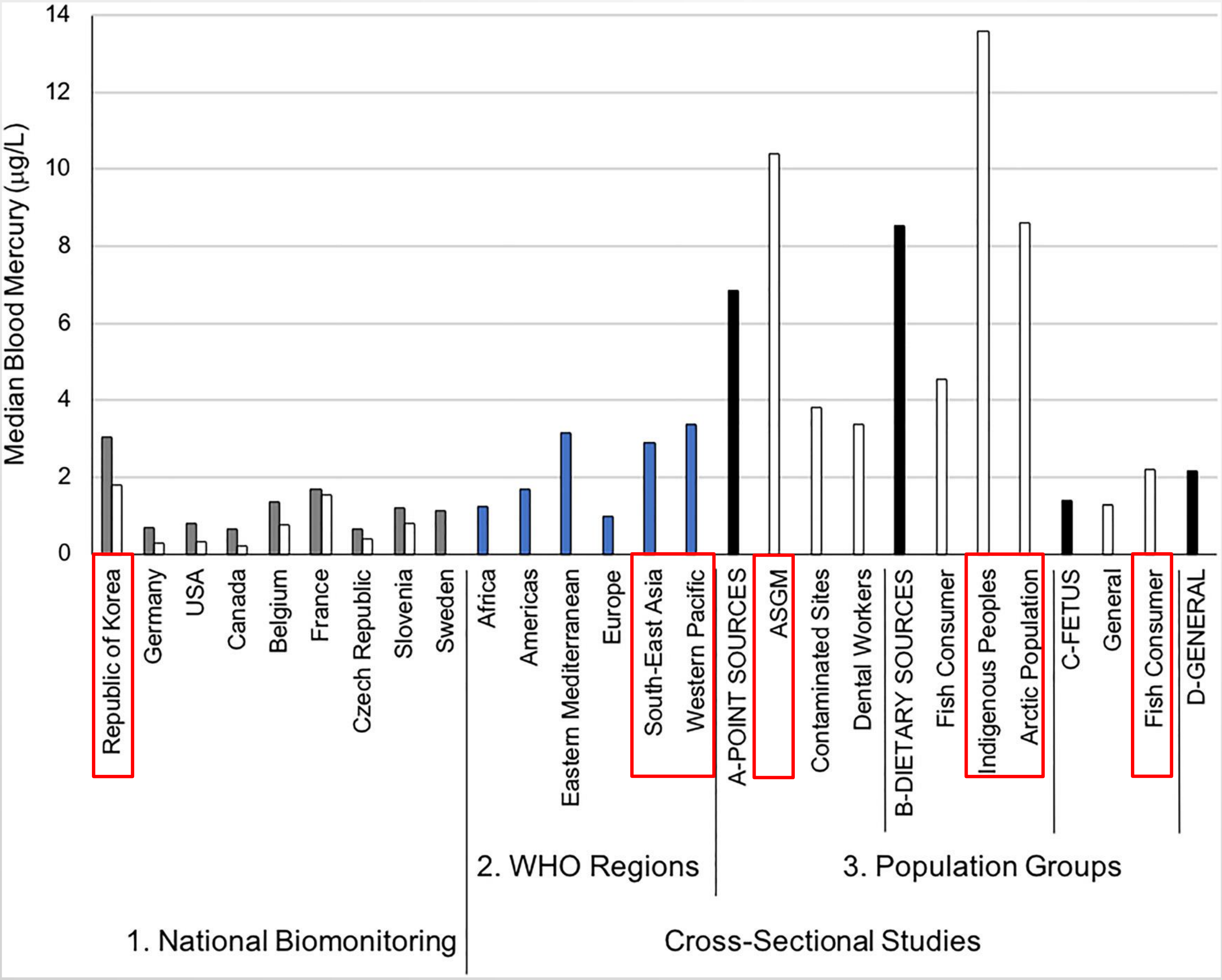
Method: A systematic search of the peer-reviewed scientific literature was performed using three databases. *A priori* search strategy, eligibility criteria, and data extraction steps were used to identify relevant studies.

Results: We collected 424,858 mercury biomarker measurements from 335,991 individuals represented in 312 articles from 75 countries. General background populations with insignificant exposures have blood, hair, and urine mercury levels that generally fall under 5 μg/L, 2 μg/g, and 3 μg/L, respectively. We identified four populations of concern: *a*) Arctic populations who consume fish and marine mammals; *b*) tropical riverine communities (especially Amazonian) who consume fish and in some cases may be exposed to mining; *c*) coastal and/or small-island communities who substantially depend on seafood; and *d*) individuals who either work or reside among artisanal and small-scale gold mining sites.

Conclusions: This review suggests that all populations worldwide are exposed to some amount of mercury and that there is great variability in exposures within and across countries and regions. There remain many geographic regions and subpopulations with limited data, thus hindering evidence-based decision making. This type of information is critical in helping understand exposures, particularly in light of certain stipulations in the Minamata Convention on Mercury. https://doi.org/10.1289/EHP3904

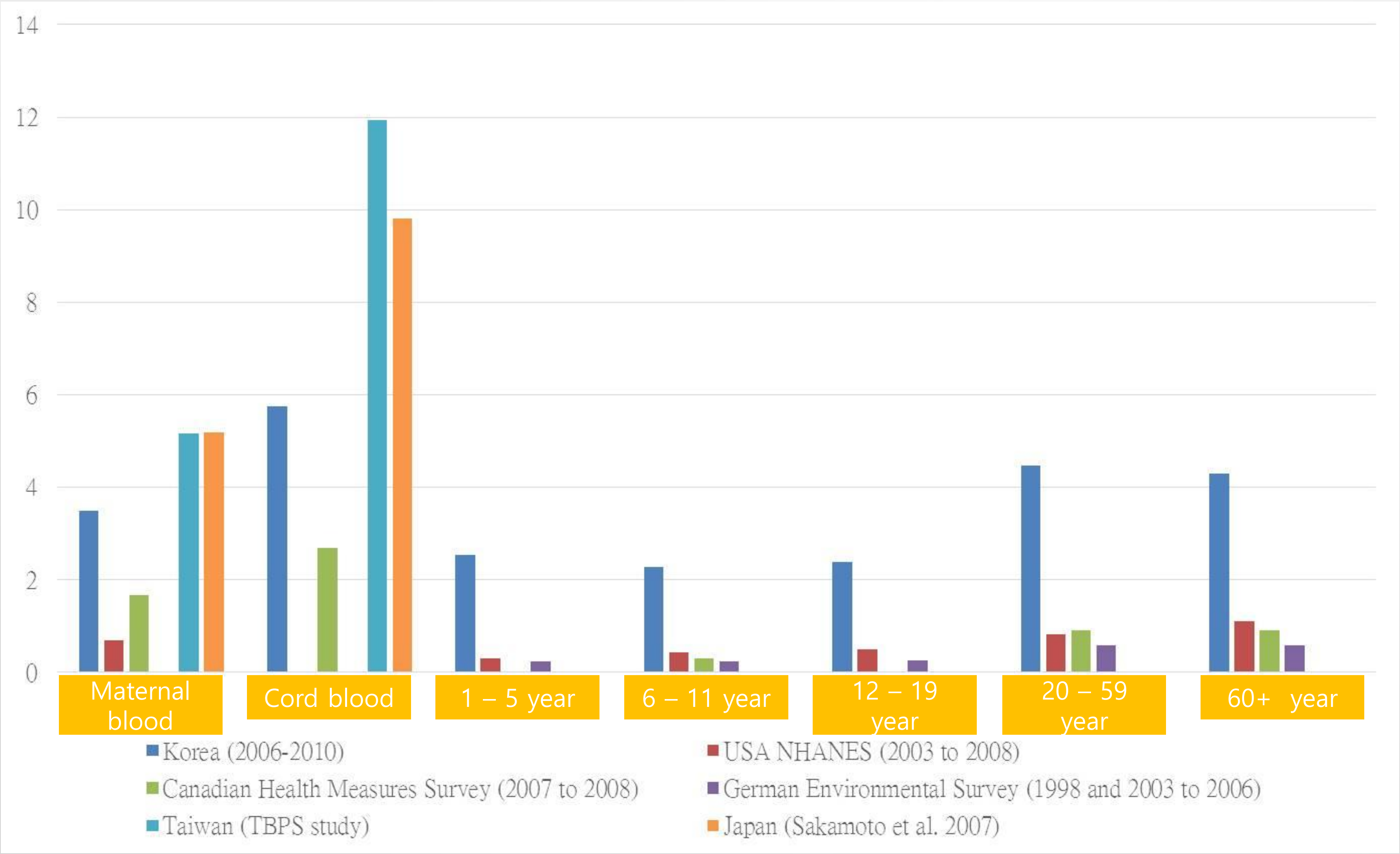
Published in Environmental Health Perspectives

Blood Hg Concentrations



Basu et al., 2018

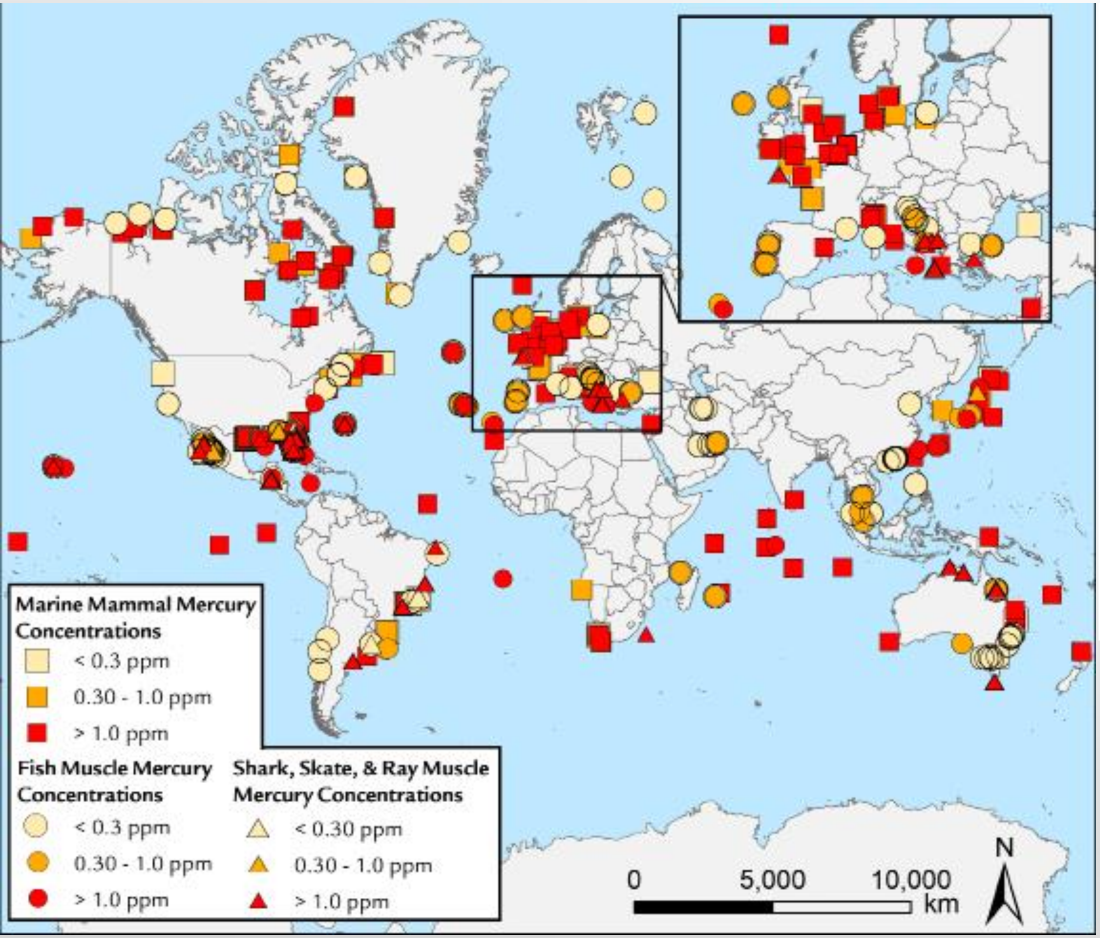
Blood Hg Concentration by Countries



Courtesy of Dr. Eunhee Ha

Global Hg Pollution

- Fish consumption is the major exposure route of Hg to many people worldwide.
- Hg concentrations in fish are elevated globally.

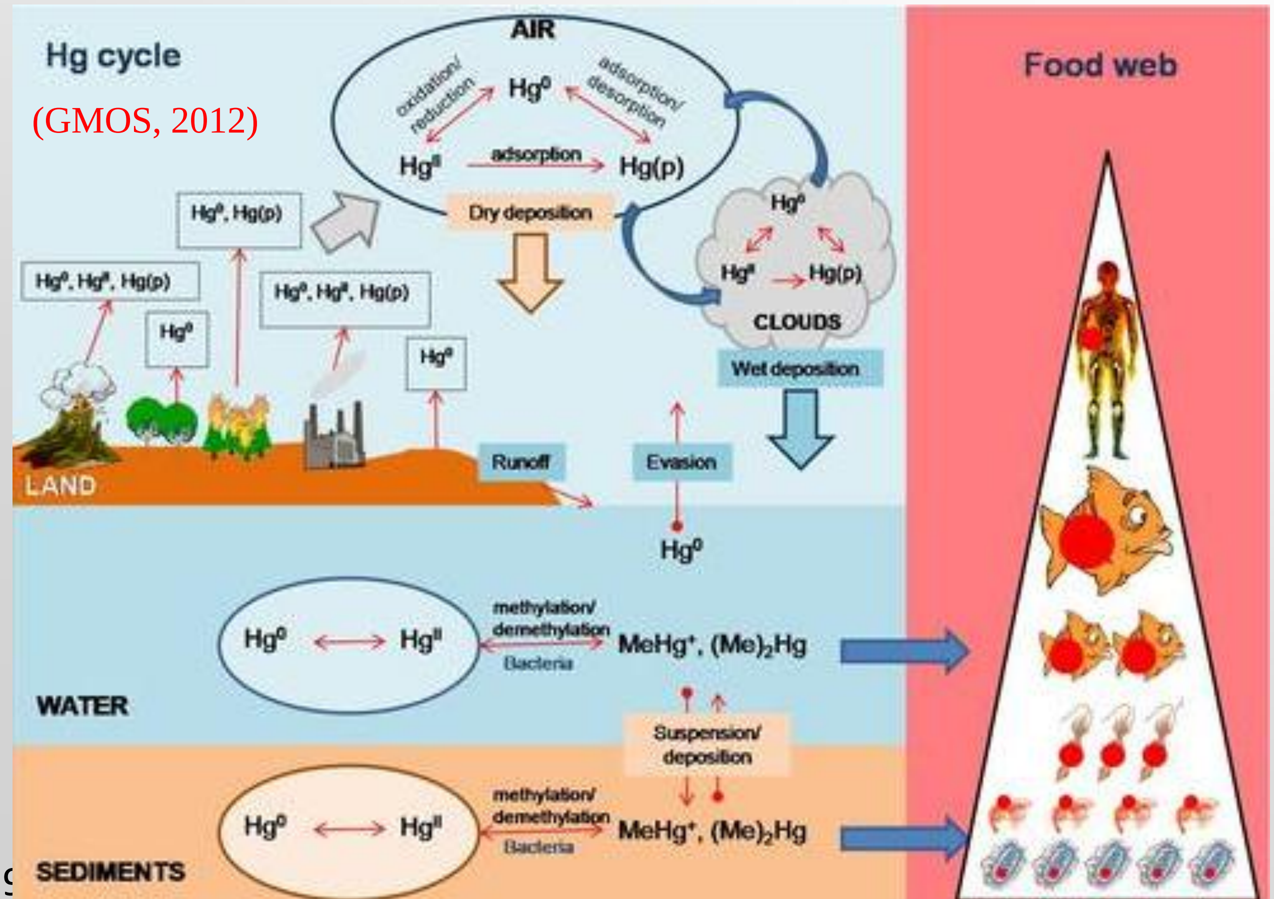


Nation	Standards
International Food Standards (Codex Alimentarius)	Fish: less than 0.5 mg/kg of methyl mercury Carnivorous fish (shark, swordfish, and tuna): less than 1 mg/kg of methyl mercury
US	Fish: less than 1 mg/kg of methyl mercury
EU	Fish: less than 0.5 mg/kg of total mercury Carnivorous fish including shark: less than 1 mg/kg of total mercury
Japan	Seafood (excluding abyssal fish and tuna): less than 0.4 mg/kg of total mercury, less than 0.3 mg/kg of methyl mercury
Australia and New Zealand	Fish: less than 0.5 mg/kg of total mercury Carnivorous fish including shark: less than 1 mg/kg of total mercury
Korea	Seafood (excluding abyssal fish and tuna): less than 0.5 mg/kg of total mercury

(Evers et al., 2012)

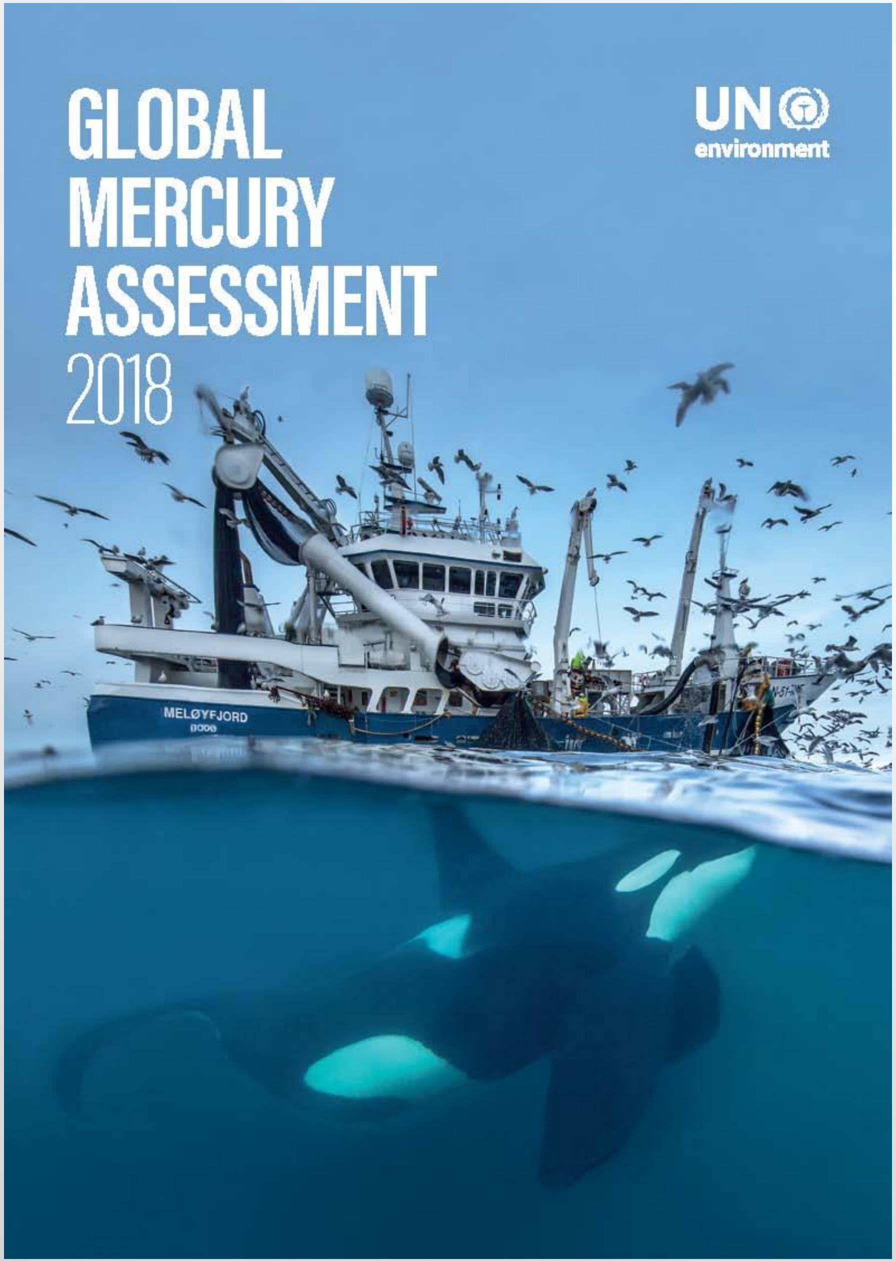
Global Hg Pollution

- Atmospheric deposition is the major source of Hg to many aquatic ecosystems.
- Once deposits from atmosphere, inorganic Hg can get methylated by bacteria to form MeHg then bioaccumulates through food chain, resulting in higher concentrations in large long-lived predatory fish.



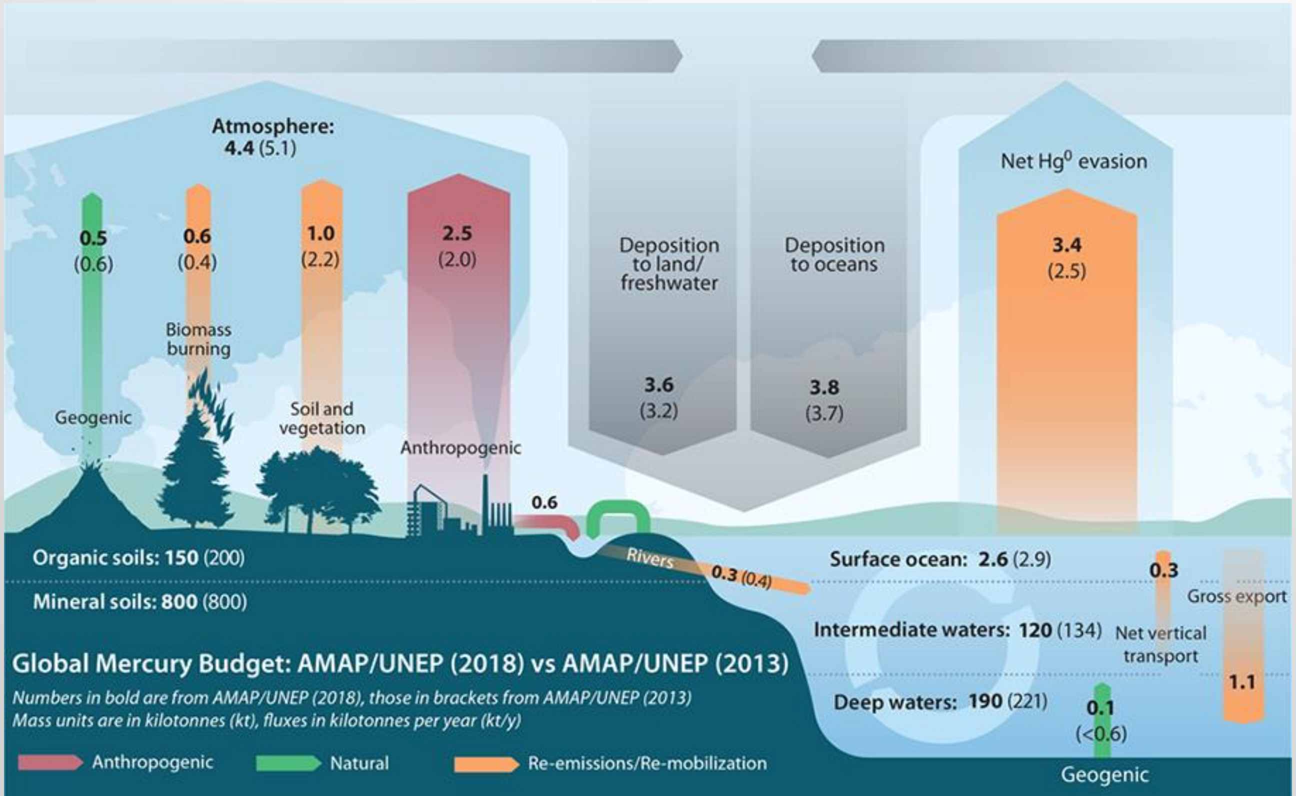
Atmospheric Mercury Cycling

Global Mercury Assessment 2018



Sources of Atmospheric Hg

- **Natural emissions**: mercury released from natural weathering of Hg-containing rocks or by geothermal activity. **500 Mg yr^{-1}**
- **Anthropogenic emissions**: mercury released as a result of current human activities. **2500 Mg yr^{-1}**
- **Re-emissions**: mercury released to the atmosphere that are derived from past natural and anthropogenic releases. **5000 Mg yr^{-1}**



(Outridge et al., 2018)

Anthropogenic Hg Emissions in 2015

- Anthropogenic Hg emission is an important contributor to the Hg in the atmosphere. Major sources include:
  - ASGM
  - Coal combustion
  - Cement production
  - Non-ferrous metal production

Sector	Mercury emission (range), tonnes	Sector % of total
Artisanal and small-scale gold mining (ASGM)	838 (675-1000)	37.7
Biomass burning (domestic, industrial and power plant) *	51.9 (44.3-62.1)	2.33
Cement production (raw materials and fuel, excluding coal)	233 (117-782)	10.5
Cremation emissions	3.77 (3.51-4.02)	0.17
Chlor-alkali production (mercury process)	15.1 (12.2-18.3)	0.68
Non-ferrous metal production (primary Al, Cu, Pb, Zn)	228 (154-338)	10.3
Large-scale gold production	84.5 (72.3-97.4)	3.8
Mercury production	13.8 (7.9-19.7)	0.62
Oil refining	14.4 (11.5-17.2)	0.65
Pig iron and steel production (primary)	29.8 (19.1-76.0)	1.34
Stationary combustion of coal (domestic/residential, transportation)	55.8 (36.7-69.4)	2.51
Stationary combustion of gas (domestic/residential, transportation)	0.165 (0.13-0.22)	0.01
Stationary combustion of oil (domestic/residential, transportation)	2.70 (2.33-3.21)	0.12
Stationary combustion of coal (industrial)	126 (106-146)	5.67
Stationary combustion of gas (industrial)	0.123 (0.10-0.15)	0.01
Stationary combustion of oil (industrial)	1.40 (1.18-1.69)	0.06
Stationary combustion of coal (power plants)	292 (255-346)	13.1
Stationary combustion of gas (power plants)	0.349 (0.285-0.435)	0.02
Stationary combustion of oil (power plants)	2.45 (2.17-2.84)	0.11
Secondary steel production *	10.1 (7.65-18.1)	0.46
Vinyl-chloride monomer (mercury catalyst) *	58.2 (28.0-88.8)	2.6
Waste (other waste)	147 (120-223)	6.6
Waste incineration (controlled burning)	15.0 (8.9-32.3)	0.67
Total	*2220 (2000-2820)*	*100*

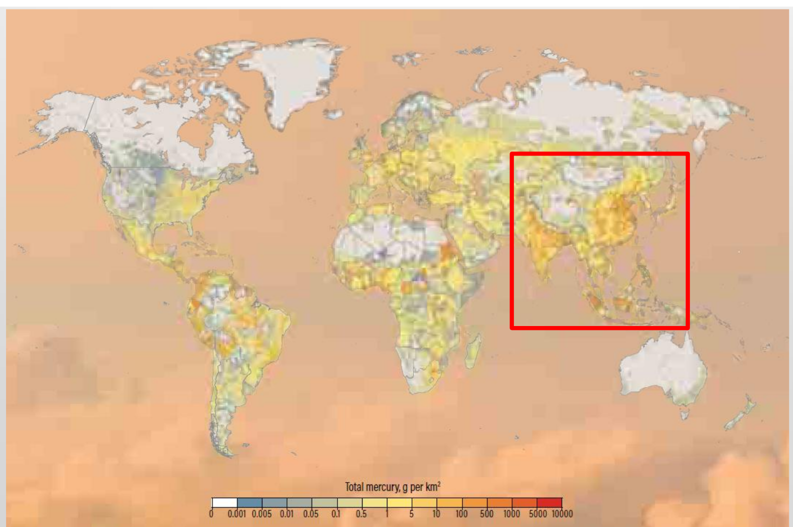
(UNEP, 2018)

Concerns in Asia

Anthropogenic Hg Emissions in 2015

▼ Quantities of mercury emitted to air from anthropogenic sources in 2015, by different sectors in different regions.

	Sector group (emissions, tonnes)				Regional total (range), tonnes	% of global total
	Fuel combustion	Industry sectors	Intentional-use (including product waste)	Artisanal and small-scale gold mining		
Australia, New Zealand & Oceania	3.57	4.07	1.15	0.0	8.79 (6.93-13.7)	0.4
Central America and the Caribbean	5.69	19.1	6.71	14.3	45.8 (37.2-61.4)	2.1
CIS & other European countries	26.4	64.7	20.7	12.7	124 (105-170)	5.6
East and Southeast Asia	229	307	109	214	859 (685-1430)	38.6
EU28	46.5	22.0	8.64	0.0	77.2 (67.2-107)	3.5
Middle Eastern States	11.4	29.0	12.1	0.225	52.8 (40.7-93.8)	2.4
North Africa	1.36	12.6	6.89	0.0	20.9 (13.5-45.8)	0.9
North America	27.0	7.63	5.77	0.0	40.4 (33.8-59.6)	1.8
South America	8.25	47.3	13.5	340	409 (308-522)	18.4
South Asia	125	59.1	37.2	4.50	225 (190-296)	10.1
Sub-Saharan Africa	48.9	41.9	17.1	252	360 (276-445)	16.2
Global inventory	533	614	239	838	2220 (2000-2820)	100.0



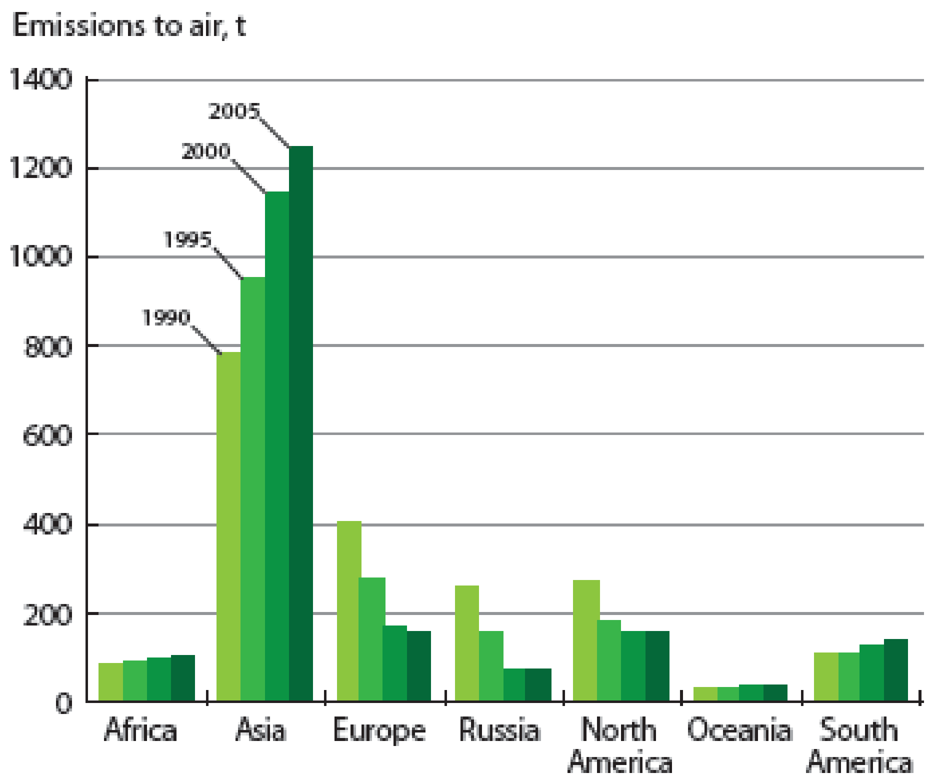
(UNEP, 2018)

Anthropogenic Hg Emissions in 2015

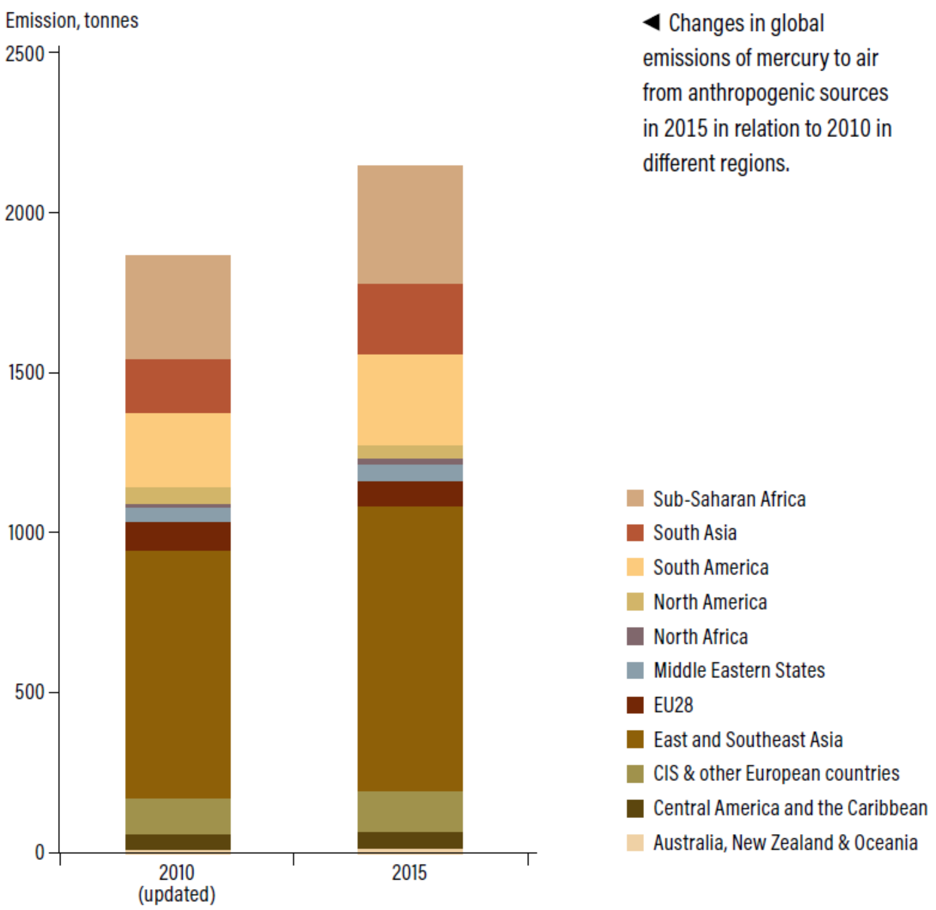
(UNEP, 2018)

Trends in Anthropogenic Hg Emissions

- Anthropogenic Hg emissions from Europe and North America are declining, whereas emissions from Asia are increasing.



Estimates of annual anthropogenic mercury emissions from different continents/regions, 1990-2005.



(UNEP, 2013)

(UNEP, 2018)

Projections of Global Hg Emissions in 2050

- It is likely that Hg emission will increase in the future. The main driving force is the expansion of coal-burning electricity generation, especially in Asia.

Projections of Global Mercury Emissions in 2050

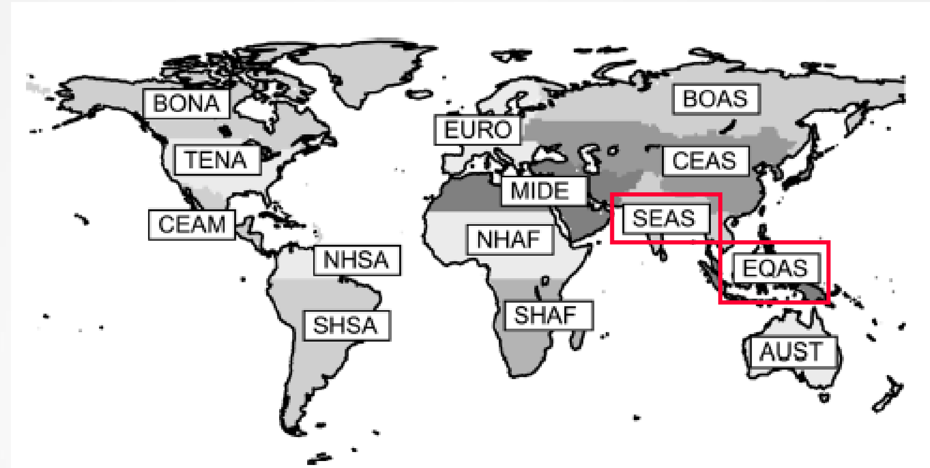
DAVID G. STREETS,*,† QIANG ZHANG,† AND YE WU‡

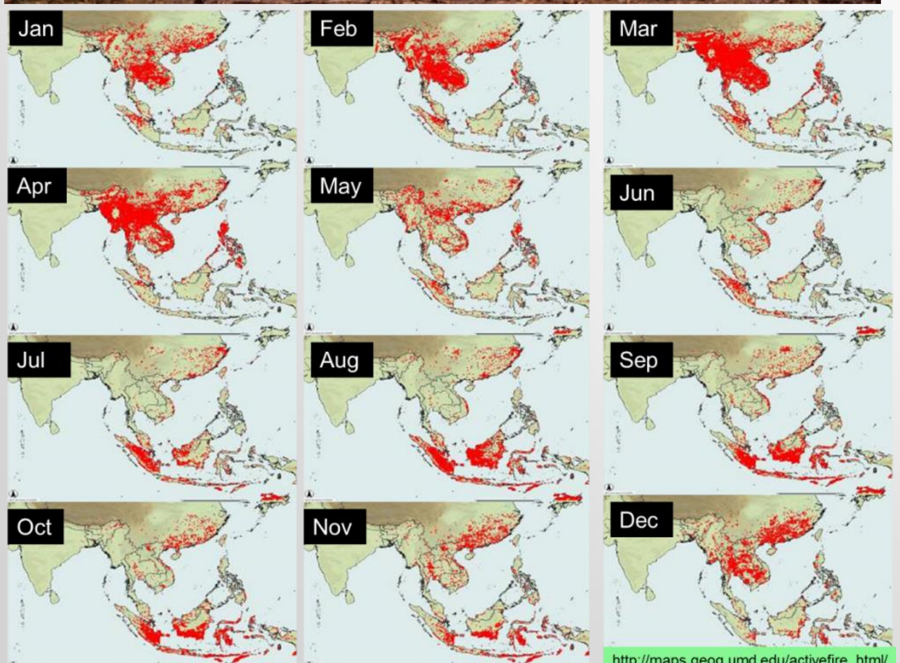
TABLE 4. Mercury Emissions in 2050 by Scenario and World Region (Mg/yr)

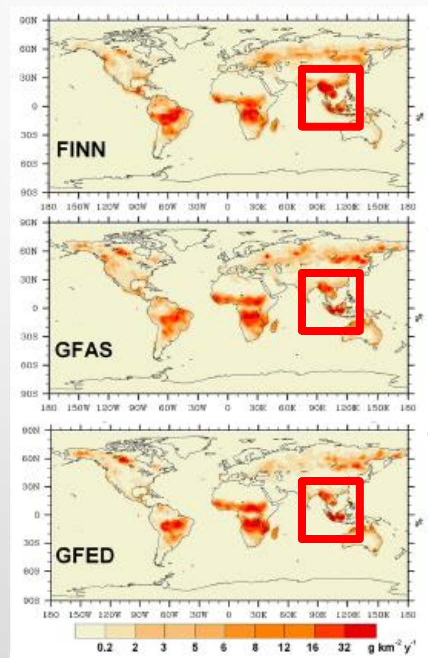
scenario	North America	Central and South America	Africa	Europe, Russia, Middle East	Asia and Oceania	world
2050 A1B	225.9	473.6	509.6	676.5	2970.0	4855.6
2050 A2	239.1	415.6	375.5	667.3	2208.5	3905.9
2050 B1	121.9	340.4	357.0	358.1	1208.9	2386.2
2050 B2	131.3	331.2	308.1	398.0	1461.4	2629.9

(Streets et al., 2009)

Biomass Burning Hg Emissions





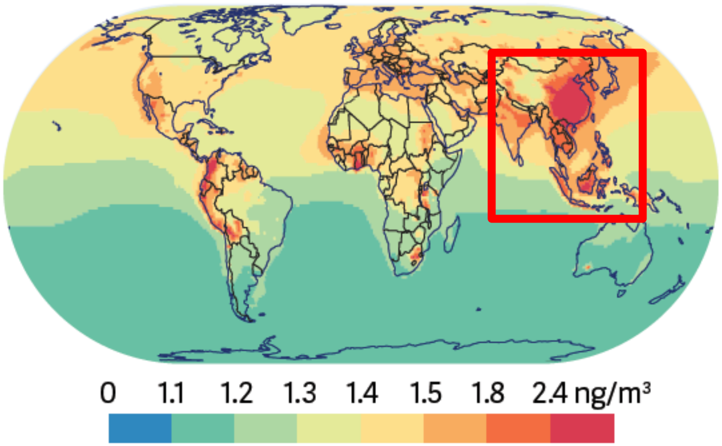


regions	Hg emissions Mg Hg/year mean	SD[a]
BONA	22	16
TENA	6	3
CEAM	22	25
NHSA	13	10
SHSA	95	39
EURO	2	1
MIDE	0	0
NHAF	83	13
SHAF	58	7
BOAS	99	83
CEAS	7	2
SEAS	57	35
EQAS	192	216
AUST	19	9
global	675	240
boreal[b]	121	85
temperate[c]	9	3
ROW[d]	545	224

SEAS + EQAS = 249 Mg Hg/year = 37% of global biomass burning emission

Distribution of Atmospheric Hg Concentrations and Deposition Fluxes: Modeling Results

a) **Mean annual GEM conc. In 2013**



b) **Annual total Hg deposition in 2013**

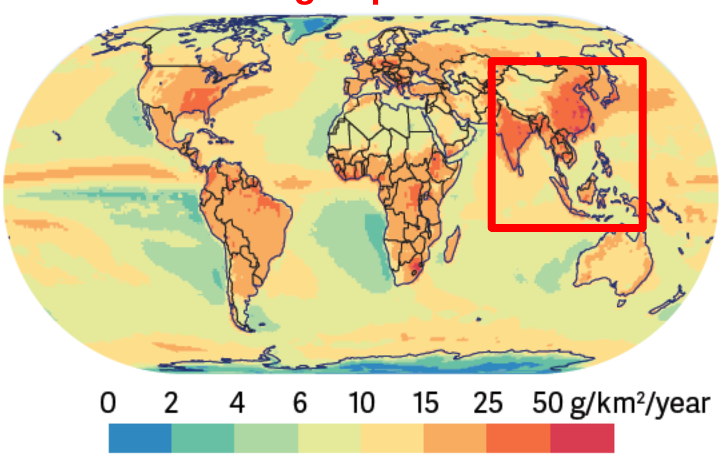
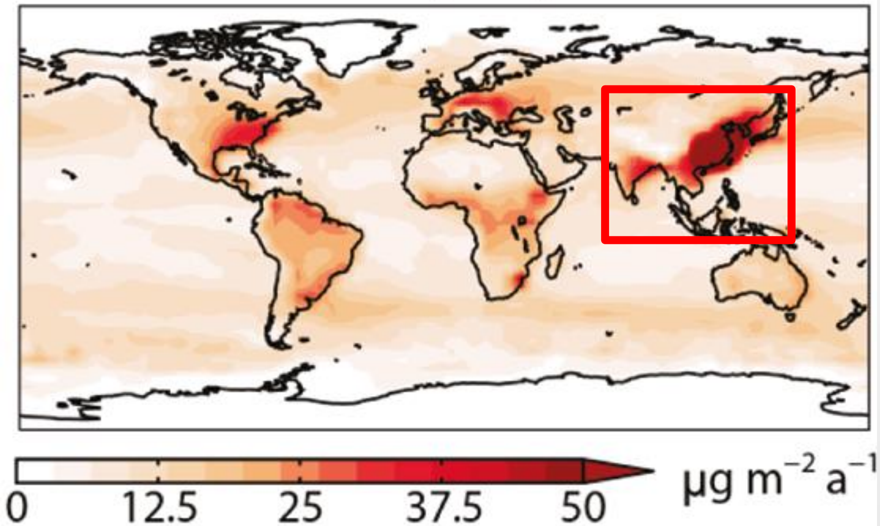


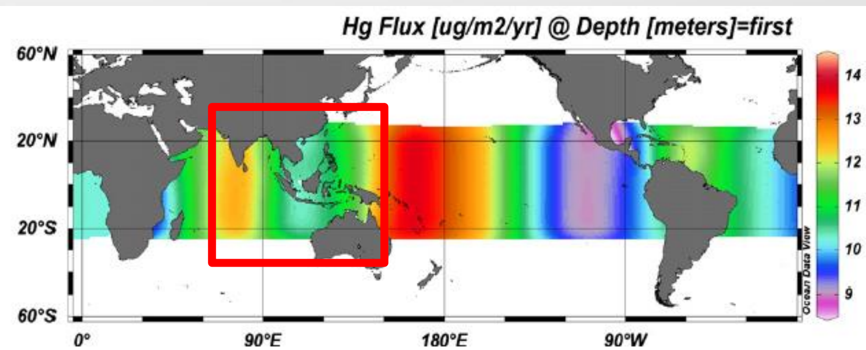
Figure 2. Global distribution of ensemble mean annual GEM concentration in ambient air (a) and annual total mercury deposition (b) in 2013.

AMAP/UNEP, 2015

Net Mercury Deposition

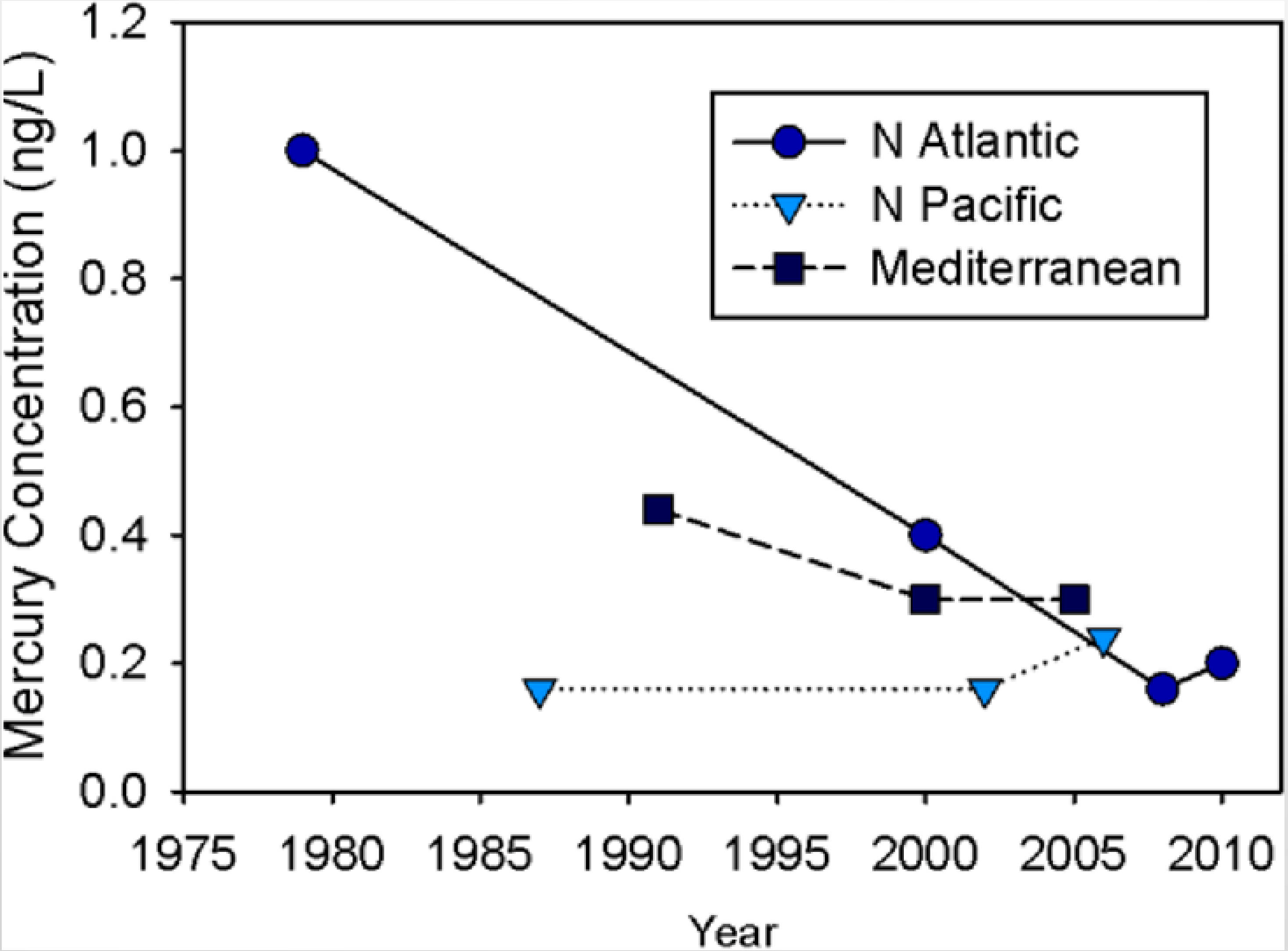


Corbitt et al., 2011



Costa et al., 2012

Trend in SW Hg Conc. in Surface Oceans



(Driscoll et al., 2013)

Rising Hg Levels in the Pacific Tuna

PHYS ORG

Mercury levels in Hawaiian bigeye, yellowfin tuna rising

7 March 2017, by Jim Erickson

Bigeye tuna. Credit: Allen Shimada, NOAA NMFS OST

Mercury concentrations in Hawaiian-caught bigeye and yellowfin tuna are steadily rising and mirror increases in North Pacific waters that have been linked to atmospheric mercury emissions from Asia.

Researchers compiled and re-analyzed data from previously published reports on yellowfin and bigeye tuna caught near Hawaii over the past four decades, then used a mathematical model to look for trends.

They found that mercury concentrations in yellowfin tuna increased about 5.5 percent per year between 1998 and 2008. Levels in bigeye tuna increased about 3.9 percent per year from 2002 to 2008. Mercury concentrations tended to be greater in bigeye tuna than in yellowfin tuna.

The work was reported in a study scheduled for online publication March 6 in the journal *Environmental Toxicology and Chemistry*. The first author is Paul Drevnick, a former University of Michigan researcher who now works for the Alberta provincial government in Calgary. The other author is Barbara Brooks of the Hawaii Department of Health.

Most of the work was done while Drevnick was at U-M, and the research was funded in part by the university. The new study updates yellowfin findings that Drevnick reported two years ago and expands the effort to include bigeye tuna.

"This paper confirms our previous work showing that mercury concentrations in yellowfin tuna caught near Hawaii are increasing, and it demonstrates that the same phenomenon is happening in bigeye tuna," Drevnick said.

Both yellowfin and bigeye tuna are marketed as ahi and are widely used in raw fish dishes—especially sashimi—or for grilling. In January, the U.S. Food and Drug Administration and the U.S. Environmental Protection Agency added bigeye tuna to its list of fish to be avoided by pregnant women, women who might become pregnant, breastfeeding women and young children due to mercury concerns.

Mercury is a toxic trace metal that can accumulate to high concentrations in fish, posing a health risk to people who eat large, predatory marine fish such as swordfish and tuna. In the open ocean, the principal source of mercury is atmospheric deposition from human activities, especially emissions from coal-fired power plants and artisanal gold mines.

In North Atlantic waters, mercury concentrations peaked in the 1980s and '90s and are now declining in response to environmental regulations in North America and Europe.

But in the North Pacific, mercury concentrations in waters shallower than 1,000 meters increased about 3 percent per year between 1995 and 2006 and are expected to double by 2050 if current mercury deposition rates are maintained, according to Drevnick.

"The temporal trend in mercury concentrations in

PHYS ORG

Mercury levels in Hawaiian yellowfin tuna increasing

2 February 2015

Mercury concentrations in Hawaiian yellowfin tuna are increasing at a rate of 3.8 percent or more per year, according to a new University of Michigan-led study that suggests rising atmospheric levels of the toxin are to blame.

Mercury is a potent toxin that can accumulate to high concentrations in fish, posing a health risk to people who eat large, predatory marine fish such as swordfish and tuna. In the open ocean, the principal source of mercury is atmospheric deposition from human activities, especially emissions from coal-fired power plants and artisanal gold mining.

For decades, scientists have expected to see mercury levels in open-ocean fish increase in response to rising atmospheric concentrations, but evidence for that hypothesis has been hard to find. In fact, some studies have suggested that there has been no change in mercury concentration in ocean fish.

By compiling and re-analyzing three previously published reports on yellowfin tuna caught near Hawaii, U-M's Paul Drevnick and two colleagues found that the concentration of mercury in that species increased at least 3.8 percent per year from 1998 to 2008.

A paper about the study is scheduled for online publication in the journal *Environmental Toxicology and Chemistry* on Feb. 2. The other authors are Carl Lamborg of the Woods Hole Oceanographic Institution, now at the University of California at Santa Cruz, and Martin Horgan.

"The take-home message is that mercury in tuna appears to be increasing in lockstep with data and model predictions for mercury concentrations in water in the North Pacific," said Drevnick, an assistant research scientist at the U-M School of Natural Resources and Environment and at the U-M Biological Station. "This study confirms that mercury levels in open ocean fish are responsive to mercury emissions."

Drevnick and his colleagues reanalyzed data from three studies that sampled the same yellowfin tuna population near Hawaii in 1971, 1998 and 2008. In each of the three studies, muscle tissues were tested for total mercury, nearly all of which was the toxic organic form, methylmercury.

In their re-analysis, Drevnick and his colleagues included yellowfins between 48 and 167 pounds and used a computer model that controls for the effect of fish body size. Data from 229 fish were analyzed: 111 from 1971, 104 from 1998 and 14 from 2008.

The researchers found that mercury concentrations in the yellowfins did not change between the 1971 and 1998 datasets. However, concentrations were higher in 2008 than in either 1971 or 1998. Between 1998 and 2008, the mercury concentration in yellowfins increased at a rate greater than or equal to 3.8 percent a year, according to the new study.

"Mercury levels are increasing globally in ocean water, and our study is the first to show a consequent increase in mercury in an open-water fish," Drevick said. "More stringent policies are needed to reduce releases of mercury into the atmosphere. If current deposition rates are maintained, North Pacific waters will double in mercury by 2050."

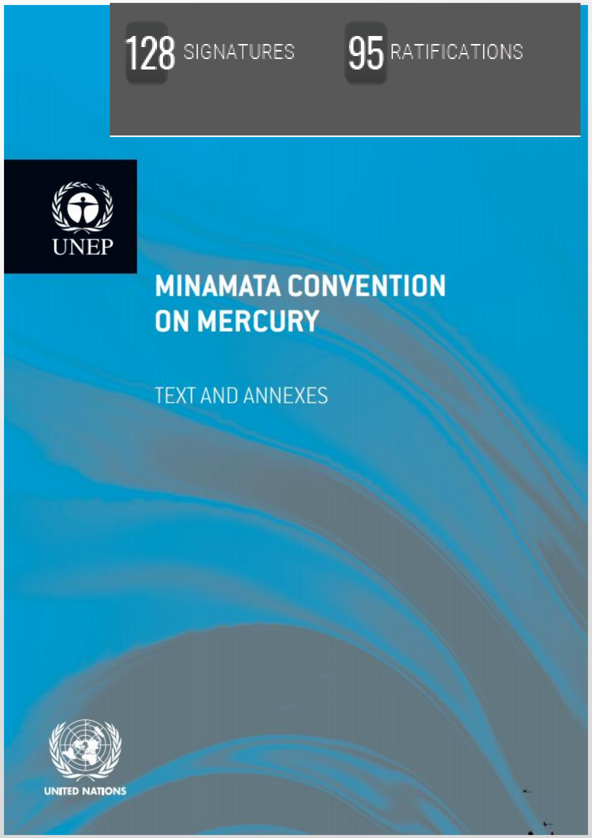
Yellowfin tuna, often marketed as ahi, is widely used in raw fish dishes—especially sashimi—or for grilling. The Natural Resources Defense Council's guide to mercury in sushi lists yellowfin tuna as a "high mercury" species.

More information: Drevnick, P. E., Lamborg, C. H. and Horgan, M. J. (2015), Increase in mercury in Pacific yellowfin tuna. *Environmental Toxicology*

International Actions

Minamata Convention on Mercury

- The Minamata Convention on Mercury was opened for signature by governments at a Diplomatic Conference on October 9-11, 2013 in Japan.
- Minamata Convention on Mercury entered into force on August 16, 2017.



Minamata Convention on Mercury

Article 19
Research, development and monitoring

1. Parties shall endeavour to cooperate to develop and improve, taking into account their respective circumstances and capabilities:

(a) Inventories of use, consumption, and anthropogenic emissions to air and releases to water and land of mercury and mercury compounds;

(b) Modelling and geographically representative monitoring of levels of mercury and mercury compounds in vulnerable populations and in environmental media, including biotic media such as fish, marine mammals, sea turtles and birds, as well as collaboration in the collection and exchange of relevant and appropriate samples;

(c) Assessments of the impact of mercury and mercury compounds on human health and the environment, in addition to social, economic and cultural impacts, particularly in respect of vulnerable populations;

(d) Harmonized methodologies for the activities undertaken under subparagraphs (a), (b) and (c);

(e) Information on the environmental cycle, transport (including long-range transport and deposition), transformation and fate of mercury and mercury compounds in a range of ecosystems, taking appropriate account of the distinction between anthropogenic and natural emissions and releases of mercury and of remobilization of mercury from historic deposition;

(f) Information on commerce and trade in mercury and mercury compounds and mercury-added products; and

(g) Information and research on the technical and economic availability of mercury-free products and processes and on best available techniques and best environmental practices to reduce and monitor emissions and releases of mercury and mercury compounds.

2. Parties should, where appropriate, build on existing monitoring networks and research programmes in undertaking the activities identified in paragraph 1.

Article 22
Effectiveness evaluation

1. The Conference of the Parties shall evaluate the effectiveness of this Convention, beginning no later than six years after the date of entry into force of the Convention and periodically thereafter at intervals to be decided by it.

2. To facilitate the evaluation, the Conference of the Parties shall, at its first meeting, initiate the establishment of arrangements for providing itself with comparable monitoring data on the presence and movement of mercury and mercury compounds in the environment as well as trends in levels of mercury and mercury compounds observed in biotic media and vulnerable populations.

3. The evaluation shall be conducted on the basis of available scientific, environmental, technical, financial and economic information, including:

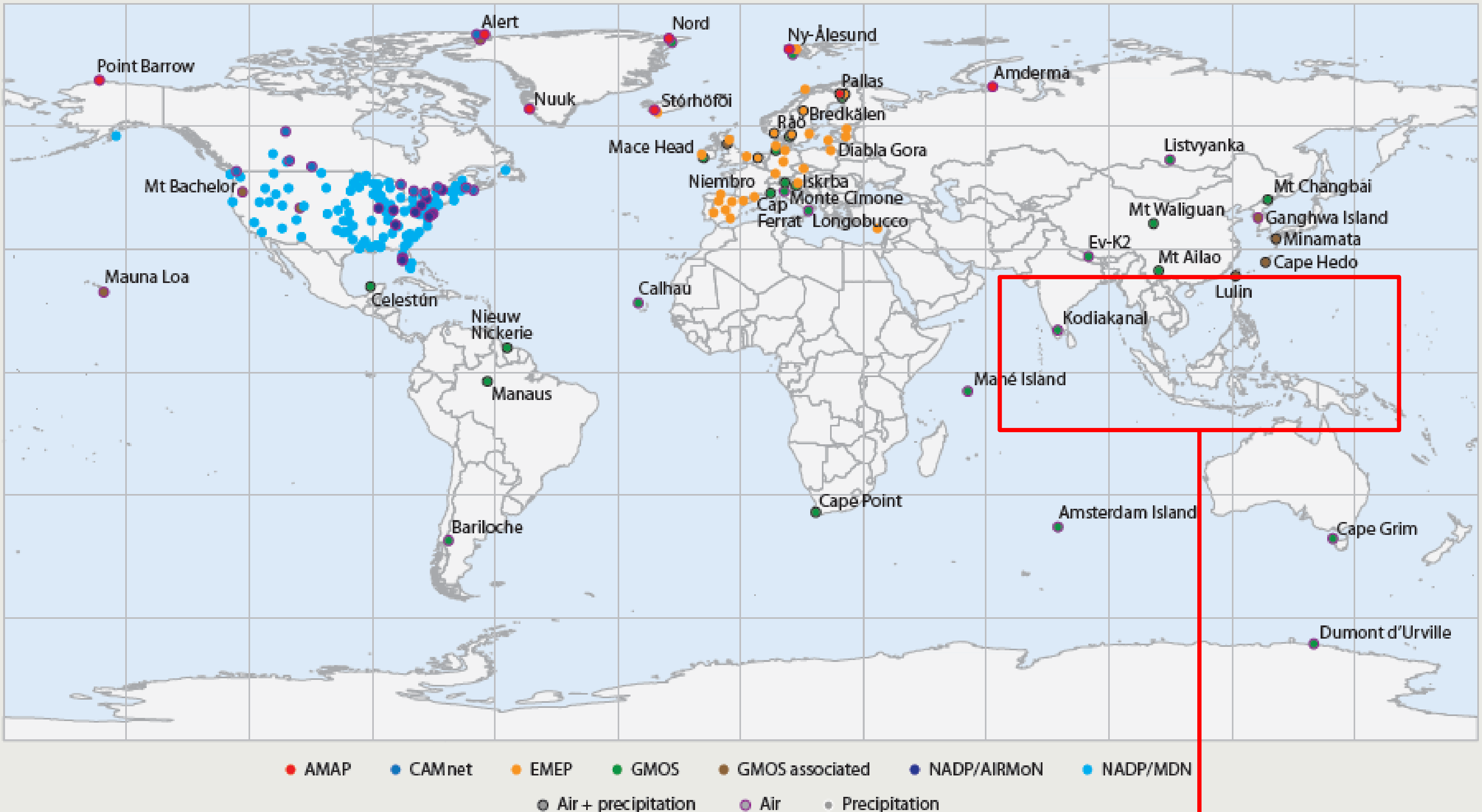
(a) Reports and other monitoring information provided to the Conference of the Parties pursuant to paragraph 2;

(b) Reports submitted pursuant to Article 21;

(c) Information and recommendations provided pursuant to Article 15; and

(d) Reports and other relevant information on the operation of the financial assistance, technology transfer and capacity-building arrangements put in place under this Convention.

Atmospheric Hg Monitoring Worldwide



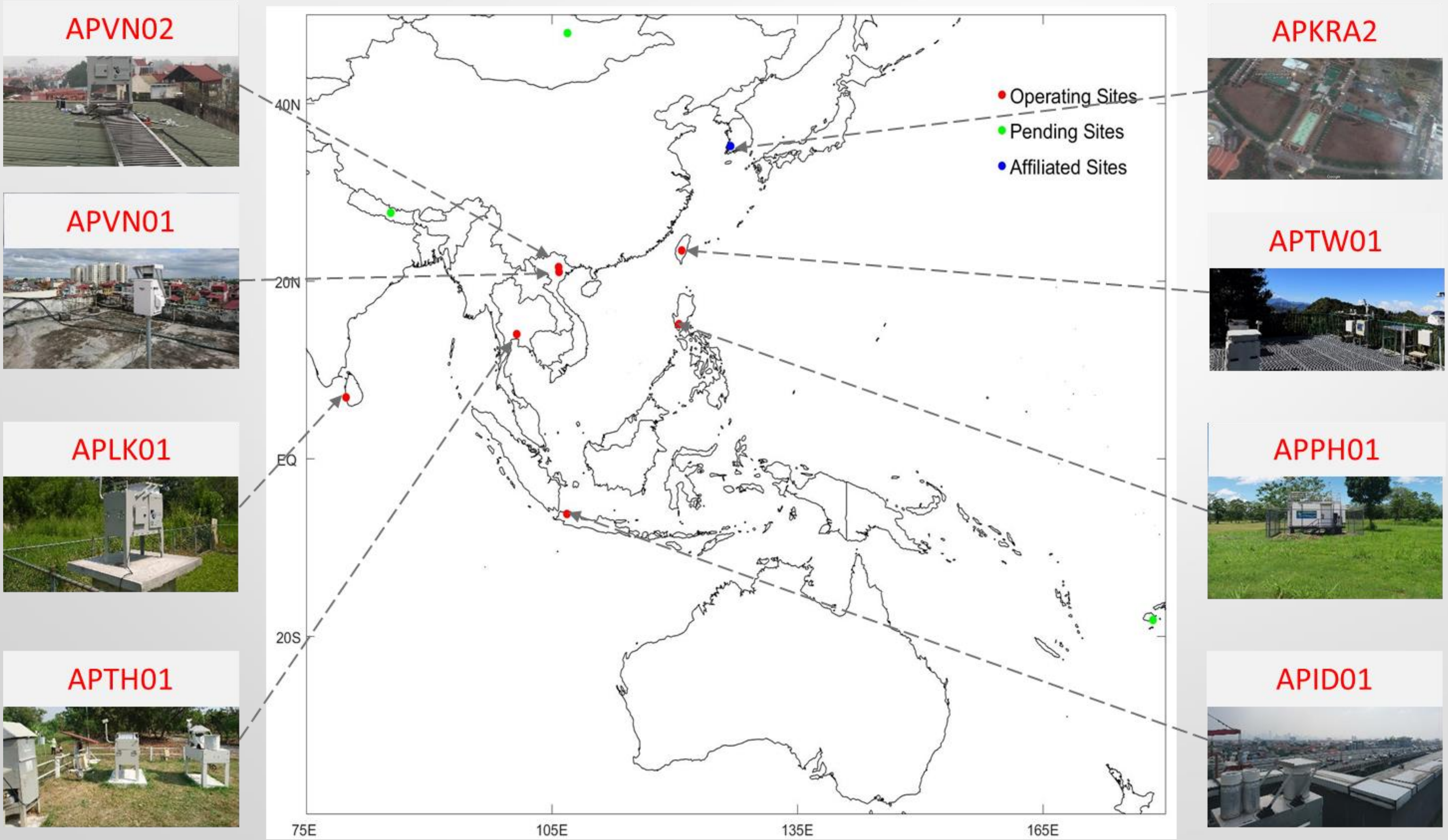
Currently, long-term or background atmospheric Hg monitoring activities in SE and S Asia are still lacking.

Asia Pacific Mercury Monitoring Network

Asia Pacific Mercury Monitoring Network

Systematically monitor wet deposition and atmospheric concentrations of mercury in a network of stations throughout the Asia-Pacific region

APMMN Site Map



THANK YOU!

Contact:
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