Mercury Science Bulletin - Recent Findings from Scientific Research

Massachusetts Institute of Technology

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MIT JOINT PROGRAM ON THE SCIENCE AND POLICY of GLOBAL CHANGE

1. Introduction

This poster summarizes recent advances in mercury science and policy from the academic literature, related to outstanding issues in the developing mercury treaty.

MIT's Joint Program on the Science & Policy of Global Change aims to improve knowledge of interactions among human and natural Earth systems through interdisciplinary research. Our goal here is to communicate state-of-the-science information on mercury emissions in a way that is policy relevant and to facilitate the strengthening of the science-policy interface.

1. Mercury continues to cycle through the earth system long after it is emitted.
2. Options for reducing mercury emissions have many additional social benefits.
3. Mercury releases to land and water are significant and trans-boundary in nature.

For a copy of this poster and more mercury science and policy updates, take a picture of this QR code with your phone.

2. Historic & Future Mercury Trends depend on Human Actions and Policy Decisions

Since 2000 BCE, 350 Gg of mercury have been released by humans. Only 50 Gg have returned to the Earth's crust. **Thus mercury is increasing in our atmosphere, land surface, and ocean because of human actions** (1, 2).

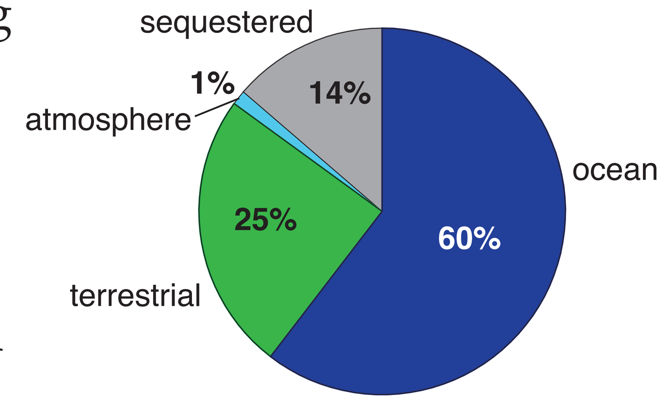


Figure 1. Where is human mercury now? Fate of all-time anthropogenic emissions

Mercury moves between reservoirs on timescales between 0.2 to 6000 years. The subsurface ocean is at the center of this cycling, and is the primary mercury repository for all releases to the atmosphere, land or water (2).

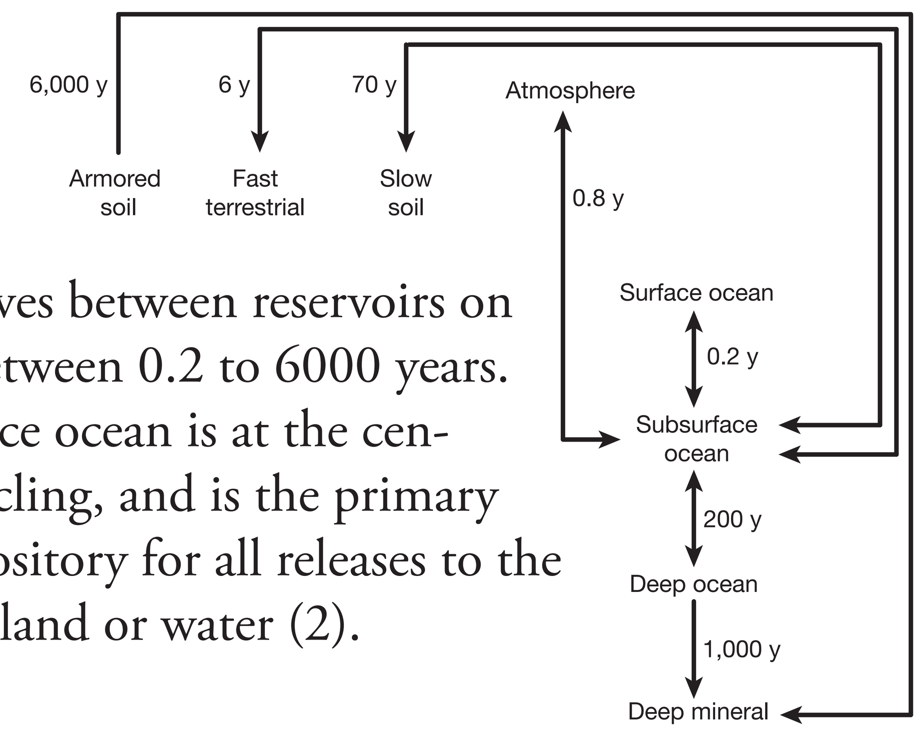


Figure 2. Timescales of mercury cycling range from months to millennia.

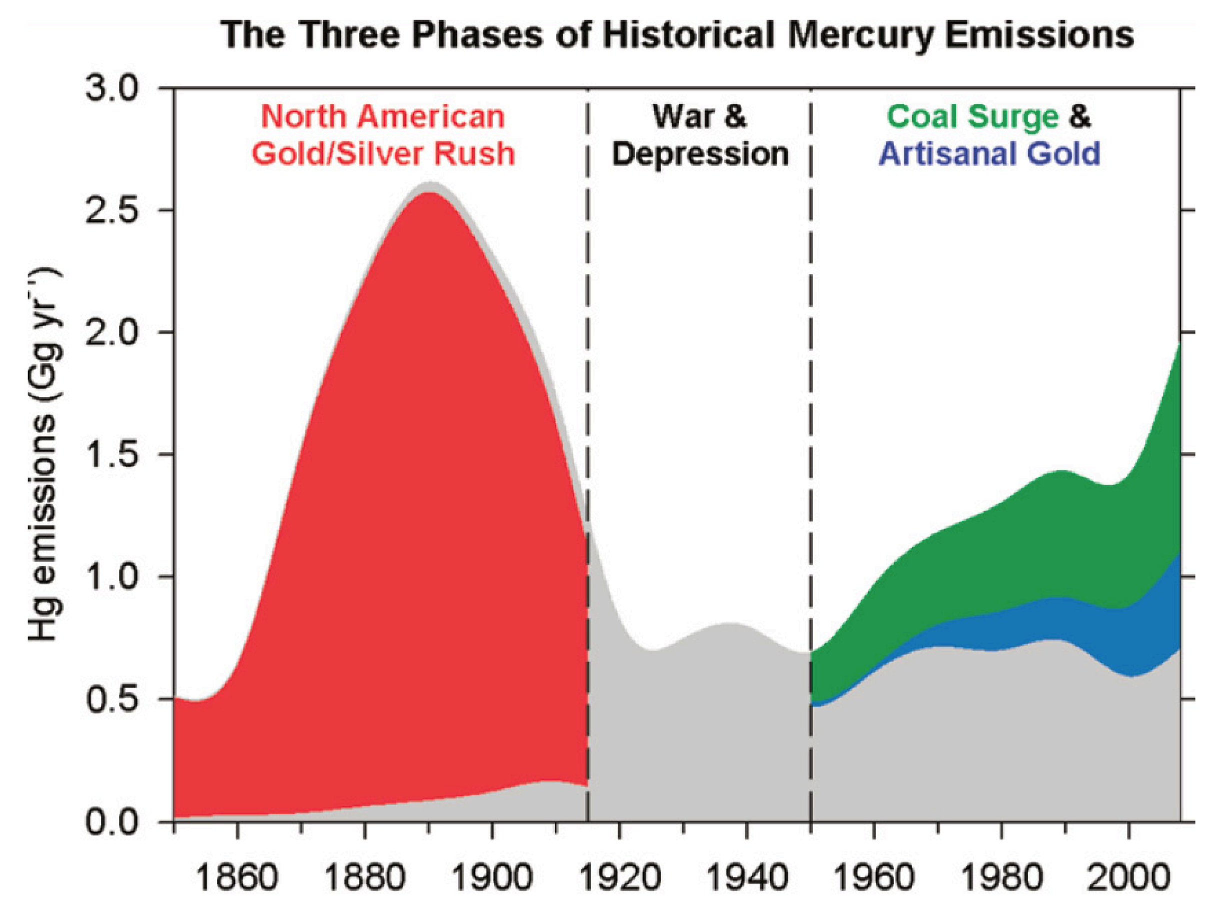
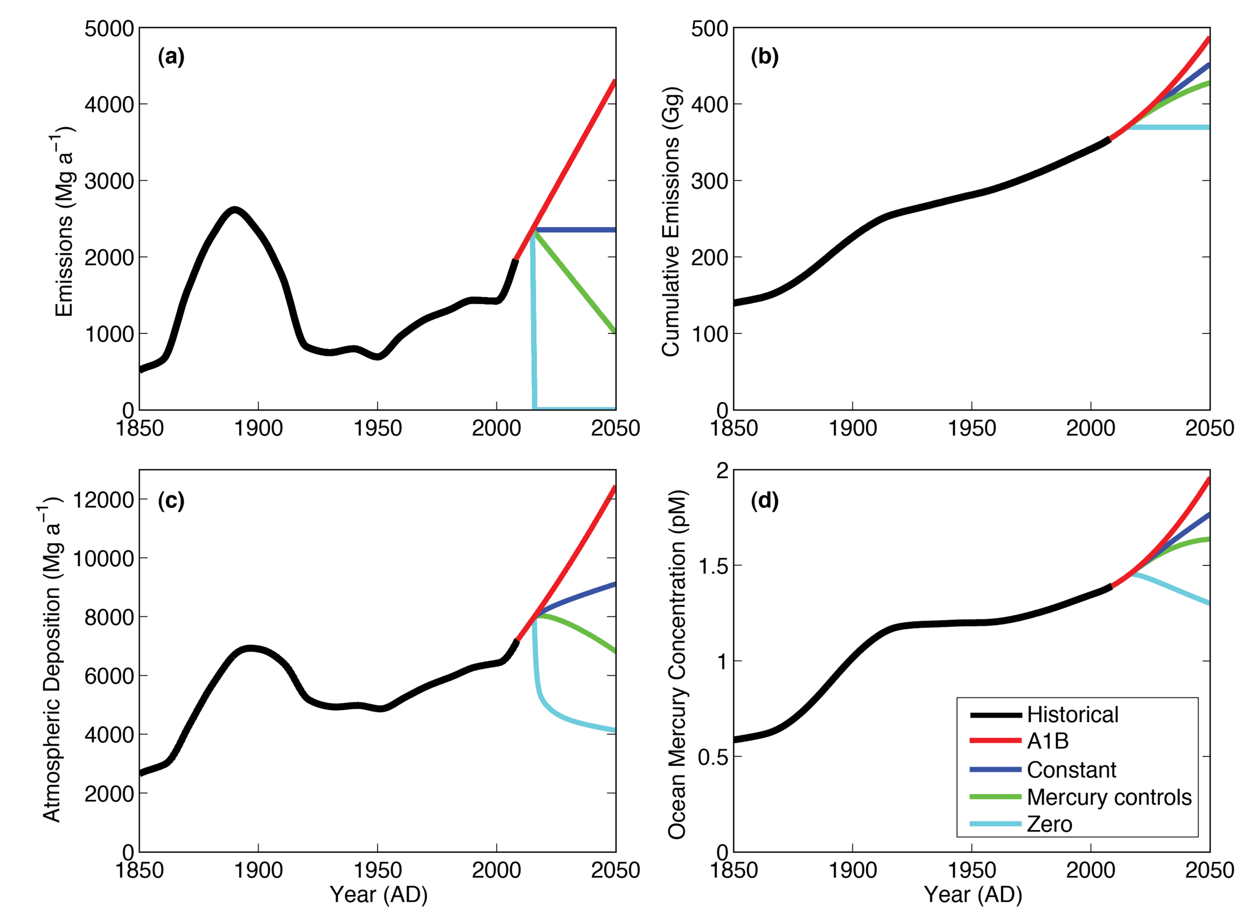


Figure 3. Gold and silver mining during the 19th Century contributed to high mercury emissions, which fell during the two world wars and the Great Depression. Over the past 60 years, mercury emissions have increased primarily due to coal combustion and artisanal and small-scale gold mining (ASGM). **Mercury emissions are still increasing globally** (3).

Mercury's long residence time means that even if future emissions are held constant, atmospheric deposition and ocean mercury concentration will continue to increase. **Current mercury emissions commit us to mercury concentrations far in the future.**

Figure 4. This figure shows four different theoretical emissions trajectories and their consequences (1, 2).



3. Reducing Coal Emissions has Multiple Benefits

There are multiple approaches for reducing mercury emissions that are cost-effective, and have many additional social and economic benefits.

- Social benefits to some mercury reduction methods include savings in energy demand, fuel costs, carbon emissions, and other harmful air pollutants (NO_x, SO_2). **These co-benefits of mercury reductions have not been included in most studies estimating the benefits of controls** (4, 5, 6).
- Many strategies exist to reduce mercury air emissions from coal. These include: reducing coal use, pre-treating coal, and post-combustion technologies.
- Ingestion and inhalation of methyl mercury cost society globally, based only on IQ losses, an estimated **US$6.6 billion annually** (4).

	Control Method	Mercury Reduction Potential (%)	Co-benefits
Pre-combustion	Reduced coal usage (*e.g. through improved efficiency*)	Up to 34 %	Climate, efficiency, air quality
Pre-combustion	Coal treatment (*e.g. washing, beneficiation, blending, additives*)	10 - 78 %	Air quality, efficiency
Post-combustion	PM Control	1 - 90 %	Air quality
Post-combustion	PM Control and Sorbent Injection	2- 98 %	Air quality
Post-combustion	PM Control and Wet Flue Gas Desulfurization	10 - 98 %	Air quality

Table 1. Total emissions could decrease from 2005–2020 by 50–60% under stricter emission control, such as in the case of the Extended Emission Control (EXEC) and the Maximum Feasible Technological Reduction (MFTR) scenarios (4, 5, 6). **In this case, annual benefits in 2020 could be US$1.8–2.2 billion** (4).

4. Releases to Land & Water have Impacts

- Releases to land and water contribute significant mercury burdens to local watershed hotspots and impact global trans-boundary reservoirs, such as the oceans.
- **Mercury releases to land and water form a non-negligible component of methylmercury in the open ocean.** Addressing releases to land and water would be necessary to inventory, evaluate, and control these releases over time and to understand the total global mercury budget.
- **Commercial and industrial products and processes release mercury to land and water through their use and eventual waste streams.** Continued use of mercury in products or processes would threaten local and global mercury reservoirs through these downstream releases.

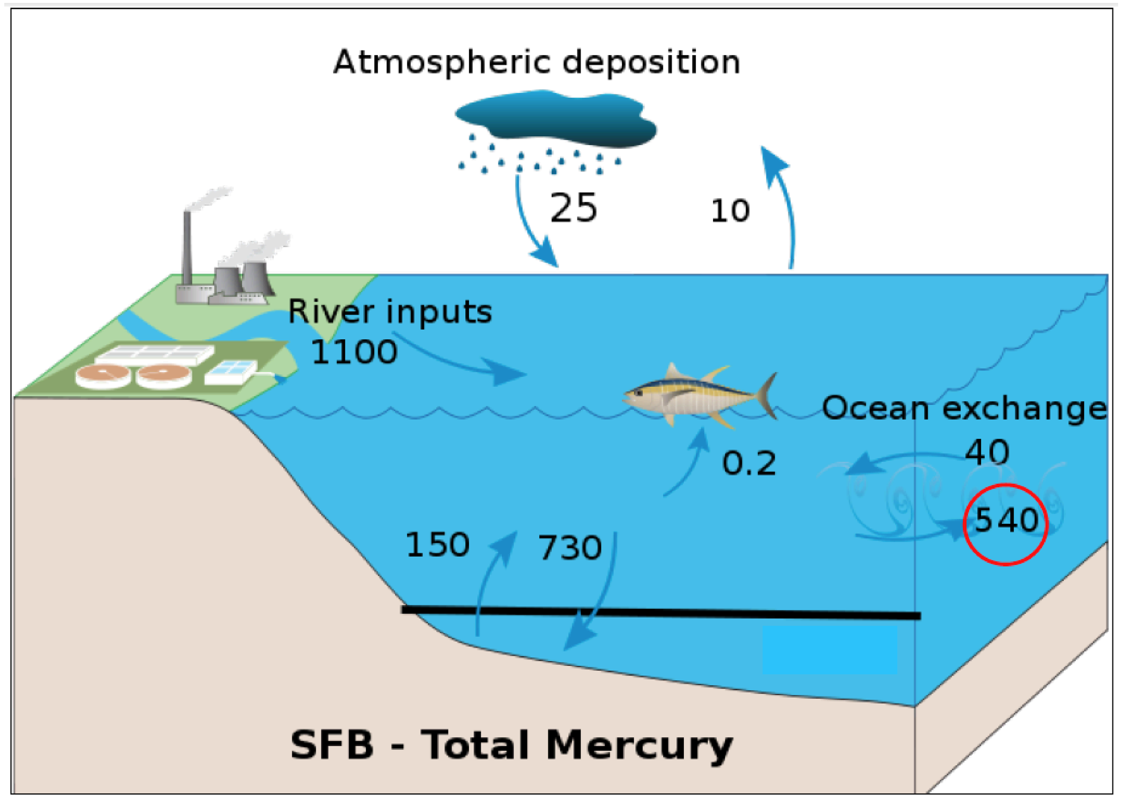


Figure 5. Mercury releases to land and water can end up in rivers, and ultimately offshore. For example, it is estimated that 50% of riverine mercury inputs to the San Francisco Bay estuary eventually end up in the coastal ocean (7). Units are in kg/year.

Sources & Acknowledgements:

(1) Sunderland, E. M. and Selin, N.E. (2013). Future trends in environmental mercury concentrations: implications for prevention strategies. *Environmental Health*.
(2) H. M. Amos, D. J. Jacob, D. G. Streets, and E. M. Sunderland. Legacy of all-time anthropogenic emissions on the global mercury cycle. Under review at *Global Biogeochemical Cycles*.
(3) D. G. Streets, M. K. Devane, Z. Lu, T. C. Bond, E. M. Sunderland and D. J. Jacob (2011). All-time releases of mercury to the atmosphere from human activities. *Environmental Science & Technology.*
(4) Sundseth, K., Pacyna, J. M., Pacyna, E. G., Munthe, J., Belhaj, M., & Astrom, S. (2010). Economic benefits from decreased mercury emissions: Projections for 2020. *Journal of Cleaner Production*.
(5) Pacyna, J. M., Sundseth, K., Pacyna, E. G., Jozewicz, W., Munthe, J., Belhaj, M., & Aström, S. (2010). An Assessment of Costs and Benefits Associated with Mercury Emission Reductions from Major Anthropogenic Sources. *Journal of the Air & Waste Management Association*.
(6) United Nations Environment Programme. (2010). *Process Optimization Guidance for Reducing Mercury Emissions from Coal Combustion in Power Plants*. Geneva, Switzerland.
(7) Chen, C.Y., C.T. Driscoll, K.F. Lambert, R.P. Mason, L.R. Rardin, C.V. Schmitt, N.S. Serrell & E.M. Sunderland. (2012). *Sources to Seafood: Mercury Pollution in the Marine Environment*.

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