Mercury inputs to Chinese marginal seas - Impact of industrialization and development of China

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1. Introduction

Atmosphere deposition is global important to open ocean.

The graphic, “Mercury in the Open Ocean: Sources to Seafood” is reproduced from Sources to Seafood: Mercury Pollution in the Marine Environment by the Coastal and Marine Mercury Ecosystem Research Collaborative, December 2012.
1. Introduction

River input is more important to coastal ocean

Contributions of riverine discharges to modeled annual total Hg concentrations

Zhang et al. (2015 GBC)
1. Introduction

Hypothesis: Mercury inputs to Chinese marginal seas may have been changed

China is the largest emitter of atmospheric Hg in the world

China’s Economic Reform policy started in 1978
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Objective
Historical changes

1. Dry density test & $^{210}$Pb Dating
Nanjing Institute of Geography and Limnology, CAS

2. Total Hg concentration
Shanghai Key Laboratory of Atmospheric Particle Pollution Prevention, Fudan University, China

3. Hg isotopic composition
University of Wisconsin-Madison’s State Laboratory of Hygiene
2. Experimental methods

1. Dry density test & $^{210}$Pb Dating
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2. Total Hg concentration
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3. Hg isotopic composition
   University of Wisconsin-Madison’s State Laboratory of Hygiene
3. Results and Discussion
The sedimentation efficiency, or proportion of inflowing sediment retained by a reservoir, are averagely 30 to 40% for global reservoirs.
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Mercury isotopes showed significant changes in the past decades.
3. Results and Discussion

Mercury isotope may be a source tracer

Bergquist and Blum (2007) Science

Atmospheric Hg\textsuperscript{0}: (-)MIF

Aqueous Hg\textsuperscript{II}: (+)MIF

\begin{align*}
\Delta \^\text{199}Hg &= \Delta \^\text{201}Hg = 1.08 \pm 0.07(\sigma) \\
\end{align*}

Bergquist and Blum (2007) Science

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3. Results and Discussion

① Industrial Hg (δ²⁰²Hg: -0.5 ± 0.4‰; Δ¹⁹⁹Hg: 0.0 ± 0.1‰; σ, n=292)
  Sonke et al., 2010; Cooke et al., 2013; Donovan et al., 2013; 2015; Ma et al., 2013; Mil-Homens et al., 2013; Balogh et al., 2015; Bonsignore et al. 2015; Lepak et al., 2015; Wiederhold et al., 2014; 2015; Guedron et al., 2016; Yin et al., 2016a

② Soil Hg (δ²⁰²Hg: -1.9 ± 0.4‰; Δ¹⁹⁹Hg: -0.3 ± 0.1‰; σ, n=110)
  Biswas et al., 2008; Demers et al., 2013; Zhang et al., 2013; Jiskra et al., 2015

③ Precipitation-derived Hg (δ²⁰²Hg: -1.2 ± 1.1‰; Δ¹⁹⁹Hg: 0.4 ± 0.3‰; σ, n=104).
  Gratz et al., 2010; Sherman et al., 2011; Chen et al., 2012; Demers et al., 2013; Wang et al., 2015
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River inputs:
Mercury in major rivers is mainly particulate-bound (80-90%). Particulate Hg is relatively conservative.
3. Results and Discussion

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Atmospheric inputs:
Seawater contains more soluble Hg species, and precipitation Hg are more soluble and more photoreduced.

Adsorption of soluble Hg results in more negative $\delta^{202}\text{Hg}$ in the solid phase (Wiederhold et al., 2010; Jiskra et al., 2012)
3. Results and Discussion

Triple Mixing Model

\[ F_{\text{ind.}} + F_{\text{wat.}} + F_{\text{atm.}} = 1 \]
\[ F_{\text{ind.}} \cdot \delta^{202}\text{Hg}_{\text{ind.}} + F_{\text{wat.}} \cdot \delta^{202}\text{Hg}_{\text{wat.}} + F_{\text{atm.}} \cdot \delta^{202}\text{Hg}_{\text{atm.}} = \delta^{202}\text{Hg}_{\text{spl.}} \]
\[ F_{\text{ind.}} \cdot \Delta^{199}\text{Hg}_{\text{ind.}} + F_{\text{wat.}} \cdot \Delta^{199}\text{Hg}_{\text{wat.}} + F_{\text{atm.}} \cdot \Delta^{199}\text{Hg}_{\text{atm.}} = \Delta^{199}\text{Hg}_{\text{spl.}} \]

Model assumption:

1. Industrial Hg and soil Hg were strongly bound to particles, with limited isotope fractionation.
2. Precipitation-derived Hg was adsorbed to particles prior to sedimentation, resulting a negative shift of about 0.6 ‰ for \( \delta^{202}\text{Hg} \) in the solid phase.
3. Reemission of Hg to the atmosphere is small compared to the ocean Hg pool.
3. Results and Discussion

Model output: industrial Hg
3. Results and Discussion

Model output: soil Hg

A recent study showed that about 40% of the total input can be retained by the reservoirs.
3. Results and Discussion

Precipitation Hg seems to be controlled by river loading of soil particles.

Model output: precipitation Hg
Thank you for your attention