Arctic rivers traffic atmospheric mercury to the Arctic Ocean

A new study, led by researchers from the CNRS, the Institut National Polytechnique, Universite Paul Sabatier, and international collaborators shows that Arctic rivers carry large amounts of pollutant mercury to the Arctic Ocean. The findings provide the missing piece of a puzzle that clarifies how mid-latitude anthropogenic mercury emissions have polluted one of the most pristine regions on our planet. Until recently, mercury emissions were thought to reach the Arctic by air, and deposit directly to the Arctic marine ecosystem. The study published in PNAS (26 November, 2018) finds that Arctic rivers deliver more mercury to the Arctic Ocean than atmospheric deposition. The researchers integrated their results into a 3D coupled Ocean-atmosphere model of mercury cycling and find annual net transfer of mercury from the Arctic Ocean to the atmosphere. The new paradigm on arctic mercury cycling provides a solid basis to evaluate how arctic warming will affect mercury exposure to wildlife and humans in the near future.

Mercury (Hg) levels in arctic marine biota are among the highest globally, and affect arctic wildlife and indigenous populations that rely on seafood. The few Hg emission sources in the Arctic have left scientists to wonder how mid-latitude anthropogenic emissions reach the Arctic Ocean marine ecosystem. The discovery of massive arctic atmospheric Hg deposition events, related to sea-ice derived reactive halogen oxidants, in 1998 have fueled a paradigm where mid-latitude urban-industrial Hg emission reach the Arctic exclusively via the atmosphere, then deposit to the marine ecosystems. Subsequent research has shown that 70-80% of the deposited Hg is photochemically reemitted back to the atmosphere only hours after deposition. In 2012, a coupled 3D Ocean-atmosphere model of the arctic Hg cycle suggested that a source of Hg to the Arctic Ocean was missing. The missing source was suggested to be Arctic Rivers, in particular Russian rivers that account for 80% of run-off to the AO.

Because no seasonal observations existed for Russian rivers, Jeroen Sonke from the Geoscience Environnement Toulouse (GET) laboratory teamed up with colleagues Oleg Pokrovsky from GET, and Roman Teisserenc from the laboratoire d'Ecologie Fonctionnele (EcoLab) to gather the missing pieces of evidence. From 2012 to 2016 they monitored year-round Hg levels in the Yenisei and Severnaya Dvina rivers. Their findings, published in the journal PNAS confirm that Russian rivers transport large amounts of Hg to the Arctic Ocean. The results were then integrated into the 3D Arctic mercury model, developed by colleagues from Harvard University. The researchers confirmed what they expected all along: Anthropogenic Hg emissions do not directly reach the Arctic Ocean ecosystem. Instead, atmospheric elemental Hg is taken-up year-round by arctic tundra vegetation and soils. Springtime snow melt mobilizes the tundra soil mercury, which is bound to plant-derived carbon, via rivers to the Arctic Ocean, where it becomes partly available to the marine foodweb. The 3D model suggests that a large portion of riverine Hg is photochemically reduced in the surface Arctic Ocean and emitted to the atmosphere. The researchers indicate that the Arctic Hg cycle therefore runs in the opposite direction from what was previously thought.

The river Hg budget, together with recent observations on tundra Hg uptake and Arctic Ocean Hg dynamics, provide a consistent view of the Arctic Hg cycle where continental ecosystems traffic anthropogenic Hg emissions to the Arctic Ocean via rivers, and where the Arctic Ocean exports Hg to the atmosphere, to the Atlantic Ocean and to marine sediments. Ongoing Arctic warming and permafrost thaw risk mobilizing large amounts of tundra soil Hg to the Arctic Ocean via rivers, thereby potentially increasing health risks to humans.

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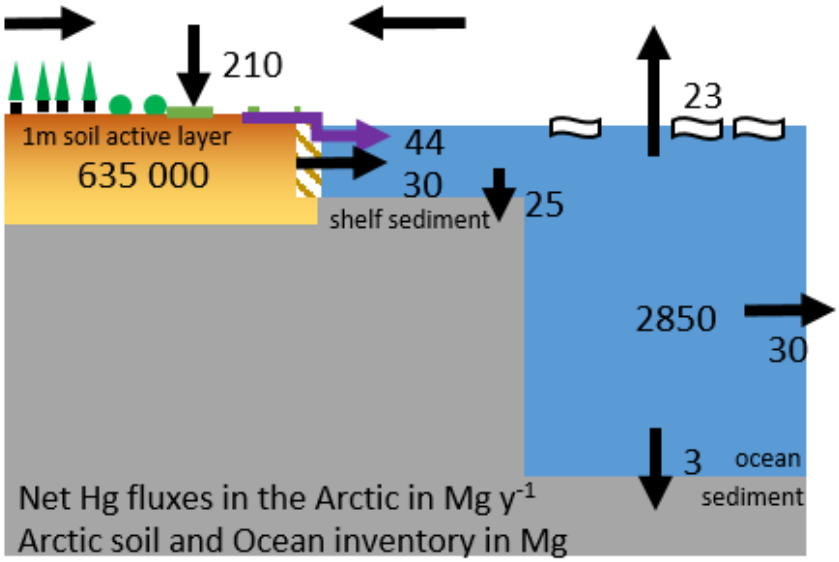

Figure. The modern Arctic Hg cycle, showing net fluxes (metric tons per year) between the different terrestrial, marine and atmospheric reservoirs (metric tons). The hatched area represents the coastal erosion Hg flux. The large river Hg flux (purple arrow) confirms a new paradigm where tundra vegetation and soil uptake of atmospheric Hg traffic mid-latitude Hg emissions to rivers and to the Arctic Ocean. Image from Sonke et al., 2018, PNAS.

Bibliography

Eurasian river spring flood observations support net Arctic Ocean mercury export to the atmosphere and Atlantic Ocean. Jeroen E. Sonke, Roman Teisserenc, Lars-Eric Heimbürger, Mariia V. Petrova, Nicolas Marusczak, Theo Le Dantec, Artem V. Chupakov, Chuxian Li, Colin P. Thackray, Elsie M. Sunderland, Nikita Tananaev, Oleg S. Pokrovski, (2018), PNAS. doi/10.1073/pnas.1811957115

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