New Initiative: Low-Cost Gaseous Mercury Network

Overview

Mercury in the environment is a well-known neurotoxin that affects the health of humans and wildlife. The National Atmospheric Deposition Program (NADP) has been a leader in measuring atmospheric inputs of mercury (Hg) into ecosystems for many years. NADP has been monitoring Hg in wet deposition since 1996 through the Mercury Deposition Network (MDN) and ambient Hg species since 2009 through the Atmospheric Mercury Network (AMNet). The MDN topped out at 126 sites in 2009 before the number of sites started to decline. Today the MDN has 81 sites with large gaps in the western US. The AMNet peaked at 25 sites and is down to 14 sites, currently all in the eastern US. AMNet is limited in scope due to the high cost of equipment and expertise needed to operate a site. NADP also has a relatively new network that has measured Hg in litterfall at 25 sites since 2008. These sites are also all in the eastern US.

Recently, significant advances in simple, low-cost technologies to measure ambient Hg concentrations provide potential new opportunities for NADP and other monitoring programs interested in addressing data gaps. Recognizing the need for more routine data on the species of mercury that contribute to dry deposition, particularly in the western US, the MELD (Mercury in the Environment and Links to Deposition) Science Committee assembled a multi-disciplinary team of experts in 2020 to evaluate five promising technologies for potential network application, including:

1. Gold-trap (dual) amalgamation for gaseous elemental mercury (GEM), with Hg-Isotope option (Advocate: Dave Krabbenhoft, USGS)

2. Gold-trap amalgamation for GEM (Advocate: Tatsuya Hattori, IDEA Consultants, Inc.)

3. Passive for Gaseous Mercury (GM, MerPAS) (Advocate: Carl Mitchel and Frank Wania, University of Toronto)

4. Direct gaseous oxidized mercury (GOM) and particle bound mercury (PBM) –

membrane/filter approaches (Advocate: Mae Gustin, UN, Reno)

5. Reactive mercury by difference (dual or switching Tekran) (Advocate: Winston Luke, NOAA; Mark Olson, WSLH, Wisconsin State Laboratory of Hygiene)

A workshop was held in January 2021, where the advocates of each approach presented and addressed a common set of questions. The assembled group of experts - the Mercury Measurement Evaluation Team (MMET) - evaluated each method and provided a Summary of Recommendations. The MMET recognized the value in all the different approaches but noted that the passive technology (i.e., MerPAS) is the most ready for routine deployment to measure GM in a long-term, large-scale network. The team also suggested that side-by-side field intercomparisons involving all of the methods under consideration would be beneficial.

Based on these recommendations, concerns about budget issues faced by the mercury networks, and the growing application of passive mercury measurement devices globally, the NADP Budget Committee passed a motion in July 2021 stating that "the Program Office will develop an implementation plan for a passive mercury monitoring network for review and consideration by the Executive Committee to enhance the economic sustainability of the NADP mercury enterprise." In response to the motion, the Program Office has proposed a two-pronged approach to the implementation plan:

> (1) a passive gaseous mercury network using primarily the MerPAS technology, that would operate on a monthly basis and provide average GM concentrations as a foundation for supplemental dry measurements, and
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> (2) an intercomparison study of all the approaches that would allow for the expansion of mercury measurement capabilities in the future.

The passive technology is well-researched and documented, and the applied technique has been shown to be an accurate and inexpensive method for determining long-term concentrations of GM in the background atmosphere. This method's ease of use also gives it potential for widespread deployment both domestically and internationally because there are

no power requirements, sampling supplies are easy to ship, and there are simple and consistent SOPs. Similarities to the passive ammonia network (AMoN) will also make it easy for NADP to manage.

NADP recognizes that while this passive network will help determine long-term trends of GM concentrations in the atmosphere, it won't address all the data needs including Hg speciation and subsequent dry deposition, source attribution, or modeling inputs. Some of these other methods could be applied on a site-specific basis or as a smaller subnetwork to address some of these questions depending on assessment needs and sponsor interests. The passive network will build on NADP's current Hg networks (MDN, AMNet, and Litterfall) and not replace them.

Each of the advocates will be invited to participate in the intercomparison study. The advocates will be asked to provide equipment/samplers and laboratory analysis for their method, while the NADP staff will provide routine field operation support and maintenance. The equipment will run at the Henry Mall location (5th Floor Roof, 6th floor laboratory space), on the University of Wisconsin – Madison campus, where NADP staff are readily available. NADP will be responsible for data records and analysis and any specific QA applications of the data. A common time period(s) for operation will need to be established. This effort will provide NADP with experience using each method and additional information that will be useful in future network designs.

Moving forward with this two-pronged approach will be advantageous to NADP and its partners for many reasons, including the ability to:

- Fill data gaps by providing a low-cost monitoring option for GM concentrations that are not currently routinely made and providing more complete coverage of Hg data across the US, particularly in the West.
- Stabilize the existing NADP Hg networks by growth and expansion of overall sites.
- Support multiple goals within NADP's organization, including those of MELD, MDN, AMNet, CitiDep (a workgroup focused on deposition to urban areas), and the health-related goals of the WSLH.

- Create opportunity for new partnerships with communities with environmental justice concerns (Tribes, small lake organizations, cities with significant waterbodies) and countries with limited resources.
- Align monitoring efforts with international monitoring initiatives, e.g., the development of a pilot global passive mercury monitoring network as undertaken by Environment and Climate Change Canada; and the consideration of passive and gold amalgamation trap methods for measuring atmospheric mercury concentrations by the Asia Pacific Mercury Monitoring Network.
- Support the goals of the Minamata Convention and the final monitoring guidance for effectiveness evaluation that calls for consistent global measurements of atmospheric mercury.
- Potentially scale up to an international Hg monitoring network.
- Build on the expertise that NADP can offer on network QA by expanding the intercomparison study into a "supersite" for global atmospheric monitoring methods development.

NADP is currently drafting a 12-point plan for new initiatives that includes details on objectives, justification, field and lab operating protocols, data management, QA, and costs. We look forward to discussing these concepts in further detail at the Fall NADP Meeting.