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Riverine Sources of Mercury to Aquatic and Terrestrial Ecological Food Webs: Effects of Remediation and Climate Change

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Problem Formulation

- The South River is a high gradient stream Hg impacts downstream of a former acetate flake and yarn facility in Waynesboro, VA (see **Figure 1**).
- Inorganic Hg (IHg) from eroding river banks continues to act as primary source to river
- Consumption of MeHg is the primary risk driver
- MeHg may be sensitive to climactic conditions (precipitation, temperature)
- **How will MeHg concentration respond to climate change and remediation?**

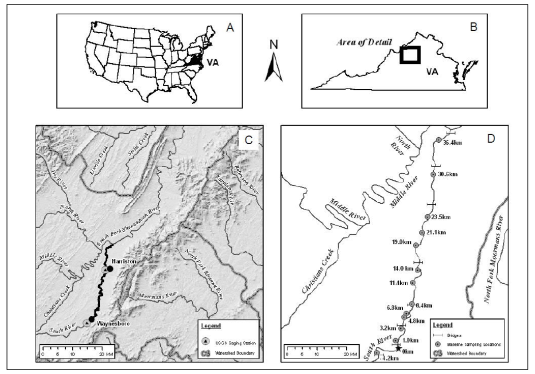

Figure 1. South River, VA Study Area for Hg. Panel C shows the study area (thick black line). Panel D, shows sample locations and the distance of the location from the former DuPont plant in Waynesboro, VA (located at RRM 0). From Flanders et al. (2010).

Remedial Approach

Contaminated Soil Removal Approach

Contaminated Soil Cap Approach

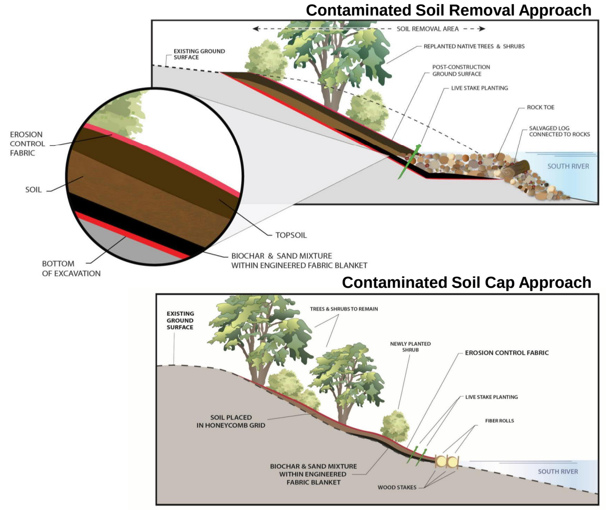

Figure 2. Remedial approaches for contaminated bank spoils

- Remedial design focuses on control of IHg sources(e.g., erosion of Hg impacted soil) to the aquatic environment (see **Figure 2**).
- Over time, remediation should reduce mercury loading to the river (see **Figure 3**).

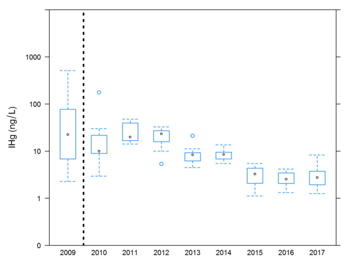

Figure 3. Example recovery time frame; South River bank stabilization pilot study filtered pore water data

Mercury Methylation May Respond to Climate Change

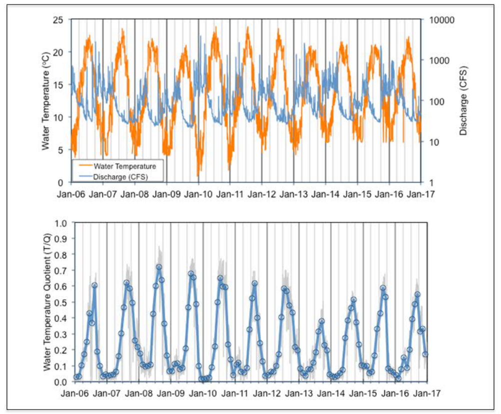

Figure 4. Surface water temperature (T) and discharge (Q) display regular seasonal patterns in the South River, with high temperatures and generally lower discharges during the spring and summer months (Panel A). Data were combined into one metric ('Water Temperature Quotient', T/Q) to illustrate seasonal patterns. CFS = cubic feet per second.

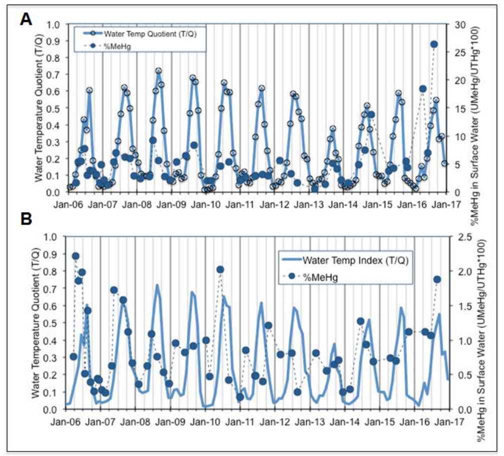

Figure 5. The percentage of THg as MeHg in unfiltered surface water samples (%MeHg) related to the Water Temperature Quotient in locations upstream of the former point source (Panel A; p = 0.016, linear regression) and downstream (Panel B; p = 0.023, linear regression).

- South River displays strong seasonal patterns in surface water temperature and discharge (see **Figure 4**).
- %MeHg in surface water closely tracks these seasonal patterns (see **Figure 5**).
- However, although increased temperatures associated with climate change (see **Figure 6**) are predicted, their effects on Hg methylation rates are uncertain (see **Figure 7**).

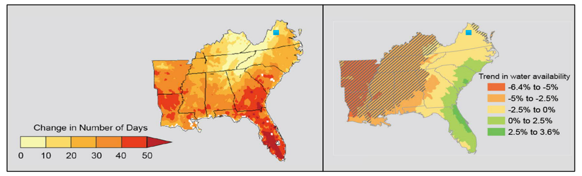

Figure 6. The southeastern region of the US is predicted to become warmer and drier as the result of climate change. The figures above are reprinted from the USEPA (2016), showing the number of days above 95ºF relative to 1971-2000 baseline (Panel A) and change in water availability between 2010 and 2060 relative to 2010.

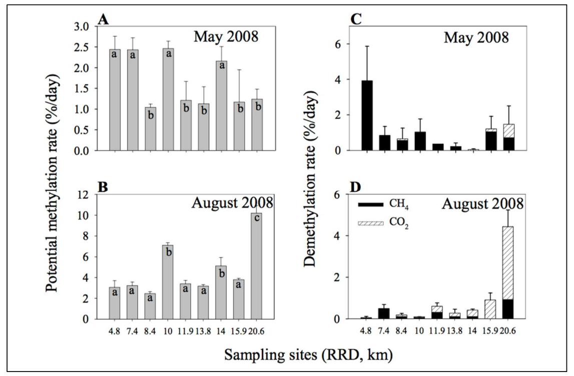

Figure 7. Potential methylation (A and B) and demethylation rates (C and D) by slurry incubations of sediments collected at nine sites downstream from the source of mercury contamination in the South River, VA. Re-printed with permission from Yu et al., (2011)

- Following source control, the concentration of IHg should decline (see **Figure 8**) due to:
  - Dilution by sediment from upstream of the historic mercury source
  - Release of fine-grained sediment from the streambed
  - Reduced bioavailability of IHg in sediment or on particles.
- Increased temperatures may create conditions favorable for methylation that could persist for longer periods throughout the year

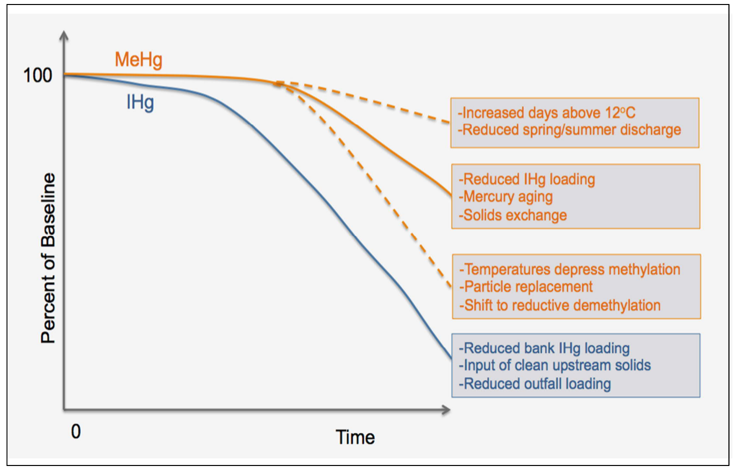

Figure 8. Conceptual model of South River recovery. IHg is predicted to decline due to source control (e.g., bank loading reductions) and ongoing recovery due to dilution with upstream solids. MeHg recovery is likely to lag behind IHg recovery, but should decline as the result of reduced IHg concentrations and mercury/particle aging. Climate change could affect this rate of MeHg decline. Declines could be slowed by a warming region and number of days above the minimum temperature for methylation in the South River, 12OC (Flanders et al., 2010) or to lower water volumes in South River. MeHg decline could be faster than anticipated as warmer temperatures decrease microbial production or increase rates of reductive demethylation, leading to evasion of Hg(0) (Yu et al., 2011).

- Future monitoring will allow for more insight into how the South River might respond to remediation and climate change.

References

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