Patterns of Mercury Cycling in the Profundal Zone of Hodges Reservoir, California

Marc Beutel, Ph.D., P.E.
Associate Professor
Civil and Environmental Engineering Department
University of California, Merced

*DTMC Meeting, September 26, 2019*
Acknowledgements

Byran Fuhrmann, PhD student, UC Merced
Dr. Peggy O’Day, Professor, UC Merced

Sarah Brower, Ph.D., Water Resources Specialist
Jeffery Pasek, Watershed Manager

Carrie Austin, California Water Board
Janis Cooke, California Water Board
Lauren Smitherman, California Water Board
California regulators are implementing a **Statewide Mercury Control Program for Reservoirs** to protect human and wildlife health.

State is asking reservoir managers to implement **pilot studies** focusing on managing water chemistry and food webs to reduce mercury in fish.

San Diego is implementing an **oxygenation project in Hodges Reservoir** as part of comprehensive water quality improvement program.

We performed a **laboratory sediment flux study** to assess response of profundal sediment to oxic and anoxic conditions.

We are also performing an **ongoing field studies** to assess impacts of oxygenation on water quality and mercury cycling.
Hodges Reservoir

- Backup water supply reservoir
- 37 million m$^3$ volume
- 35 m maximum depth
- 64,000 hectare watershed
- Urban and agriculture
- Degraded water quality
- Oxygenation in 2019
Hodges Reservoir
Hodges Oxygenation

- On-shore LOX storage
- Submerged cone near dam
- 8 tons of oxygen per day
Mercury Cycle

Bioavailable Hg(II)
Active sulfate-reducing bacteria
Methylation $>$ demethylation
Mercury Cycle

Synergy with internal loading of nutrients, manganese and iron
Chamber Incubations
Chamber Incubations

Oxic

Anoxic
Sulfate – Methylmercury Linkage

Net methylation declines as anoxia progresses

↓ Hg(II) bioavailability      ↑ Demethylation

Anoxic Stage 1

$$y = 0.345x - 190.6$$
$$R^2 = 0.62$$
$$P < 0.02$$

Anoxic Stage 2
Manganese – Methylmercury Linkage

![Graphs showing the relationship between Manganese and Methylmercury](image)

- **Surface Water Mn, µg/L**
  - Station A: ♦️
  - Station B: □️

- **Water Column Methylmercury, ng/L**

**Regression Analysis**

- $y = 0.0026x + 0.16$
- $R^2 = 0.76$
- $p < 0.001$

**Graph Details**

- X-axis: Water Column Manganese, µg/L
- Y-axis: Water Column Methylmercury, ng/L

**Note:** The graphs illustrate the correlation between manganese and methylmercury concentrations across different stations and time periods.
Temperature

Dissolved Oxygen
Hodges 2017

Seston Hg:Chl A ratio in surface waters

Zooplankton Mercury
Conclusions

- Experimental chambers show that maintenance of oxygenated conditions near the sediment-water interface represses methylmercury release.
- Both experimental chambers and field monitoring indicate that methylmercury production is associated with mildly reduced conditions.
- Mildly reduced conditions may correspond with high Hg(II) bioavailability and low demethylation.
- Oxygenation could yield synergistic repression of sediment release of nutrients, manganese, iron and methylmercury.
- Reservoir managers must avoid accidently enhancing methylmercury production due to incomplete oxygenation of the profundal zone!
Thanks for your attention!