Science of the Total Environment xxx (2014) xxx–xxx

Contents lists available at ScienceDirect

Science of the Total Environment

journal homepage: www.elsevier.com/locate/scitotenv

Preface

# Methylmercury cycling in wetlands managed for rice agriculture and wildlife: Implications for methylmercury production, transport, and bioaccumulation

Mercury (Hg) is among the most regulated toxins in North America. Despite reductions in industrial use, Hg availability appears to be increasing globally through atmospheric deposition. The primary route of exposure to humans and wildlife is dietary consumption of monomethylmercury (MeHg), a toxic, organic form of Hg that is bioaccumulated in organisms, and food webs. For the past 30 years, research on Hg has shown that wetland environments promote the microbial methylation of inorganic Hg (II) to MeHg, primarily through the activity of sulfate- and iron(III)-reducing bacteria. Agricultural wetlands, especially rice farms, are among the most abundant wetland ecosystems in temperate and tropical latitudes. In California, rice field acreage is greater than that of remaining natural wetlands, and thus, constitutes significant habitat for wildlife, especially waterfowl.

In 2007–2008, a multi-agency, multidisciplinary study was initiated to assess the extent to which wetland Hg cycling was affected by agricultural management for rice production (shallow flooding, fertilizer addition, and high rates of carbon fixation). We focused the study on the Yolo Bypass Wildlife Area, one of several wetland regions of the California Central Valley where sediment Hg concentrations are elevated due to historical gold and Hg mining. The eight publications in this Special Section detail the results from this integrated study. These publications, in addition to two others previously published (Ackerman and Eagles-Smith, 2010; Ackerman et al., 2010), are focused on the processes responsible for MeHg production, export, and bioaccumulation within agricultural wetlands (white rice, wild rice, and fallowed fields), and adjacent wetlands managed for wildlife during the annual crop cycle. We conclude that agricultural wetlands are significant sources of MeHg to downstream habitats and are areas of enhanced MeHg bioaccumulation. Our results suggest that modifications to management practices could reduce MeHg export from, and wildlife exposure within, agricultural wetlands.

We synthesized these findings in Windham-Myers et al. (in press) with a conceptual model linking ecosystem components relevant to Hg cycling. Quantitative comparison among the linked studies suggests that within-field hydrologic processes are critical controls on water and sediment chemistry, with important variability between winter and summer flooding periods, and between seasonally and permanently flooded wetlands. Hydrologic management varied between wetland habitat types, and this impacted MeHg production, export, and bioaccumulation. Bachand et al. (in this issue-a) illustrate the significance of rice plant transpiration in field-specific water budgets. Bachand et al. (in this issue-b) quantified Hg and MeHg exports from fields on a seasonal basis, emphasizing key hydrologic controls, and uncertainties in calculating Hg loads. Alpers et al. (in this issue-2013) examined spatio-temporal water quality variation to describe processes that influence MeHg concentrations and loads in surface water. Fleck et al. (in this issue-2013) discuss the role of dissolved organic matter on MeHg photodegradation in surface water. Marvin-DiPasquale et al. (in this issue) investigated sediment microbial processes, and factors controlling benthic MeHg production throughout the entire crop year. Windham-Myers et al. (in this issue-a) experimentally examined the linkages between plant-derived labile carbon, rhizosphere oxidation dynamics, and sediment MeHg production. Windham-Myers et al. (in this issue-b) explain the seasonal importance of plant growth and decomposition as factors affecting MeHg export and bioaccumulation, including the uptake and storage of Hg in plant tissue.

The information provided here improves our understanding of Hg biogeochemistry in agricultural and managed wetland settings. As rice production expands, and atmospheric Hg deposition increases globally, observations that provide a foundation for process-based information on Hg bioaccumulation are critical, particularly in the context of rice production as it pertains to global food supplies and wildlife. We anticipate that the results reported here, and information developed using a process-based approach, will aid in the development of future wetland management and monitoring plans for agriculture and wildlife in California, and globally.

## References

Ackerman JT, Eagles-Smith CA. Agricultural wetlands as potential hotspots for mercury bioaccumulation: experimental evidence using caged fish. Environ Sci Tech 2010;44:1451–7.

Ackerman JT, Miles AK, Eagles-Smith CA. Invertebrate mercury bioaccumulation in permanent, seasonal, and flooded rice wetlands within California's Central Valley. Sci Total Environ 2010;408:666–71.

Alpers CN, Fleck JA, Marvin-DiPasquale M, Stricker CA, Stephenson M, Taylor HE. Mercury cycling in agricultural and managed wetlands. Spatial and seasonal variations in water quality: Yolo Bypass, California; 2013 http://dx.doi.org/10.1016/j.scitotenv.2013.10.096 [in this issue].

Bachand PAM, Bachand SM, Fleck JA, Anderson F, Windham-Myers L. Differentiating transpiration from evaporation in seasonal agricultural wetlands and the link to advective fluxes in the root zone 2013a. http://dx.doi.org/10.1016/j.scitotenv.2013.11.026. [in this issue].

Bachand PAM, Bachand SM, Fleck JA, Alpers CN, Stephenson M, Windham-Myers L. Methylmercury production in and export from agricultural wetlands in California, USA: The need to account for physical transport processes into and out of the root zone; 2013b. http://dx.doi.org/10.1016/j.scitotenv.2013.11.086. [in this issue].

Fleck JA, Gill G, Downing BD, Bergamaschi BA, Kraus TEC, Alpers CN. Concurrent photolytic degradation of aqueous methylmercury and dissolved organic matter. Sci Total Environ 2013. http://dx.doi.org/10.1016/j.scitotenv.2013.03.107. [in this issue].

Marvin-DiPasquale M, Windham-Myers L, Agee JL, Kakouros E, Kieu LH, Fleck J, Stricker C. Methylmercury production in sediment from agricultural and non-agricultural wetlands in the Yolo Bypass, California. Sci Total Environ [in this issue]. http://dx.doi.org/http://dx.doi.org/10.1016/j.scitotenv.2013.09.098.

Windham-Myers, L, Fleck, JA, Ackerman, JT, Marvin-DiPasquale, M, Stricker, CA, Heim, WA, Bachand, PA, Eagles-Smith, CA, Gill, G, Stephenson, M, Alpers, CN. Mercury

0048-9697/$ – see front matter. Published by Elsevier B.V.
http://dx.doi.org/10.1016/j.scitotenv.2014.01.046

cycling in agricultural and managed wetlands: a synthesis of methylmercury production, hydrologic export, and bioaccumulation from an integrated field study: Sci Total Environ [in press]. http://dx.doi.org/http://dx.doi.org/10.1016/j.scitotenv.2014.01.033
Windham-Myers L, Marvin-DiPasquale M, Stricker CA, Agee JL, Kieu, LH, Kakouros E. Mercury cycling in agricultural and managed wetlands, Yolo Bypass, California: Experimental evidence of vegetation-driven changes in sediment biogeochemistry and methylmercury production. Sci Total Environ [in this issue]. http://dx.doi.org/http://dx.doi.org/10.1016/j.scitotenv.2013.05.028.
Windham-Myers L, Marvin-DiPasquale M, Kakouros E, Agee JL, Kieu LH, Stricker CA, Fleck JA, Alpers CN, Ackerman JT. Mercury cycling in agricultural and managed wetlands, Yolo Bypass, California: Seasonal influences of vegetation on mercury methylation, storage, and transport. Sci Total Environ [in this issue]. http://dx.doi.org/http://dx.doi.org/10.1016/j.scitotenv.2013.05.027.

Lisamarie Windham-Myers
*U.S. Geological Survey, Western Region Branch of Regional Research, 345 Middlefield Road, MS 480, Menlo Park, CA 94025, United States*
Tel.: +1 650 329 4447; fax: +1 650 329 4463.
*E-mail addresses*: lwindham@usgs.gov, lwindham-myers@usgs.gov.

14 January 2014
Available online xxxx

Please cite this article as: Windham-Myers L, Methylmercury cycling in wetlands managed for rice agriculture and wildlife: Implications for methylmercury production, transport, and bioaccumulation, Sci Total Environ (2014), http://dx.doi.org/10.1016/j.scitotenv.2014.01.046