Title:

Methane Dynamics in the Illinois Waterway from Lake Michigan to the Confluence of the Mississippi River: Contrasting Seasonal Patterns of Methane in Urban and Agricultural Environments

Authors:

Fazio, David J., U.S. Geological Survey – Central Midwest Water Science Center, djfazio@usgs.gov, ORCID: 0000-0003-0254-5162

Wickland, Kimberly P., U.S. Geological Survey – Geosciences and Environmental Change Science Center, kpwick@usgs.gov, ORCID: 0000-0002-6400-0590

Loken, Luke C., U.S. Geological Survey – Upper Midwest Water Science Center, lloken@usgs.gov, ORCID: 0000-0003-3194-1498

Soderstrom, Carolyn M., U.S. Geological Survey – Central Midwest Water Science Center, csoderstrom@usgs.gov, ORCID: 0000-0003-0501-2572

Abstract:

The 541-kilometer-long Illinois Waterway is a highly managed, navigable system of rivers, canals, and series of locks that connect Lake Michigan with the Mississippi River. Its watershed encompasses densely populated urban areas (e.g., Chicago, Illinois) and intensively managed agricultural regions of the Midwestern United States. Using a boat-mounted, mobile-sensor platform, dissolved methane (CH_4) and related water-quality physiochemical properties were sampled at a frequency of 1 hertz, and a spatial resolution of approximately 1 sample every 12 meters, along the entirety of the Illinois Waterway. In total five different field sampling campaigns were completed from May 2022 to July 2023. Dissolved CH_4 concentrations were consistently elevated in the upper Illinois Waterway within the urban areas of greater Chicago, ranging from 1.14 micromoles per liter (µmol/L) to very high levels reaching 11.9 µmol/L. Elevated dissolved CH_4 (2.69 µmol/L) at relatively low water temperatures (<10 degrees Celsius) measured during the March–April sampling indicates a fluvial ecosystem that is more responsive to its watershed and lateral inputs than to internal drivers such as water temperature. This persistently elevated CH_4 in an urban waterway is likely heavily influenced by population density, human activities, and urban infrastructure. While CH_4 concentrations tended to decrease below outfalls of treated wastewater effluent, untreated wastewater released during combined sewer overflows resulted in elevated CH_4 concentrations in the waterway. In contrast, CH_4 concentrations in agricultural reaches had a discernible seasonal pattern, with concentrations peaking during the summer months aligning with elevated water temperatures and lower discharge conditions. This seasonality indicates fundamentally different controls of CH_4 in agricultural landscapes, potentially linked to agricultural practices. Other influences include tributaries, and the hydrologic connectivity of wetlands and backwater sloughs adjacent to the Illinois Waterway. The divergent CH_4 concentration patterns observed across the Illinois Waterway highlight the importance of anthropogenic influences, internal controls, hydrology, and land management practices in influencing CH_4 concentrations and emission to the atmosphere. These spatial-temporal data can be used to identify and quantify distinct sources of CH_4 and aid modeling of

greenhouse gas emissions from riverine ecosystems and the resultant contributions to the carbon budget in the Illinois Waterway.