Maumee River sediments as a nitrogen source or sink to Lake Erie: the competing roles of ammonium recycling and denitrification

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Abstract:

Since the 1990s, Lake Erie has experienced toxic cyanobacterial blooms due to high nutrient (nitrogen and phosphorus) inputs from its tributaries. These blooms negatively affect aquatic life, pets and livestock, and humans, as evidenced by shutdown of the City of Toledo water treatment plant in August 2014. The Maumee River has the largest drainage area into western Lake Erie and is most responsible for high nitrogen (N) and phosphorus (P) loads to Maumee Bay and the western basin. Previous studies have compared orthophosphate and nitrate (NO_3^-) loads from the Maumee relative to harmful algal blooms in Lake Erie; however, no studies have evaluated the transformations and fate of N within the river, even though phytoplankton biomass accumulation is seasonally limited by N in the western basin. The overall objective of the project was to determine whether Maumee River sediments are a source or sink of bioavailable N for primary productivity, including harmful cyanobacterial blooms in western Lake Erie. Preliminary results focused on dissolved gas fluxes across the sediment-water interface and suggest that Maumee River and Bay sediments exhibit active microbial processing, as evidenced by high sediment oxygen demand. While nutrient flux data are still pending (analyses delayed by restricted access to laboratory facilities during global pandemic), dissolved gas fluxes indicate that Maumee River sediments act as a net N sink, primarily via denitrification. River sediments thus perform a valuable ecosystem service by removing bioavailable N before it is discharged to Maumee Bay, where it can provide fuel for cyanobacteria bloom biomass and cyanotoxin production. However, isotope patterns for NH_4^+ also show that Maumee River (and Bay) sediments release substantial amounts of NH_4^+ to the overlying water. Since denitrification converts NO_3^- to N_2 gas, and NO_3^- is energetically less favorable for cyanobacteria assimilation compared to NH_4^+, the positive effects of N removal via denitrification (and anammox) are mitigated to some extent by sediment NH_4^+ releases. These results support numerous other studies showing that watershed N loads into western Lake Erie and other aquatic systems are impacted by non-N-fixing, toxin-producing cyanobacteria taxa.

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