Quantifying the role of mayflies (*Hexagenia* sp.) in the transfer of toxic metals in western Lake Erie

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Background

Mayflies have made a strong recovery in the western Lake Erie basin in the past decade with annual production of more then 5000 mg/m^2 in some locales. Mayfly nymphs are among the largest aquatic insects in the Great Lakes and are important both as a highly desirable food source for sport fish and as bioturbators of [contaminated] sediment. Mayflies are active burrowers typically penetrating 5 to 10 cm deep. They spend nearly their entire life (up to 2 years) in the sediments, consuming organic matter in the sediments, and thus providing ample opportunity to accumulate persistent bioaccumulative toxic metals (PBTs) from contaminated sediments. Previous workers have shown that mayflies bioaccumulate PCB congeners and PAH compounds to a much greater extent than other benthic invertebrates like dreissenid mussels, amphipods, and crayfish. As such, mayflies may provide a direct pathway for transfer of PBTs from contaminated sediments to important sport fish, and ultimately to humans who consume these fish.

Objectives

The objectives of this study were to determine the concentration and distribution of heavy metals in sediments and mayfly nymphs in the western Lake Erie basin and to quantify the potential role of mayflies in the transfer of persistent PBTs from contaminated sediment to valuable sport fish.

Methods

Sediment (top 3-cm) and mayfly nymphs were collected from 24 locations across the western basin of Lake Erie in May 2007. Sampling sites were selected so as to provide quantify mayfly distribution and potential sediment contamination throughout the U.S. western basin. Following appropriate EPA protocols, samples were analyzed for 16 elements using ICP-OES or ICP-MS. In addition, sediments were analyzed for percent organic matter. These data were integrated into a Geographical Information System (GIS) database to track the distribution of toxic metals through the environment and in the mayflies.

Results

Metal concentrations in sediments exceeded EPA effect levels at many of the sample sites across the western basin. Sediment heavy metal distribution profiles indicate that highest concentration occurred in the middle of the western basin. Percent organic matter in the sediments was significantly higher in these offshore (>5km from shore) sites and had a significant linear relationship with sediment metal concentrations. *Hexagenia* sp. were distributed throughout the western basin, but were at highest density (1350/m^2) within the Detroit River plume. The Cd and Zn levels in mayflies averaged approximately 4 times and 2 times higher (respectfully) than sediment levels. All other mayfly concentrations were below sediment metal concentrations. Concentrations of Cd and Pb were higher than the Probable Effect Level for impacting organisms in most of

the offshore sediments. Spatial representation (GIS maps) of metal concentrations in mayflies exhibited similar patterns to the spatial distribution of heavy metals in the sediments with higher concentrations of metals in mayflies residing in the central region of the western basin.

Implications

Toxic metals in sediments are of great concern due to the potential to be transferred up the food chain. The results of this study suggest that mayflies may play an important role in the trophic-transfer of metals, especially cadmium and zinc which had concentrations averaging 4 and 2 times higher (respectfully) than sediment levels. The Ohio Lake Erie Commission's most recent Lake Erie Quality Index Assessment for contaminated sediments yielded a rating of "Poor" (OLEC 2004). Remediation projects have focused on point source pollution of the major contributing rivers (OLEC 2006); however, the results of this study suggest heavy metals sediment contamination may be found far from a known pollution point source. Metal concentrations in sediments exceeded EPA effect levels at many of the sample sites across the western basin with the highest sediment metal concentrations at sites located in the middle of the basin. In addition, because sediment down flux rates are high in the western basin, mayfly nymphs are potentially resuspending toxic contaminants due to bioturbation, which may also increase fish contamination even without direct ingestion of mayfly nymphs.

Abstract

Although the quality of the Lake Erie environment has been improving as evidenced by the most recent Lake Erie Quality Index Assessment (Ohio Lake Erie Commission 2004), the extent and abundance of contaminated sediments still results in a "Poor" rating for this factor. Additionally, abundant mayfly nymphs live in these sediments before they emerge in June and July, and they are important food sources for many sport and commercially caught fish. To better assess the link between sediments, mayflies and fish, we measured the concentration of persistent toxic metals in sediments and mayflies throughout the U.S. western basin of Lake Erie. Our expectation was that we would find heavy metals in sediments and mayflies around the major tributaries (Detroit and Maumee rivers). Mayfly abundance was highest in the Detroit River plume (1350 nymphs per square meter of sediment or about 125 per square foot), but toxic metal concentrations were highest in the deepest waters of the basin. Sediment concentrations for cadmium and lead exceeded the levels that would probably have an effect on sediment-dwelling organisms at many locations and these metals appear to be adhered to the organic matter mayflies consume. Both cadmium and zinc appear to bioaccumulate because they were 4- and 2-times greater in mayfly tissues, respectively, compared to the sediment; thus, mayflies may be a conduit for transfer to fishes. Additionally, mayfly nymphs are potentially resuspending toxic contaminants due to bioturbation as they burrow in sediments, which may also increase fish exposure even without direct ingestion of mayfly nymphs.