Toxaphene Mass Balance for the Upper Great Lakes of North America

Deborah L. Swackhamer, Roger F. Pearson, Shawn Schottler, and Daniel G. Symonik

Environmental and Occupational Health, School of Public Health, Box 807 Mayo Bldg.
University of Minnesota, Minneapolis, Minnesota, USA

Introduction

It has been reported that toxaphene concentrations in lake trout from Lake Superior are greater than concentrations in lake trout from the other Great Lakes of North America, and that the concentrations in the other Great Lakes have declined over the last 15 years while they have not declined in Lake Superior (Glassmeyer et al., 1997). This is unexpected, since Lake Superior has the lowest concentrations of other similar organochlorine contaminants compared to the other Great Lakes due to its larger volume and less developed drainage basin (Eisenreich, 1987).

Toxaphene is thought to enter the Great Lakes from atmospheric deposition following long range transport from the southern US and Central America (Hoff et al., 1993). However, we recently reported that the northern basin of Lake Michigan has received significant non-atmospheric inputs of toxaphene historically and currently (Pearson et al., 1997).

Materials and Methods

We have collected water and sediment samples from two upper Great Lakes, Lake Michigan and Lake Superior. Water was collected from open water sites during 1992 and 1996-98, and sediment cores were obtained in 1991, 1992, and 1997.

Samples were extracted by accepted methods and analyzed using gas chromatographic electron capture negative ion mass spectrometry in selected ion mode (Swackhamer et al., 1987; Swackhamer et al., 1997; Pearson et al., 1997).

Mass Balance Model

Using air data for toxaphene from the U.S./Canadian Integrated Atmospheric Deposition Network, we have constructed a dynamic mass balance model for the upper Great Lakes. The model was built using the STELLA II framework, and was parameterized to run from 1950 - 1995 on 3 month intervals. The purpose of this model was three-fold: (1) to assess whether atmospheric deposition can account for the observed water (and fish) concentrations of toxaphene given the differences in the physical characteristics of the lakes; (2) to determine whether atmospheric deposition can account for the observed

sediment record for northern Lake Michigan; and (3) using sensitivity analyses, determine the most sensitive parameters and processes controlling toxaphene fate in the Great Lakes.

Results and Discussion

The model predicts the observed sediment profiles and current water concentrations in Lake Superior very well using atmospheric inputs of toxaphene only. The results indicate that toxaphene concentrations are highest in Lake Superior water because the lake has been losing toxaphene more slowly than the other lakes. The colder temperatures have decreased evaporative losses, and lower sedimentation rates have decreased losses to the sediments relative to the other Great Lakes. Both Lake Michigan and Lake Superior reached comparable toxaphene concentrations at approximately 1980, but the rate of decline since then has been more rapid in Lake Michigan.

The model results predict current water concentrations in Lake Michigan reasonably well. The model predicts current and past sediment concentrations in the southern basin of the lake well, but does not predict the observed profiles from the northern basin. While sensitivity analyses indicate that the model is sensitive to the air-water mass transfer coefficient, the water-sediment partition coefficient, and the air source function, changes in these parameters are unable to predict the observed sediment profiles for the northern basin. Modeling results are consistent with a non-atmospheric source of toxaphene to northern Lake Michigan.

References

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