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PhD Thesis, May 2005

Abstract

Numerous sampling and analysis programs to evaluate polychlorinated biphenyl (PCB) levels in the Upper Hudson River water, sediment, and biota have been conducted. Increased PCB loadings from the sediment to the water column under low-flow conditions during the late spring to early summer months have been observed. Mechanisms potentially responsible for the low-flow release of PCB compounds from the sediment to the water column in the Upper Hudson River were identified, and include physicochemical processes (desorption, diffusion, solubilization), microorganism activity, and bioturbation. These mechanisms can be affected by environmental factors such as temperature, organic matter, and essential nutrients. Hypotheses pertaining to the effect of the environmental factors on the low-flow release mechanisms in the Upper Hudson River were analyzed using available literature and data to assess the importance of each factor on the low-flow increased release of PCBs from the sediment to the water column during the late spring and early summer months. Results of the analysis indicated that sediment temperature is an important factor governing the low-flow PCB release, as increased sediment temperature leads to increased microbial and bioturbator activity and to increased rates of physicochemical PCB release processes such as solubilization, desorption, and diffusion.

Long-term (48 week) experiments with small-scale laboratory microcosms were performed to study the effect of temperature on PCB transport in and release from river sediment with fine scale resolution. Temperature significantly affected PCB transport in Grasse River sediment (Massena, NY) and a synthetic sediment system. The fastest transport occurred in biologically-active Grasse River sediment followed by biologically-inactive (killed) Grasse River sediment and synthetic sediment. As demonstrated by the appearance of small amounts of a dechlorination by-product, PCB dechlorination occurred at low-levels in the biologically-active microcosms.

A one-dimensional transport model with sorption and retarded diffusion was used to fit the experimental data. Effective diffusion coefficients were determined from fitting the model to the experimental data for each PCB compound. The strongest temperature dependence for biologically-active Grasse River sediment microcosms was observed for 2-chlorobiphenyl (BZ1), the lowest molecular weight and most mobile congener studied, with an average effective diffusion coefficient at 15°C of 4.6×10^{-8} cm²/sec and at 50°C of 1.8×10^{-7} cm²/sec. In killed Grasse River sediment, the average effective diffusion coefficient for BZ1 was 5 times higher, for 2,5-dichlorobiphenyl (BZ9) was 5 times higher, and for 2,4,5-trichlorobiphenyl (BZ29) was 3 times higher at 50°C than at 15°C. There was very little transport of BZ29, BZ9, and BZ1 in the synthetic microcosms, which made it difficult to identify temperature trends.

The rates of PCB transport in biologically-active Grasse River sediment were significantly affected by microbial gas bubble generation. In biologically-active Grasse River sediment microcosms, gas bubble generation increased the effective diffusion coefficient by an order of magnitude or more over the similar systems studied with no microbial activity.