FINAL REPORT
to
Hudson River Foundation

Anaerobic Dechlorination of PCBs in the Tidal Estuary of the Hudson River - A Comparison with the Upper Hudson

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Objectives

In contrast to the extensive dechlorination of PCBs observed in the upper Hudson River, no clear evidence of dechlorination was found in the tidal estuary of the river. In terms of dechlorination, however, the lower Hudson is different from upstream in two important ways: sediment PCB levels are much lower and the sulfate concentration is higher. Therefore, the major purpose of this work is to determine (1) whether reductive dechlorination of PCBs occurs in the lower Hudson and what the dechlorination potential is and (2) the effects of high sulfate concentrations and low sediment PCB levels on dechlorination in the estuary.

Dechlorinating microorganisms in the lower Hudson River

We have sampled sediments from 8 sites between river miles (RM) 18 - 56. The cores were analyzed for PCB congeners at various depths using both Soxhlet extraction and the EPA sonication methods. All sites appeared to have been contaminated by a mixture of Aroclor 1242 and other Aroclors (Table 1).

Table 1

Station	Location	River Miles
1	Yonkers	18.6
2	Piermont	25.5
3	Buoy #5	30.8
4	East Havestraw	36.0
5	Peekskill	44.0
6	Highland Falls	49.5
7	Foundry Cove	52.0
8	South of Newburgh	56.0

In the absence of information about their relative proportions, however, it was difficult to determine whether in situ dechlorination had occurred. Therefore, various laboratory investigations were carried out as described below to determine whether the sediments harbored dechlorinating microorganisms and if they do, what their dechlorinating potential was. Summarizing the results, we failed to find any evidence of dechlorinating microorganisms in the lower Hudson River despite extensive series of incubation experiments. It appears, therefore, that there is no natural dechlorinating taking place in this area.

Experiment I

For each sediment core, we investigated the presence of dechlorinating microorganisms using the congener assay method which we developed earlier. PCB-free sediments spiked with either 2,3,4-trichlorobiphenyl and 25/34-tetrachlorobiphenyls at an optimum concentration (300 ppm), were made into slurries synthetic anaerobic medium or filtered river water from Nyack. [These congeners were universally dechlorinated by dechlorinators from most known PCB contamination sites, to the best of our knowledge.] These sediment slurries were inoculated with sediment inocula from various sampling sites. The assay showed no evidence of dechlorination except one of the triplicates inoculated with sediment slurries from Station 8 (RM 56, South of Newburgh) after 1.5 years of incubation.

Experiment II

To simulate in situ dechlorination, experiments have been set up in the laboratory with contaminated sediments from four sites at RM 18, 31, 44, and 52, using river water from each site to make slurries. In parallel experiments, sediments from RM 31 and 44 were spiked with Aroclor 1242 and 1254 at 150 ppm each above the ambient level to determine whether there is potential for dechlorination at higher PCB levels. No transformation was observed after 25 weeks of incubation.

Experiment III

To investigate the concentration effects of PCBs, sediments spiked with Aroclor 1242 at 16 different concentrations ranging from 1 to 200 ppm were inoculated with the supernatant of slurries made of sediments from Highland Falls (Station 6). These experiments also failed to demonstrate dechlorination at any concentration after an 8-month incubation.

Experiment IV

To determine whether fatty acids (acetate, propionic acid, butyric acid, and palmitic acid) may enrich dechlorinators, a mixture of fatty acids, which are used by most anaerobic microorganisms, was added slurries of Aroclor 1242-spiked sediments. These slurries were then inoculated with sediment microorganisms from Piermont (Station 2), Peekskill (Station 5), and Palisade Park, and incubated under N_2/CO_2 and H_2/CO_2 atmospheres. Although a large amount of methane and H_2S were detected, no dechlorination was found.

In another experiments, sediments from each station were enriched with the fatty acid mixture and incubated for 6 weeks. Then, the supernatants of these enriched sediments were tested for dechlorination in Aroclor 1242-amended sediments. Here again, no dechlorination was detected after a 9-month incubation.

A manuscript is in preparation to report these results in a scientific journal.

Effects of sulfate on PCB dechlorination

Since it was not possible to detect dechlorinating microorganisms in sediments from the lower Hudson River, we used sediment populations from the upper Hudson to determine the effect of sulfate on PCB dechlorination. Sediments spiked with Aroclor 1242 were made into slurries using artificial sea-water medium which had various sulfate concentrations ranging from 3 to 23 mM. [Sulfate concentrations at sampling sites in the lower Hudson were between 0.2 at Station 8 (Newburgh) and 18 mM Station 1 near Yonkers.] The time course of dechlorination clearly demonstrated that dechlorination was inhibited at concentrations above 3 mM; above this concentration, there was no statistical difference in the extent of dechlorination with sulfate concentrations (Fig. 1).

When the number of dechlorinators was estimated using the most probably number technique, the number decreased with sulfate concentrations (Fig. 2). It appears from the present data that the decreased dechlorination at higher sulfate concentration may in part be related to a decrease in dechlorinator numbers. However, on the other hand, there is a possibility that a decrease in methanogens at higher sulfate

concentrations may also have contributed to a reduced level of dechlorination. Our recent studies have revealed that there are types of dechlorinators which require the presence of methanogens, and thus, even when the number of dechlorinator is the same, the extent of dechlorination was reduced by nearly a half when methanogenesis was suppressed by a metabolic inhibitor (Kim and Rhee, unpublished).

The present results suggest that the sulfate concentration in the lower Hudson may be inhibitory to PCB dechlorination. However, the absence of dechlorinators cannot be explained by high ambient sulfate concentrations alone, because our experiments show that they can grow at these concentrations. A manuscript is in preparation to report the effects of sulfate.

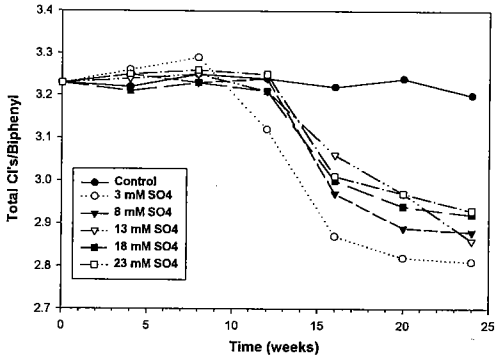

Figure 2. Time course of dechlorination at different sulfate concentrations.

Publications

The following papers have been published supported in part by the present grant.

X Liu, RC Sokol, O-S Kwon, CM Bethoney, and G-Y Rhee. 1996. An investigation of factors limiting the reductive dechlorination of polychlorinated biphenyls. ETC vol. 15, No. 10 pp 1738-1744.

Kim, JS and GY Rhee. 1997. Population dynamics of Polychlorinated Biphenyl - dechlorination microorganisms in Contaminated Sediments. Applied and Environmental Microbiology May 1997, pp. 1771-1776.

Sokol, RC., CM Bethoney, and G-Y Rhee. 1998. Reductive dechlorination of preexisting sediment polychlorinated biphenyls with long-term laboratory incubation. ETC vol 17, No. 6 pp. 982-987

Kim, J and G-Y Rhee. 1998. Reductive dechlorination of polychlorinated biphenyls: interactions of dechlorinating microorganisms with methanogens and sulfate reducers. Environ. Toxicol. Chem. In review.

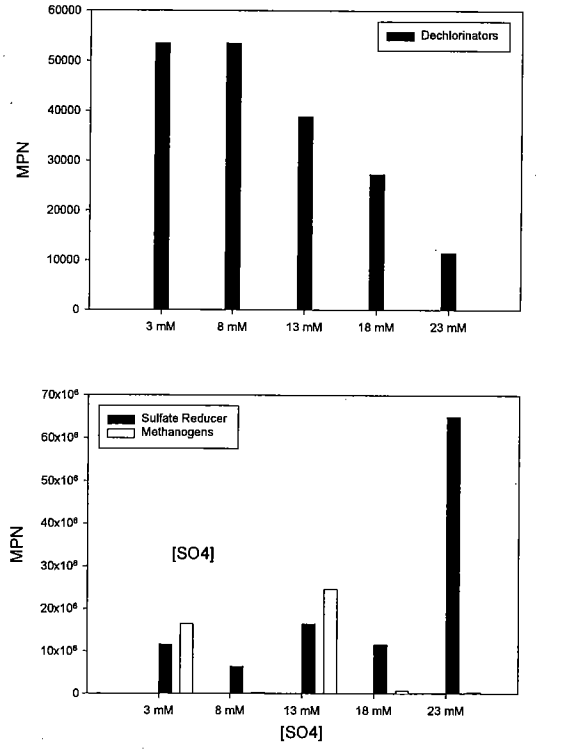

Figure 1. Number of dechlorinating microorganisms (top), and methanogens and sulfate reducers at different sulfate concentrations.