Reductive debromination of polybrominated diphenyl ethers (PBDEs) by anaerobic sediment microorganisms

Ewa M Skoczynska[1], Bart Zegers[1], Pim de Voogt[1], John R Parsons[1]

[1]IBED, University of Amsterdam

Introduction

The environmental fate and effects of brominated flame retardants have been receiving increasing interest. Because of their high hydrophobicity, polybrominated diphenyl ether (PBDE) flame retardants in the aquatic environment are mainly present in sediments and biota. Microbial degradation in sediments could potentially play an important role in the environmental fate of these compounds. Dehalogenation in anaerobic sediments has been found for many chlorinated aromatic compounds such as PCBs and PCDDs [1]. Recent reports indicate that PBDEs are debrominated in the gut of carp, presumably by bacteria [2] and in anaerobic activated sludge [3]. In this study we investigated the potential for reductive debromination of a number of PBDE congeners in anaerobic sediment suspensions.

Materials and Methods

Sediment samples (20 g) from the Western Scheldt were suspended in 60 ml anaerobic medium containing acetate, lactate and pyruvate as electron donors. The suspensions were spiked with individual BDE congeners 2,2',4,4',5-pentabromodiphenyl ether (BDE-99, 74.1 ng/g sediment), 2,2',3,4,4',5',6-heptabromodiphenyl ether (BDE-183, 96.3 ng/g), 2,2',3,3',4,4',5,5',6-nonabromodiphenyl ether (BDE-206, 11.59 µg/g), 2,2',3,3',4,4',5',6,6'-nonabromodiphenyl ether (BDE-207, 11.03 µg/g), 2,2',3,3',4,5,5',6,6'-nonabromodiphenyl ether (BDE-208, 10.44 µg/g) and decabromodiphenyl ether (BDE-209, 14.04 µg/g) and incubated anaerobically at room temperature in the dark. At appropriate times sediment samples were extracted with hexane/acetone and analysed using GC-LRMS.

Results and Discussion

As reported at Dioxin 2004 [4], a rapid decrease in the concentration of BDE 209 in the sediment microcosms was observed during the first two months of the experiment, followed by a period showing no significant degradation. Removal of BDE-99 and BDE-183 was much slower (Fig. 1). The GC-MS chromatograms of samples taken during the course of the experiment with BDE-209 showed that new peaks appeared with retention times slightly shorter than that of BDE 209 (Fig. 2). These peaks were identified as the three nonabrominated congeners BDE-206, BDE-207 and BDE-208 by comparison of their retention times and mass spectra with authentic samples.

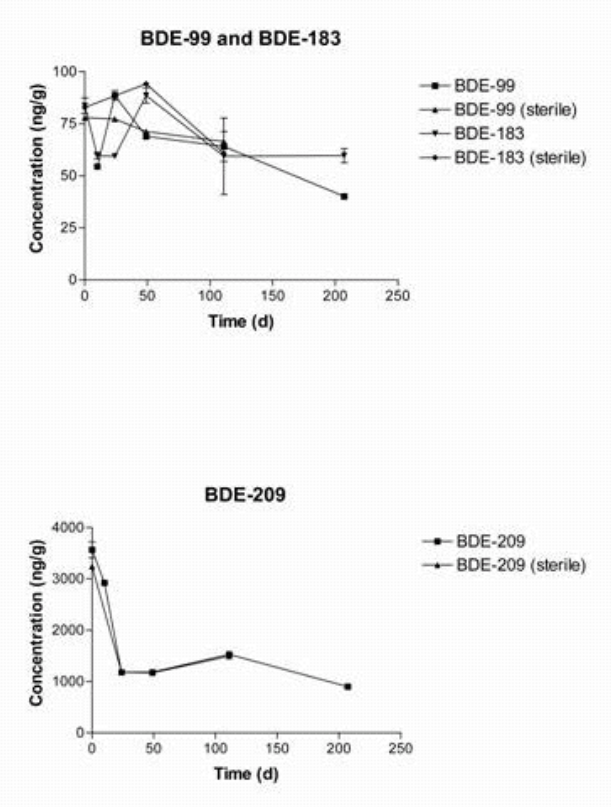

Fig. 1. Removal of brominated diphenyl ethers from anaerobic sediment microcosms.

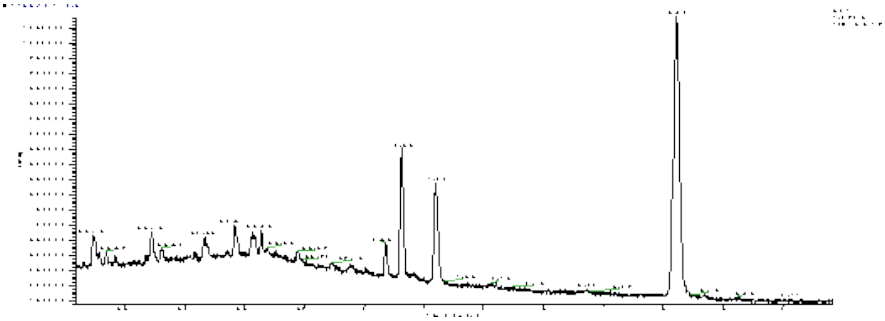

Fig. 2. Formation of debrominated products from decabromodiphenyl ether (BDE-209).

We subsequently carried out sediment incubations with the three nonabrominated congeners in order to investigate whether these were end products of debromination of BDE-209 or were themselves susceptible to further debrominations. This experiment is still in progress.

These results demonstrate that there is a potential for debromination of PBDEs in Western Scheldt sediments. Although this process could contribute significantly to the removal of PBDEs from the environment, it may also be a reason for concern, as it would convert the relatively poorly bioavailable BDE 209 into congeners more readily taken up by biota.

Acknowledgements
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