Biomagnification of PBDEs through coastal food web in Tokyo Bay

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Introduction

Among the studies on bioaccumulations of polybrominated diphenyl ethers (PBDEs), several researchers have studied the biomagnification of PBDEs via the food web in marine ecosystems using nitrogen stable isotope ratio ($\delta^{15}N$) (Burreau et al., 2006; Kelly et al., 2008; Wan et al., 2008). Though PBDEs have similar chemical structures with polychlorinated biphenyl (PCBs), difference of biomagnifications between PBDEs and PCBs have not been revealed.

The object of the study was comparison of biomagnifications with PBDEs and PCBs.

Materials and Methods

Sampling and sample treatment

Three species of fishes, one specie of crab and two species of bivalves were collected from Tokyo Bay in 2006. The muscle tissues of the fishes and crab and soft tissues of the bivalves were homogenized and stored in cool until extraction.

Stable isotope analysis

To determine stable carbon and nitrogen isotope ratios in the tissues, aliquots of tissues were dried, ground to powder and then immersed in chloroform/methanol (2:1, v/v) to remove lipids. Stable isotopes were measured with an ANCA-SL MS (PDZ Europa).

Chemical analysis

All the biological samples were freeze-dried and extracted by pressurized solvent extraction with dichloromethane (DCM): acetone (3:1/v:v). The extracts were purified by gel permeation chromatography (GPC) for removing high-molecular-weight substances and two types of silica gel column chromatography (5% H_2O deactivated silica gel and activated silica gel). After cleanup, BDE209 was determined by GC-ECD (Agilent technology) and the other 19 PBDE and 38 PCB congeners were measured with GC-ITMS (Thermo Fisher Electron).

Results and Discussion

The biomagnification of BDE99 and CB99 were showed by plotting congener concentrations in the tissue samples against $\delta^{15}N$ (Fig.1). All PCBs showed a positive correlation between $\delta^{15}N$ and congener concentration: as $\delta^{15}N$ increased (i.e., as trophic level increased), concentrations of the PCBs increased, clearly indicating that all PCBs were biomagnified.

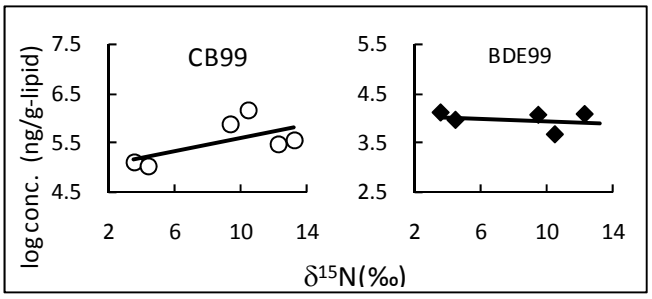

Fig.1 $\delta_{15}N$ vs BDE99 and CB99 concentration

Among the PBDEs, concentrations of several (i.e., BDE47, 100 and 154) were positively correlated with $\delta^{15}N$, indicating biomagnifications of these PBDEs also. However, other PBDEs (BDE15, 28, 66, 71 and 99) showed no positive correlation, implying that they were not biomagnified. It was indicating that their concentrations decreased as trophic level increased. This result can be explained by metabolism of these congeners. Future studies with more diverse species would give a clearer view of the biomagnification of PBDEs.

The slope of the regression line of $\delta^{15}N$ against congener concentration in an organism in the food web shows the degree of biomagnification, or "biomagnification power" according to Burreau et al. (2006). The biomagnification power of both PBDEs and PCBs tended to increase as hydrophobicity, Fig. 2 shows the biomagnification power of each congener plotted against K_{ow}. For both PCBs and PBDEs, biomagnification power and K_{ow} were positively correlated, indicating that more hydrophobic compounds are more biomagnified. The increased biomagnifications of PCBs with hydrophobicity is consistent with the results of Burreau et al. (2006) and Olsson et al. (2000).

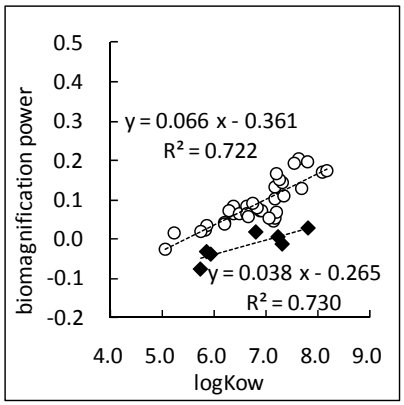

Fig.2 log K_{ow} vs biomagnification

However, our results for PBDEs were different from those of Burreau et al. (2006). Our results show that biomagnification power increased as bromination increased up to hexa-BDE, but Burreau et al. (2006) observed the maximum biomagnification power at tetra-BDE, and higherbrominated congeners had lower biomagnification power.

This difference may be explained again by differences in species and their metabolisms. PBDEs had lower biomagnification power than corresponding PCBs (Fig. 2). That is, PBDEs were less biomagnified than PCBs. Our results are consistent with those of Kelly et al. (2008), who found smaller trophic magnification of PBDEs than of PCBs in the Canadian Arctic food web. One explanation is that PBDEs could be more metabolizable than PCBs. Further studies are necessary to understand the metabolism of PBDEs.

References

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