DISTRIBUTION OF PCBs AND PBDEs IN FISH AND SEDIMENT FROM THE QINGHAI LAKE, CHINA

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Introduction

Polychlorinated biphenyls (PCBs) and polybrominated diphenyl ethers (PBDEs), as typical persistent organic pollutants (POPs), can undergo long-range atmospheric transport (LRAT) from the contaminated environments to the pristine areas far away from any anthropogenic activities. PCBs were historically synthesized and widely used as dielectric fluid in electrical transformers and capacitors for half a century. PBDEs are bromine-based compounds used as flame retardants in plastics, textiles and electronic products since 1970s. Although PBDEs were produced much later than PCBs, they have already been ubiquitously found in the remote areas far away from emission source.

Tibetan Plateau, as the highest plateau in the world, is located in the southwest of China. Except for occasional missions by adventurers and explorers, no evident human activities exist in this area. The Qinghai Lake, located in the northeast of the plateau, is the biggest inland salt lake in China. The biological populations in the lake showed the obvious characteristics of alpine biota communities [1], and the scale-less carp, *Gymnocypris przewalskii*, is the dominant fish species, which could be used to reflect the lake environment and evaluate the environmental behavior of the contaminants. In the present study, the levels and distributions of PCBs and PBDEs were investigated in the fish and sediment samples from the Qinghai Lake.

Materials and method

The fish (scale-less carp, *Gymnocypris przewalskii*, n=10) samples were collected from the Qinghai Lake and transferred to the laboratory. The muscle was freeze-dried and homogenized, and then stored under the frozen temperature (-20 ^{o}C) until analysis. Accelerated solvent extraction (ASE) was employed to do the extraction. Before the extraction, 68A-LCS and PBDE-LCS (^{13}C-BDE-47, 99, 153) were spiked. The extracts were concentrated and cleaned up by GPC (AccuPrep^{TM}, J_2-Scientific, USA) and multilayer silica column (packed from the bottom up with 1 g silica gel, 4 g basic silica gel, 1 g silica gel, 8 g acid silica gel, 2 g silica gel and 2 cm anhydrous sodium sulfate and eluted with 100 mL n-hexane). Prior to instrumental analysis, 68A-IS was added to final concentrated solution for recovery calculation.

The sediment samples (n=3) were collected using stainless steel sediment sampler, then sealed with foil and transferred to the laboratory. They were freeze-dried and homogenized, then about 10 g dry samples were extracted with *n*-hexane/DCM=1:1 (v:v) by ASE. 68A-LCS and PBDE-LCS were spiked for quantification before the extraction and 68A-IS was added before injection.

PCBs and PBDEs were analyzed using high-resolution gas chromatography coupled with high-resolution mass spectrometry (HRGC/HRMS) and quantified based on an isotope dilution method. Total organic carbon (TOC) in the sediments was determined on TOC Analyzer (O.I Analyzer, College Station, TX, USA) with a combustion method under the temperature of 900 ^{o}C.

Results and discussion

The lipid content of the fish samples was 9.8% on average and body lengths were between 25.5 cm and 32.2 cm, which indicated they were 7-9 years old [2]. The total organic carbon (TOC) contents in the sediments were in the range of 27.6-75.2 mgC.g^{-1}.

The concentrations of PCBs in the muscle of scale-less carp were in the range of 1.29-3.66 ng.g^{-1}wet weight (ww) with 2.67 ng.g^{-1}ww on average, which were at the same level as our previous report on PCBs in the fish across Tibetan Plateua lakes [3], but slightly lower than the results from the other remote areas in the world (0.68-17 ng.g^{-1}ww [4], 4.2-24 ng.g^{-1}ww [5] and 8.2±4.8 ng.g^{-1}ww [6] in the fish muscle from European high mountain lakes), The concentrations of dioxin-like PCBs were 0.13-0.57 pg WHO-TEQ.g^{-1}ww with PCB-105 and 118 as the main congeners. The indicator PCBs accounted for about 28% of total PCBs with an average concentration of 0.76 ng.g^{-1}ww. PCB-153, 101, 138 and 28 were the most abundant congeners in the samples, which is in agreement with the report from European high mountain lakes [4]. Notably, PCB-209 was significantly detected in all the fish samples (208 pg.g^{-1}ww on average), which indicated the significant bioaccumulation in this aqueous system.

The average concentration of PBDEs was 67.6 pg.g^{-1}ww (48.7-93.0 pg.g^{-1}ww) with the dominant congeners of BDE-47 (50%), 154 (15%) and 28 (12%), which is consistent with the results from other remote lakes (0.32-1.6 ng.g^{-1}ww [5] and 69-730 pg.g^{-1}ww [7] in the fish muscle from lakes of European high mountain and Greenland), but much lower than that from the lakes of northwest America (6.9±1.4-18±1 ng.g^{-1}ww) [8]. Similar to PCBs in the scale-less carps, BDE-209 was detected with an average concentration of 32.3 pg.g^{-1}ww, which is different from the reports on European high mountain lakes [6].

In the sediment samples, the concentrations of PCBs were in the range of 89.0-356 pg.g^{-1}dry weight (dw) with the dominant congener of PCB-28, PBDEs were 5.2-54 pg.g^{-1}dw and BDE-209 was not detected in any samples, which were much lower than the reports from other remote lakes [9,10].

Differently with the distribution pattern of contaminants in the fish, PCBs and PBDEs were

predominated by the lower chlorinated and brominated congeners in the sediments (Figure 1 and 2), which is in agreement with the report from Labandeira et al.[8], who suggested that the main reason may be due to low bioavailability potential or biotransformation processes.

Qinghai Lake is a famous National Nature Reserve of China. The water mainly comes from mountain areas in the west China, where no obvious pollution source existed. In our previous work, PCBs and PBDEs could also been detected in the surface soil from the Tibetan Plateau and mainly attributed to the long-range atmospheric transport from emission source, PCBs and PBDEs in this aqueous system of Qinghai lake were closely related to the atmospheric deposition and redistribution in the environment. In addition, bird migration is a significant pathway for transmission of POPs from polluted area, as an important bird habitat, the Qinghai Lake could be the destination of some POPs carried by birds, and they were finally bioaccumulated by fish in the lake.

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Figure 1. The distribution of PCBs in the fish and sediment samples

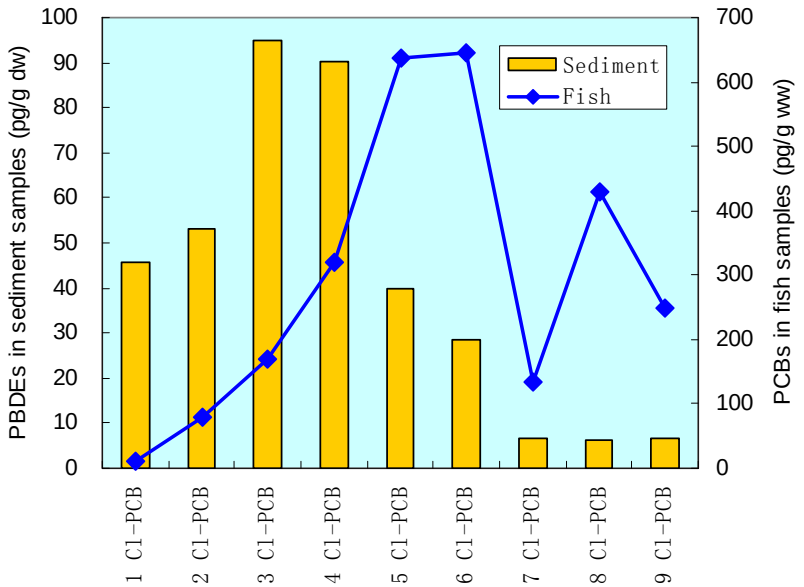

Figure 2. The distribution of PBDEs in the fish and sediment samples