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Occurrence, distribution and seasonal variations of polychlorinated biphenyls and polybrominated diphenyl ethers in surface waters of the East Lake, China

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HIGHLIGHTS

- Levels of PCBs and PBDEs were relatively low in the biggest urban lake in China.
- The concentration of both PCBs and PBDEs showed seasonal variations.
- PCBs and PBDEs were from different potential sources in this area.
- The eco-toxicological risks of PCBs and PBDEs were low in the East Lake.

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ABSTRACT

Polychlorinated biphenyls (PCBs) and polybrominated diphenyl ethers (PBDEs) in the surface water of the East Lake, China were investigated in winter (2012) and summer (2013). A hundred and eight samples were collected from 36 sampling sites and analyzed for the 31 PCB and 10 PBDE congeners. Concentrations of both PCBs and PBDEs showed obvious seasonal variations. The average PCB concentrations in the East Lake ranged from 3.17 to 6.09 ng L^{-1} in winter and 0.19 to 0.99 ng L^{-1} in summer. CB-44, 105, 118 and 179 were dominant in both winter and summer. The average PBDE concentrations in the East Lake ranged from 2.92 to 5.54 ng L^{-1} in winter and 0.67 to 1.51 ng L^{-1} in summer. BDE-47 was predominant in both winter and summer, which accounted for more than 37% of the total PBDEs concentration from all sampling sites. Independent-Samples *t*-test showed statistical significance of ΣPCBs and ΣPBDEs between winter and summer samples. The analysis of distribution, pattern and seasonal variations indicated the different potential sources of PCBs and PBDEs in the East Lake. The potential eco-toxicological risk was also discussed in the study.

1. Introduction

Polychlorinated biphenyls (PCBs) and polybrominated diphenyl ethers (PBDEs) are organic halogenated compounds originating from anthropogenic activities. These compounds have become ubiquitous in environmental and biological samples worldwide because of the persistence and long-range transport (Nouira et al., 2013; Zhang et al., 2013). PCBs, a well-known class of persistent organic pollutants (POPs) formerly used in a variety of industrial and commercial applications, are found in biota all over the world (Frouin et al., 2013; Ge et al., 2013), causing great concern due to their persistence and toxicity (Diamond et al., 2010). Although banned in most countries in the 1970s, PCBs remain in the environment and in humans. A large amount of literature indicates that PCBs and their metabolites can cause adverse health effects including carcinogenicity and endocrine disruption (Safe, 1989; Robertson and Ludewig, 2011; Boas et al., 2012), and moreover PCBs can cause neurotoxicity and developmental disorders of children (Schantz et al., 2003; Pessah et al., 2010). PBDEs are one class of brominated flame retardants (BFRs) that have been used extensively for decades in textiles, plastics, and electronics leading to spread of PBDEs into the environment (Rotander et al., 2012). Three major commercial PBDE products (penta-BDE, octa-BDE, and deca-BDE) have recently been or are currently used (Grant et al., 2011). Since early 1980s, PBDEs have been found in various environmental and biological samples, such as water, sediment, eel, and sea trout (Nouira et al., 2013; Julshamn et al., 2013). Bioaccumulation in wildlife has been documented in numerous studies, and PBDEs contamination was reported even in places with no local point source or industrial production (Law, 2003; ter Schure et al., 2004; Covaci et al., 2011). A lot of studies have been done

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about the toxic effects of PBDEs, which suggested that these compounds might impact thyroid hormone levels, thyroid, liver and kidney morphology, neurodevelopment and behavior, reproductive success, as well as fetal toxicity/teratogenicity (Branchi et al., 2003; Darnerud, 2003; Tseng et al., 2006; Costa et al., 2008; Albina et al., 2010; Alonso et al., 2010; Belles et al., 2010; Zhang et al., 2011). Due to their persistent characteristics and toxicological effects, penta- and octa-BDEs have been banned in all products in the European Union, Japan and the United States (Frederiksen et al., 2009; Domingo, 2012).

The past 30 years has witnessed rapid industrialization of China, as well as gradual release of some persistent pollutants into the environment (Su et al., 2012). Aquatic ecosystems are like an ultimate sink for all these organic compounds. Water, sediments and even those suspended particles represent important potential exposure pathways for organic pollutants to aquatic species (Van Ael et al., 2012). The East Lake is the biggest urban lake in China suffering more from pollutants than rural lakes. The aims of present study were to determine concentrations, to analyze the distribution and seasonal variations, to investigate the pattern and potential pollutant sources and to estimate the potential eco-toxicological risks of PCBs and PBDEs in the East Lake.

2. Materials and methods

2.1. Study area and sample collection

The East Lake (Donghu) is a subtropical shallow lake close to the Yangtze River, located in Wuhan city, Hubei province, central China (Fig. 1). It is the biggest urban lake in China, which has an area of 33 km^2 and an approximate average depth of 2.5 m. Over 100 small-scale enterprises, 11 hospitals and 200,000 residential homes are located around the lake. Surface water samples were collected in the East Lake, including four lakelets Guozheng (L1), Tangling (L2), Niuchao (L3) and Houhu (L4) Lake, and the sampling sites are also shown in Fig. 1. One hundred and eight water samples were collected from 36 sites with pre-cleaned Teflon bottles and transported to the laboratory immediately after sampling. The samples were stored in the refrigerator at 4 °C until analysis. The sampling campaign was conducted twice in December 2012 and May 2013, respectively.

2.2. Sample extraction and clean up

In all samples, 31 PCB congeners (IUPAC numbers: CB 8, 28, 30, 44, 49, 52, 60, 66, 70, 74, 77, 82, 87, 99, 101, 105, 114, 118, 126, 128, 153, 156, 158, 166, 169, 170, 179, 180, 183, 198, 209) were analyzed, in which CB 77, 105, 114, 118, 126, 156, 169 are dioxin-like congeners. 10 PBEDs (IUPAC numbers: BDE 28, 35, 47, 66, 77, 85, 99, 100, 153, 154) were targeted for analysis as well in the study.

A liquid–liquid extraction method was used to extract the analytes. An 800 mL of water sample was placed in a 1 L separatory funnel, then 30 g of sodium chloride was added and dissolved, and finally the sample was extracted with dichloromethane (40 mL × 3). The extract was concentrated to approximate 5 mL and then cleaned up by passing through a glass column packed with neutral alumina (4 cm, deactivated), neutral silica (4 cm, deactivated) and anhydrous sodium sulfate (2 cm) from the bottom to the top. The eluent was concentrated to dryness under a gentle nitrogen stream and dissolved in 80 μL of hexane for GC analysis.

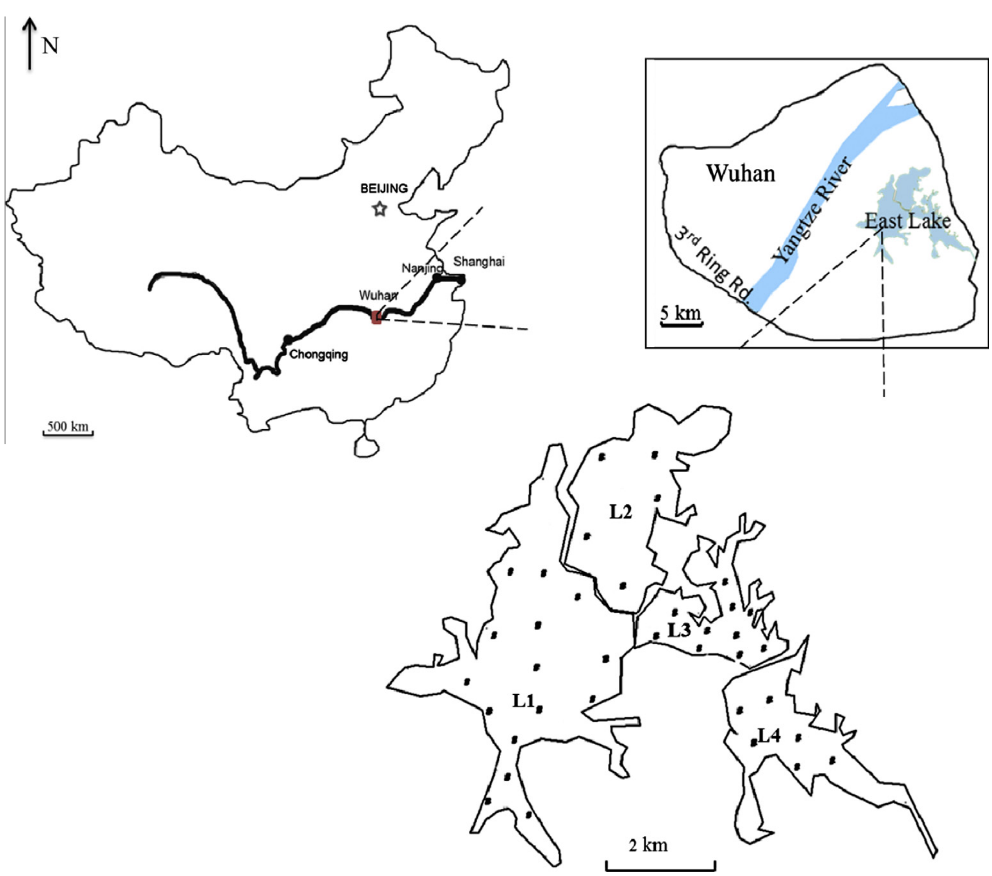

Fig. 1. Locations of study area in the East Lake, Wuhan city, China.

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