POLYCHLORINATED BIPHENYLS IN SURFACE SOILS OF DALIAN, CHINA

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Abstract

Concentration levels of polychlorinated biphenyls (PCBs) in surface soil samples (1-5 cm) from 14 sites (4 urban industrial, 7 urban business/residential, 2 urban garden, and 1 rural) were collected from Dalian, a coastal city in Liaoning Province, China, and analyzed by GC/MS. A total of 57 PCB congeners were identified, and the mean concentration of total PCBs among all the sites was 2.7 ng/g dw (dry weight) with a range of 1.3 to 4.8 ng/g dw. The major PCB homologue group in the soil samples is penta-PCB followed by hexa- and tetra-PCBs. For the urban sites, the soil samples collected in the industrial areas are highest, followed by the business/residential sites and the agricultural sites, but the differences are not significant. PCB concentrations are much higher in urban sites than the rural site, and much higher percentage of lighter weighted molecular PCBs were found in the rural site than the urban sites in Dalian, possibly indicating the "urban fractionation effect".

Introduction

Polychlorinated biphenyls (PCBs) are typical persistent organic pollutants (POPs), which are highly persistent, toxic, and bioaccumulative contaminants in the environment. PCBs had been widely used for industrial purposes such as dielectric fluids in electrical transformers, capacitors, hydraulic and heat transfer fluids, and plasticizers. PCBs are released from commercial PCB products that are the potential primary source of PCBs.

Soils are natural sinks and environmental reservoirs for PCBs. Being lipophilic compounds, PCBs adsorb to the organic carbon of the soil, and due to the low mobility and high persistence, these contaminants accumulate in the soil. Urban areas are major sources of atmospheric PCBs to surrounding regions. Atmospheric transport from major urban areas can lead to significant PCBs loading to surrounding terrestrial and aquatic ecosystems. Therefore, the soil of urban areas is an important contamination source of PCBs. It is necessary to measure PCBs levels and distributions in the soil of urban areas. Dalian (E120°58'-123°31', N38°43'-40°10') was selected as a typical coastal city, which situated in northeastern monsoonal area of China.

Materials and Methods

Sampling Details of soil samples collection, extraction and clean up are presented elsewhere[1]. A total of 14 surface soil samples (0-5cm) were collected at the area of the city of Dalian in January, 2007, among which, 4 were industrial (10#, 11#, 12# and 13#), 7 were business/residential (1#, 2#, 5# ,6#, 7#, 8#, and 9#), 2 were garden (3# and 4#), and 1 rural (14#). The samples were packed in a solvent-rinsed glass bottle with Teflon-lined cap, sent to the laboratory of the International Joint Research Center for Persistent Toxic Pollutants (IJRC-PTS), Dalian Maritime University, Dalian, China and stored at -20°C until analysis.

Analysis. Three groups of PCB standards were purchased from the Accustandard, Inc. (New Haven, CT), Catalog numbers C-IADN-01, 02, and 03 containing a total 84 PCB congeners. 20g dry weight of soil was take into Soxhlet extracted for 24h with 200 ml mix solvent (n-hexane/acetone, 1:1 v/v). The extract was filtered through a funnel filled with anhydrous sodium sulfate, and then rotary-evaporated to 1ml. The extract was passed through 10 g silica gel column, eluted with 50 ml mix of hexane and dichloromethane (1:1,v/v). The elution was rotary-evaporated to 2 ml and then reduced to 0.1 ml under a gentler nitrogen gas flow. All PCBs were identified and quantified with GC-MS (Finnigan PolarisQ), DB-5 MS of 0.25 mm ID and 60m length was used. The column oven temperature was programmed at a rate of 10°C/min from an initial temperature of 80°C (2-min hold) to a temperature of 160°C (1-min hold), 1.5°C/min to 230°C (15 min hold), 20°C/min to a temperature of 280°C (10-min hold). Injector and transfer line temperatures were 250°C and 280°C, respectively.

QA/QC. All samples were spiked with a labeled recovery standard (CB 65 and 155) prior to extraction. Sample recoveries averaged for CB 65 89± 5% and 89±10% for CB 155 in all samples. Spike samples were included at a rate of one for every 7 soils extracted, and the average recoveries of all 84 PCBs are form 78% - 120%. All results were not blank corrected.

Results and discussion

The levels and the spatial distributions of ΣPCBs (total 57 PCBs) in surface soil are shown in Figure 1. The average concentration of total PCBs among the 14 sites was 2.7 ng/g dw with a range from 1.3 to 4.8 ng/g dw. The lowest and the highest PCBs concentration are 14# and 5# sites, which are rural area and urban resident area, respectively. The top 2 PCB congeners/congener pairs found in all soil samples were 153/132, 31/28, 105, 92, 97, 81, 15, 110, 144, and 76, and the major PCB homologue group residing in surface soil was penta-PCB (39.5%), followed by tetra-PCB (17.3%) and hexa-PCB (17.2%).

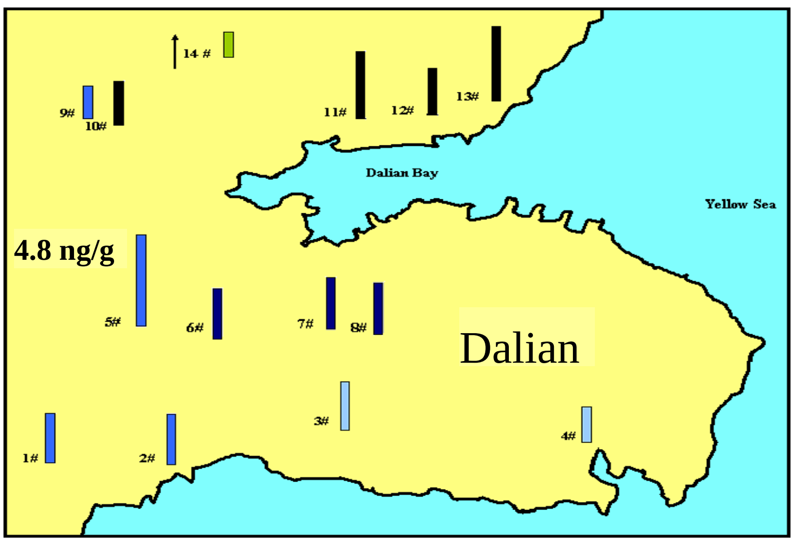

Figure 1. The levels and the spatial distributions of ΣPCBs in surface soil of Dalian.

Figure 2 presents average concentrations of total PCB in 4 different regions: urban industrial area, urban business/residential area, urban gardens, and rural site, and the homologue compositions in the soil samples from these 4 different regions are shown in Figure 3. Average PCB concentrations are much higher in urban sites than the rural site. For the urban sites, PCBs in the soil samples collected in the industrial area are highest, followed by the business/residential sites and the garden sites, but the differences are not significant. Figure 3 indicates that the top PCB homologue group residing in surface soil was penta-PCB for all urban samples, and tetra-PCB for the rural site.

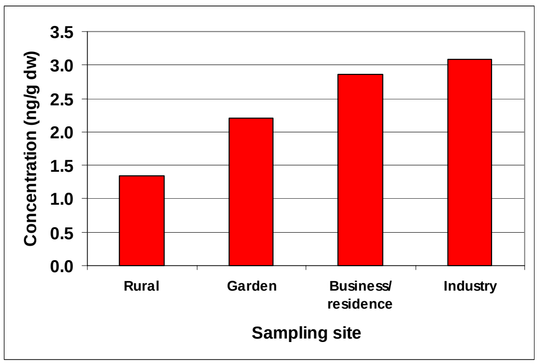

Figure 2. Average concentrations of total PCB in 4 different regions

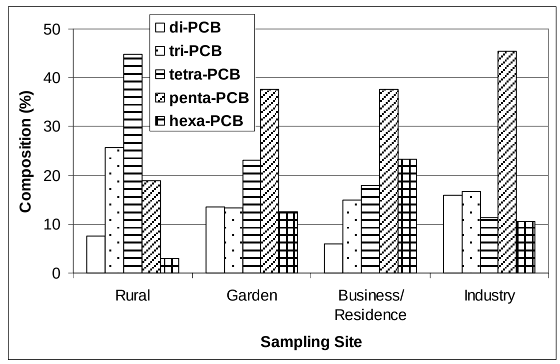

Figure 3. Composition of PCB homologue groups in the soil samples from urban industrial sites, urban business/residential sites, urban garden sites, and rural site.

The real patterns of PCB profile in different cities vary. For example, Kang et al[2] analyzed sediment in the Pearl River Delta in 1997, and found that the major PCB homologue was hexa-PCB in the sediment samples close to the City of Guangzhou, and penta-PCB in those near Macao. In 1989, some arbitrary disposal of used electronic appliances resulted in the release of significant PCBs in the area of Wentai, Zhejiang Province[3-5]. The major PCB homologue in the contaminated soil switched from tetra-PCB in 1993 and 1997 to penta-PCB in 1999. Figure 4 presents compositions of PCB homologue groups in Dalian urban and rural areas, along with PCB homologue profile among average 9 urban sites from 2005 Chinese national study[1]. While the top PCB homologue group among average 9 urban sites from 2005 Chinese national study was hexa-PCB followed by tri-PCB and di-PCB[1], the major homologue in Dalian urban surface soil was penta-PCB, followed by hexa-PCB and tetra-PCB.

Figure 4 also shows that much higher percentage (78% for di- to tetra-PCB) of lighter weighted molecular PCBs were found in the rural site than the urban sites in Dalian (with only 42% for di- to tetra-PCB). This possibly indicates the “urban fractionation effect” first demonstrated by Harner et al[6] by sampling air in the city of Toronto, Canada and then by Ren et al[1] by sampling soil in the city of Shanghai, China[1], showing enrichment of lighter weighted molecular PCB homologues and depletion of heavier weighted molecular PCB homologues with sampling sites away from the urban center, which have been considered as the major sources of PCBs.

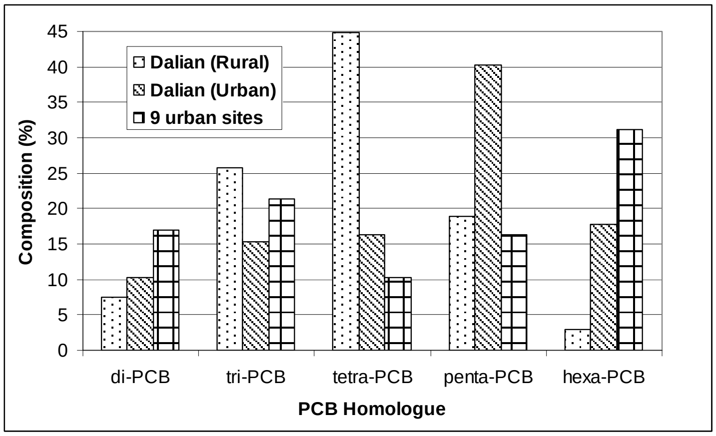

Figure 4. Composition of PCB homologue groups in the soil samples from urban and rural site. PCB homologue profile among average 9 urban sites from 2005 Chinese national study[1] is also shown for comparison.

Acknowledgements

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References

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