Bull. Environ. Contam. Toxicol. (2001) 66:508–513

DOI: 10.1007/s00128-001-0036-8

Bulletin of Environmental Contamination and Toxicology

Distribution of Polychlorinated Biphenyls in the Bering and Chukchi Sea

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Received: 14 July 2000/Accepted: 20 December 2000

Persistent organic pollutants (POPs), including organochlorine pesticides (OCPs), polychlorinated biphenyls (PCBs), and polycyclic aromatic hydrocarbons (PAHs) are ubiquitous environmental organic micropollutants (Atlas and Giam, 1981). These compounds originate from both natural and anthropogenic sources and may be have suspected carcinogenic effects. During the last decades, many investigation reports had proved that these contaminants might be transported widely through atmosphere and eventually contaminated all over the world. Such a worldwide spread and transition was expected to affect the current status of global contamination (Iwata et al., 1993; Tanabe et al., 1983) and pose a threat to humans and wildlife, particularly marine mammals (Bruhn et al., 1999; Lockhart et al., 1992). Among these views, recent studies revealed that the Arctic region was contaminated unexpectedly high (Barrie et al., 1992; Hargrave et al., 1992; Oehme, 1991) and may be sever as a sink of POPs. The reason might be long distance atmospheric transport and low ratio transferring to the atmosphere due to the lower water temperature (Muir DC et al., 1992).

The Chinese First Arctic Research Expedition was carried out during July to September 1999. As a member country of International Arctic Science Council (IASC), Chinese government sent nearly sixty scientists to accomplish this compositive investigation of the Arctic for the first time. One of its aims was to identify regional contributions of trace elements and trace organics in the Bearing Sea and the Arctic Ocean, and then try to evaluate their impact on the environment. The surface seawater is the interface of the atmosphere and the water body and is the unique passage of mass transfer between air and seawater (Baker and Eisenreich, 1990). POPs in the surface water of the ocean impact the distribution of POPs in the marine environment strongly. One of the author (Yao

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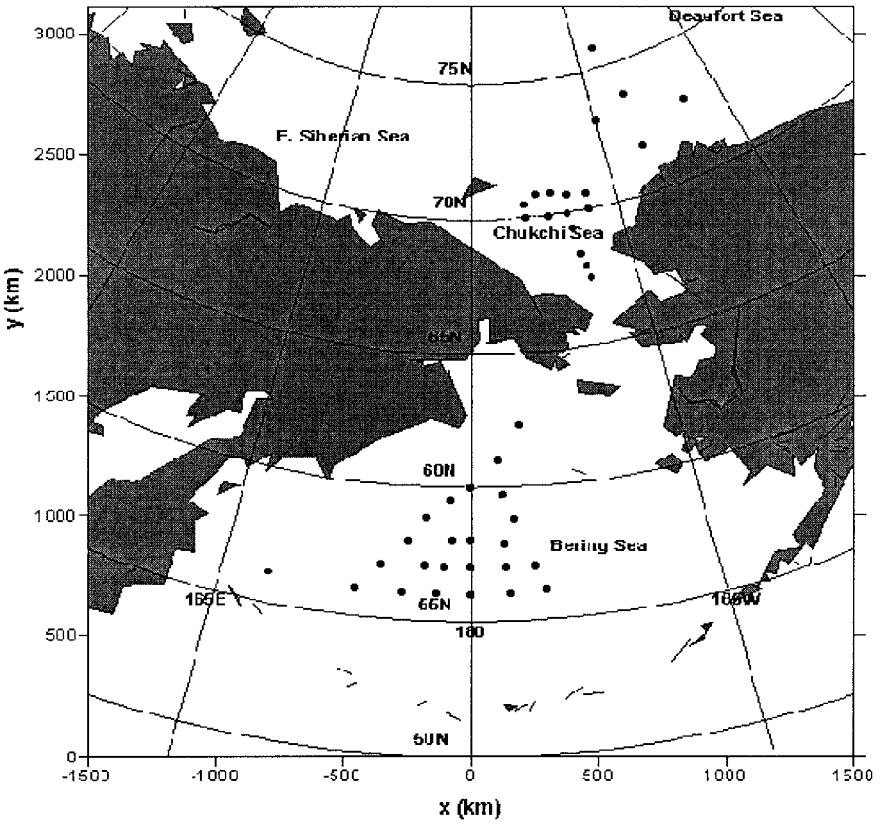

Figure 1. Locations of sampling stations

Zi-wei) took part in this expedition. During that period, Yao collected hundreds of surface water samples and we got first hand information concerning about POPs in the surface water of Bering Sea and Chukchi Sea after laboratory confirmation by GC-MS and measurement by GC-μECD.

In this paper, PCBs in the surface water of Bering and Chukchi Sea were reported. The distribution and composition of PCBs in these two sea areas were also discussed.

MATERIALS AND METHODS

The standard PCBs were obtained from ChemService Inc. (West Chester, PA, USA), including CB28, CB52, CB101, CB112, CB118, CB138, CB153, CB155, CB180, CB198 in IUPAC number.

All of the surface water samples were collected from Chinese polar research vessel XUELONG during the First Chinese Arctic Expedition in July to

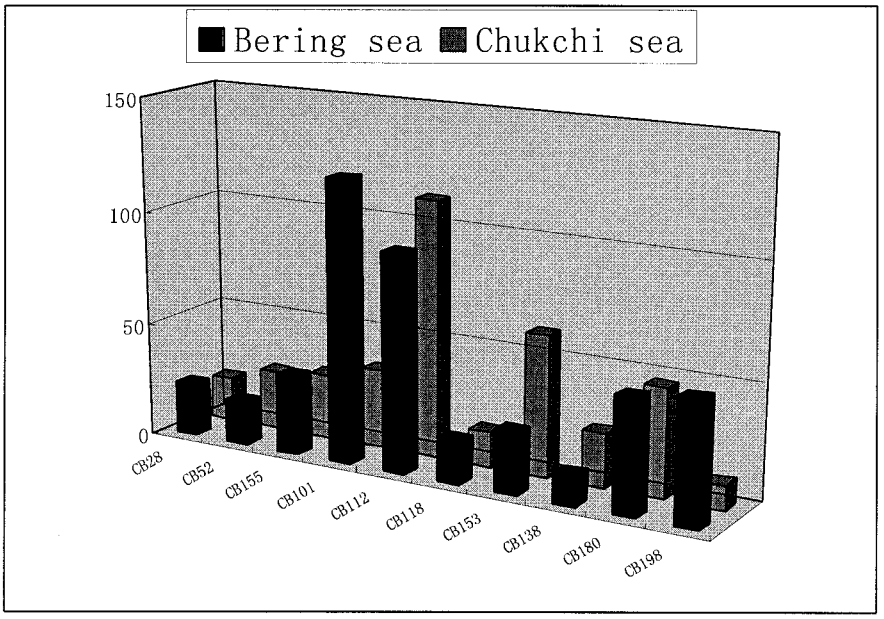

Figure 2. Composition of PCBs in the Bering and Chukchi Sea.

September 1999. The locations of the sample station were shown in Fig. 1. The sample stations were selected on the basis of the hydrographic properties of the water in the investigation area, including different marine geological forms, such as continental shelf, continental slope and deep sea. The sample stations covered the whole open sea of the Bering Sea, which area was nearly 240,000 square kilometers with the depth ranging from 140 meters to nearly 4000 meters. In the Chukchi and West Beaufort Sea, the stations covered open sea and floating ice zone. The salinity of seawater ranged from32.8 to 6.9, which indicated the increase of sea ice in the sea.

All of the water samples were handled by liquid-liquid extraction (LLE) with dichloromethane (DCM) in the vessel. These samples were shipped to the laboratory and stored below 4℃ until analysis. The samples were concentrated to nearly dryness and solvent exchanged to 5 ml hexane using rotary evaporator, then microconcentrated to 0.2ml under a mild stream of N_2. The extracted PCBs were analyzed using HP 6890A GC equipped with a ^{63}Ni micro-cell ECD (μ-ECD) and HP-1 fused silica capillary column (30m × 0.25mm i. d.) with a stationary phase thickness of 0.25 μ m. A Shimadzu 17A GC and 5050A MS was used to identify PCB congeners with column of DB-1 (30m×0.25mm, 0.25μm film thickness).

RESULTS AND DISCUSSION

It has been established that the global production of PCBs since 1920s, when they were firstly synthesized, is of the order of 10^6 tons (Jones and Voogt, 1999). PCBs usually present in the environmental sample are complex mixtures of about 135 PCB congeners (Ballschmiter and Zell, 1980) and some of them (CB28, 52, 101, 118, 138, 153 and 180) are used for biomonitoring studies (Larsen et al., 1992). Due to the limitation of single PCB standards, only ten PCB congeners are determined in this research. But according to the study of Henriksen et al (2000), the sum of 9 PCB congeners (28, 52, 99, 101, 118, 138, 153, 170 and 180) can constitute 77-83% of total PCBs.

Extended standard method was used for quantitative determination of the contaminants. Four point calibration curve with concentrations of 1pg/L, 10pg/L, 100pg/L and 1000pg/L was used, which gives high correlation coefficient (γ) than 0.998. In the laboratory, 1000 ml distilled and chemical free water was spiked with PCBs in three levels: 5pg/L, 50pg/L and 500pg/L, respectively. The recoveries of PCBs ranged from 85% to 111%, with relative standard derivation (RSD) 8-24%. Detection limits (LOD) of 10 PCBs in this method was calculated at a signal-to-noise ratio of 3. LODs ranged from 1.9pg/L (for CB112) to 3.2pg/L (for CB52), which were sensitive enough to determine PCBs at the required levels in the present study.

The sampling sites covered 24 stations in the Bering Sea and 18 stations in the Chukchi Sea. Fig 2 shows the composition of mean PCB congeners in the Bering and Chukchi Sea. The congener patterns are dominated by penta- and hexachlorobiphenyls, including the highly persistent and hydrophobic 118 and 153. The lower concentration of tri- and tetrachlorobiphenyls indicates that atmospheric deposition was probably not a major source of these PCBs (Macdonald and Metcalfe 1991). In the Bering Sea, CB101 and CB112 are the main congeners, accounting for nearly half of the total PCBs found. While in the Chukchi Sea, CB112, CB153 and CB180 contain about 60% of all PCBs.

Although a previous study by Iwata et al (1993) has demonstrated that higher concentrations of PCBs were found in the lower and mid latitude of the Northern Hemisphere, latitudinal differences in the concentrations of PCB congeners in the surface water are not so apparent. Since restrictions of the use of PCBs were enforced during the last two decades, the contamination patterns of PCBs become similar in different regions, which means their levels decrease in most contaminated areas and increase in previously clean areas, such as the Arctic regions. The sum of mean concentrations of 10 PCBs in the Bering and Chukchi

Sea of this study show no obvious difference (Table 1). But, amount of PCBs in the Chukchi Sea is about 20% lower than Bering Sea, 378.8pg/L and 459.6pg/L, respectively.

Table 1. Mean concentrations (pg/L) and ratio of detection (%) of PCB congeners in Bering and Chukchi Sea

	28	52	155	101	112	118	153	138	180	198	ΣPCB
Bering sea											
Mean	23.7	19.4	34.7	122.7	94.5	18.7	26.9	13.3	49.8	53.2	456.9
RD (%)*	12.5	75	20.8	62.5	20.8	12.5	16. 7	20.8	79.2	8.3	100
Chukchi sea											
Mean	19.7	25.9	28.3	34.7	111.9	15.5	61.3	23.6	47.2	10.7	378.8
RD (%)	11.1	61.1	11.1	16.7	11.1	5.56	11.1	22.2	44.4	11.1	77.8

* RD: ratio of detection, defined as: (detectable samples/total samples)×100

In the Bering Sea, CB52 and 180 are the most popular congeners, which are detectable in nearly 80% stations. They are also the most popular in the Chukchi Sea, but the ratio of detection decrease to 60% and 44%, respectively. In most of stations, highly chlorinated congener (such as CB198) and easy to be bioaccumulated congener (such as CB28), are near or below detection limits.

Acknowledgements. The authors acknowledge the financial assistance from the Chinese First Arctic Research Expedition, Office of Polar Expedition, State Oceanography Administrate of China and National Natural Science Foundation of China (29825114).

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