Study on the concentrations, characteristics, and sources of contamination of PCBs from surface soils of Ulsan and Masan areas of Korea

Sook Hyeon Im[1], Tadaaki Wakimoto[2] Gi Ho Jeong[3] 1) Pusan Janglim Sewage Treatment Institute, Water Quality Works Lab. Saha-gu, Pusan, 604-030, Korea. 2) Ehime University, Department of Environment Conservation, Matsuyama, Ehime 790, Japan. 3) Pusan National University, Department of Chemistry, Kumjeong-gu, Pusan, 609-735 Korea

Abstract

We collected surface soils of Ulsan and Masan areas of Korea to study the concentrations, characteristics, and sources of polychlorinated biphenyls(PCBs) contaminated in the soils. The total PCBs from Ulsan area ranged from N.D. to 108 ng/g dry weight, and that from Masan area ranged from N.D. to 2600 ng/g dry weight, respectively. These results imply that PCBs are still using for industrial uses and widespread in Korea presently. The main source of PCBs contaminated in Ulsan area is commercial PCBs, Kanechlor 600 and that in Masan area is commercial PCBs, Kanechlor mixture .

Introduction

Since their first manufacture in 1929, PCBs have found wide industrial uses, chiefly as dielectrics in electrical components, in hydraulic and vacuum pump fluids, and as various additives, diluents, and flame retardants. PCBs were noted for their bioaccumulative property and suspected of chronic ecotoxicity to mammals due to their high lipophilicity and low biodegradability. Volatilization of persistent lipophilic chemicals such as PCBs from the soils is a long-term process and can lead to a secondary pollution of the atmosphere. Although PCBs have been widely studied because of their considerable environmental persistency[1~5] and harmful biological effects[6~10], there have been rare reports[11~13] and researches about the distributions of PCBs in Korea.

This paper focuses on two compartments: Soil samples play an important role in storage of PCBs, and it may contain high levels of PCBs in industrialized regions. A number of industrial bases were created in Korea according to a series of the nationwide economic development plans since the early 1960s. Many heavy industry, shipbuilding, and chemical manufacturing facilities have been prepared

in Ulsan and Masan areas which are located in the southeastern part of Korea. During the last few years, a lot of PCBs may have been used in Korea and thus formed the sources of the environmental contaminations. In this study, we investigated on the concentrations of PCBs from surface soils of Ulsan and Masan areas of Korea, differences in the PCBs levels and in the sources of PCBs between these two areas.

Experimental Methods

Sampling

Soil samples were taken in September 1996 from Ulsan area, and in August 1994 from Masan area. The sampling sites for this study are illustrated in Fig. 1 and 2. The samples are surface soils at a depth of 2-3 cm. We classified our sampling sites as the soils of natural, street and commercial, and industrial regions, respectively. Soil samples were dried at room temperature and passed through a 2 mm mesh sieve and then stored by freezing at -4℃ until analysis.

Chemical Analysis

The clean-up procedures for PCBs analysis is as follows: Approximately 25-50 g of dried soils were placed in a reflux equipment and then the samples were extracted for 2 hours with 150 ml of 1 N KOH/EtOH solution. After cooling down to about 50-60℃, added 100 ml of n-hexane and shook lightly by hand. The extract was filtered with a filter paper and poured into a separatory funnel. The contents in the erlenmyer flask of the reflux equipment was rinsed twice with 20 ml of n-hexane, then poured the extracts into a separatory funnel. Added 50 ml of hexane-washed water, shook well, and took out the hexane phase(PCBs extracts) after two phases were completely separated. The PCBs extracts were cleaned up with 97% sulfuric acid and concentrated with a Snyder and Kuderna-Danish condenser to 3 ml. After concentration, the extract was recleaned up with silica gel and Florisil PR column. All columns were covered with anhydrous sodium sulfate. The PCBs extract adsorbed on 2 g of silica gel which was activated for 5 hours at 130℃ was eluted using 260 ml of n-hexane at a rate of 1 drop/sec. After concentrating the hexane eluate to 3 ml, it was cleaned up with 5 g of Florisil PR by eluting 110 ml of n-hexane, and then concentrated to about 3-5 ml with a stream of nitrogen. The recoveries of chemicals in these columns were in the range of 93-96%. Identification and quantitative analysis for PCBs were accomplished using a HP5890 A Series II gas chromatography (Hewlett Packard, U.S.A.) equipped with an electron capture detector (^{63}Ni). A 0.2 mm i.d. × 25 m length capillary column (Ultra 1, Crosslinked Methyl Silicon Gum) was held at 70℃ for 1 min, then the temperature was increased at a rate of 30℃/min to 200℃, and then further increased at a rate of 2℃/min to a final temperature of 240℃. Quantification of PCBs congeners was done using a 3 ppm of commercial PCBs standard, Kanechlor, KC300:400:500:600=1:1:1:1 mixture.

Results and Discussion

The main objective of this paper is to present an evidence for the presence of PCBs from surface soils of Ulsan and Masan areas of Korea. Fig. 1 and 2 show sampling sites and the approximate concentrations of PCBs from soils of Ulsan and Masan areas. The exact observed concentrations of PCBs from these sites are shown in Table 1. PCBs are ubiquitous in the sites we studied. Total PCBs were calculated as the sum of the individual congener concentrations determined. The total PCBs levels were N.D.~108 ng/g dry weight in Ulsan area and N.D.~2600 ng/g dry weight in Masan area. The major contaminated sites of Ulsan and Masan areas were identified by site 22 and site E, respectively, in which many industrial facilities are located. It is thus believed that large quantities of commercial PCBs have been used at these areas, and discharged to soils by stages.

We also detected N.D.~4.3 ng/g levels of PCBs in relatively natural rural soils of Ulsan area(site 1,2,3,19,20). It is believed that the contemporary PCBs burden in the rural regions is derived almost exclusively from cumulative atmospheric deposition over time.

We also noticed congeners patterns of the detected PCBs to identify the contamination sources of PCBs. Fig. 3 shows the congeners patterns of commercial PCBs standards and PCBs extracted from the heavily polluted surface soil taken from the site 22 of Ulsan area and site E of Masan area. By applying the "congener pattern matching" method, it was observed that soils of Masan area were polluted by low and high chloro-substituted PCBs, and that of Ulsan area were contaminated by high chloro-substituted PCBs, Kanechlor 600.

The maximum concentrations of total PCBs from three different regions are listed in Table 2. A large shipbuilding yard near site 22 of Ulsan area may lead to the relatively high concentrations of PCBs at this site. It is noticeable that PCBs contained in the paints used for applying outside of large ships have a similar congener pattern with a commercial PCBs, Kanechlor 600. The maximum concentration of Masan area is 2600 ng/g, and that of Ulsan area is 108 ng/g dry weight. This result also indicates that PCBs were more polluted in Masan area than in Ulsan area.

The results of this study imply that PCBs are still using for industrial uses and widespread in Korea presently, and the main source of PCBs contamination in Ulsan area is commercial PCBs, Kanechlor 600, and that in Masan area is commercial PCBs, Kanechlor mixture.

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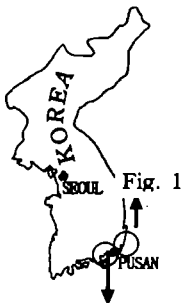
Table 1. Concentrations of PCBs from surface soils of Ulsan and Masan areas of Korea (ng/g dry weight)

Ulsan area				Masan area			
Site No.	Conc.	Site No.	Conc.	Site No.	Conc.	Site No.	Conc.
1	N.D.	13	16	A	42	M	N.D.
2	0.8	14	N.A.	B	N.D.	N	37
3	N.D.	15	15	C	N.D.	O	4.6
4	N.D.	16	N.D.	D	200	P	57
5	N.D.	17	7.3	E	2600	Q	N.D.
6	N.A.	18	13	F	N.D.	R	63
7	14	19	N.D.	G	N.D.	S	N.D.
8	20	20	4.3	H	4.9	T	15
9	3.4	21	1.8	I	52	U	N.D.
10	1.5	22	108	J	7.5	V	N.D.
11	5.4			K	8.4	W	N.D.
12	N.D.			L	N.D.		

N.D. : not detected, N.A. : not analyzed

Table 2. The maximum concentrations of PCBs from surface soils of three different regions (ng/g dry weight)

Area	Natural Regions	Street & Commercial Regions	Industrial Regions
Ulsan	4.3	16	108
Masan	not detected	57	2600



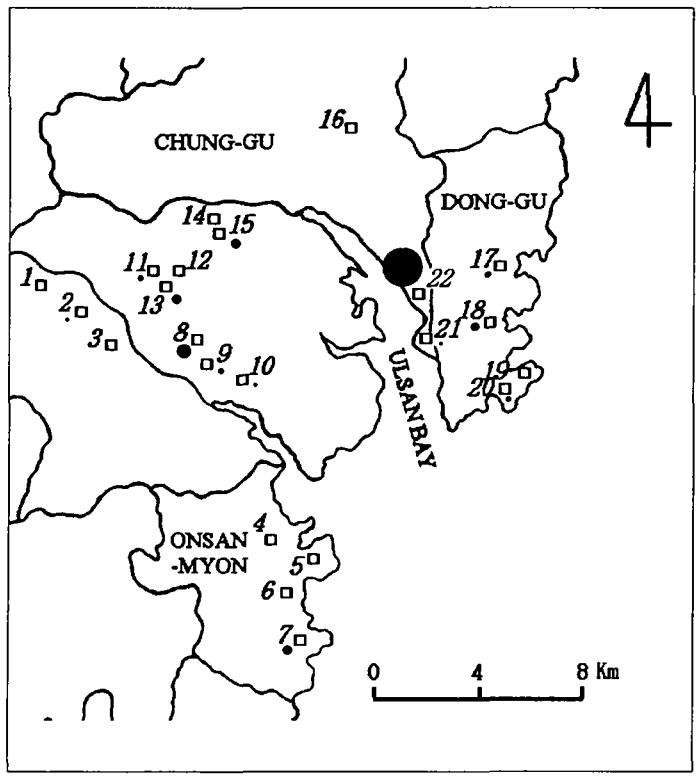


Fig. 1 Sampling sites (□ , 1-22) and concentration (● , ng/g dry weight) of PCBs obtained from surface soils of Ulsan area of Korea

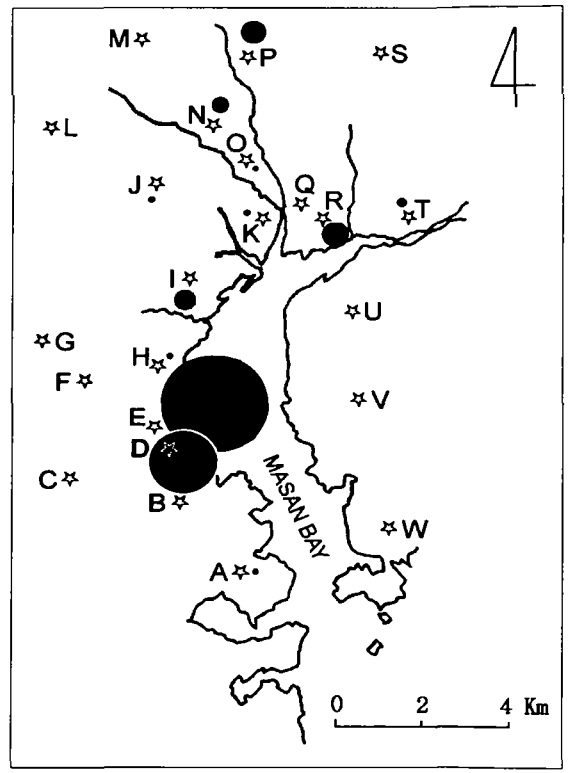


Fig. 2 Sampling sites (☆ , 1-22) and concentration (● , ng/g dry weight) of PCBs obtained from surface soils of Masan area of Korea

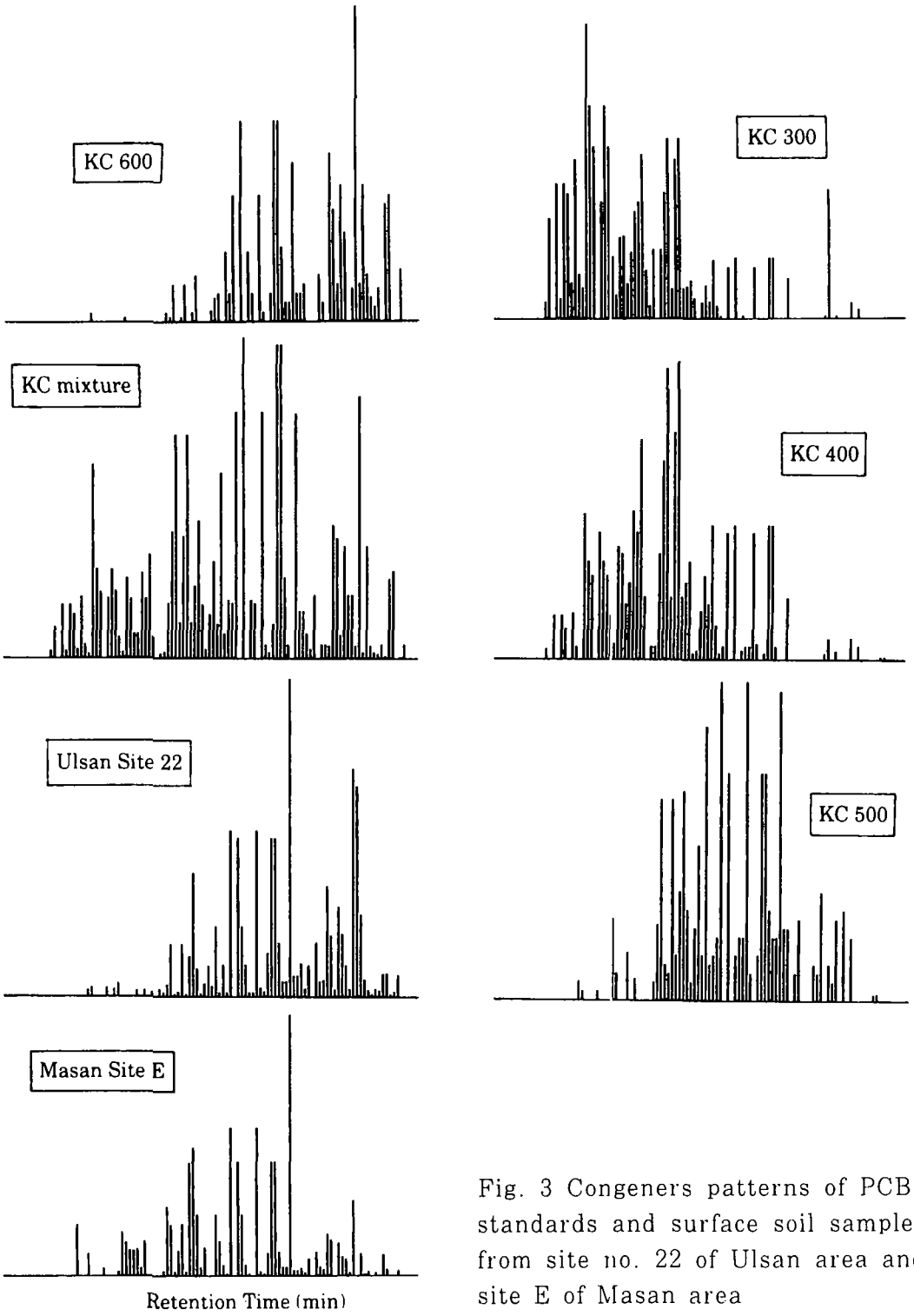


Fig. 3 Congeners patterns of PCBs standards and surface soil samples from site no. 22 of Ulsan area and site E of Masan area