ESTIMATION OF PCDDs, PCDFs, PCBs AND PAHs EMISSION FROM CREMATORIES IN KOREA

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Introduction

Recently, UNEP concluded Stockholm Convention on Persistent Organic Pollutants to reduce the discharges and make an inventory of emission sources. According to the emission source inventories from other countries, the main emission sources of PCDDs/Fs were categorized into nine sectors: iron and steel, non-ferrous metals, power plants, industrial combustion plants, small combustion units, waste incineration, road transport, mineral products production and others.[1] Waste incineration, including cremation, is the major emitter in many countries. However, only a few researches have been done on the PCDDs/DFs emission from crematories in the world [2-5], and there is no published data on emission of these chemicals from crematories in Korea.

93,493 dead bodies were cremated in Korea[6], which is 37.10 % of the entire number of the people that died in 2001. Besides, cremation increased annually about 3.7 % from 1998 to 2001. Currently only a few countries have estimated the emission amount of contaminants from crematories. The objective of this study is to estimate the emission amount and to grasp the emission characteristics of PCDDs/DFs, PCBs and PAHs from crematories in Korea.

Materials and Methods

A crematory has a secondary combustion chamber, which is connected a main combustion chamber. Cyclone and an electrostatic precipitator are linked sequentially to the secondary combustion chamber. Dead bodies get burned and cooled down in a furnace, one by one, so a crematory goes through multiple furnaces. And a crematory is operated in a batch type, not continuously and it consists of overlapped furnaces. Therefore, the value of each emission factor such as PCDDs/DFs, PCBs and PAHs was calculated by dividing the total emission amount of each factor from crematories by the total number of cremated bodies. Sampling and extraction of PCDDs/Fs were carried out according to the Korea Standard Method[7]. Multi-layered Silica gel column and activity alumina column, multi-layered silica gel column, Activity alumina column were used to purify PCDDs/DFs, PCBs, PAHs, respectively. PCDDs/DFs, PCBs and PAHs were determined by HRGC/HRMS.

Results and Discussion

Emission of PCDDs/DFs, PCBs and PAHs

The total concentration of PCDDs/DFs in flue gas was varied from 19 to 150 ng/Nm^3. The range of TEQ concentration was 0.46-2.1 ng TEQ/Nm^3. This result was lower than what was measured in Germany (8 ng TEQ/Nm^3) and in Japan (0.064-24 ng TEQ/Nm^3). The concentration of PCBs from tri- to decaCB in flue gas from crematories was in the range of 22-110 ng/Nm^3. For PAHs, it ranged from 1300 to 2300 ng/Nm^3.

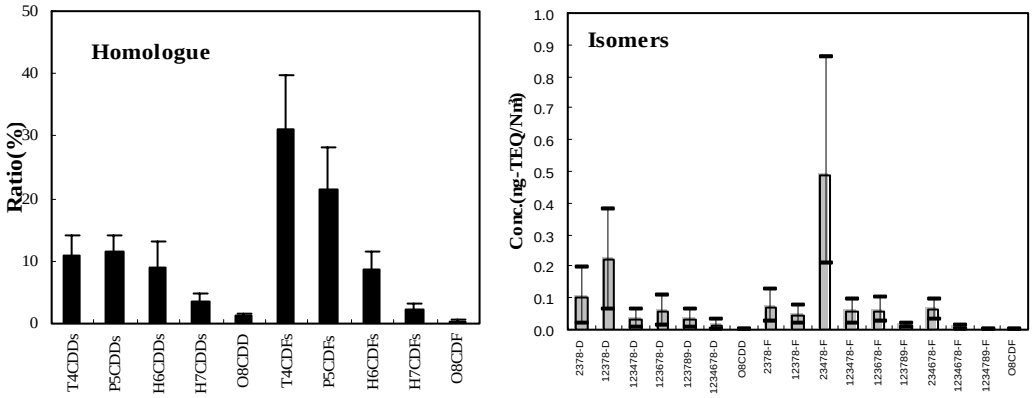

Figure 1. Homologue and 2,3,7,8-substituted profiles of PCDDs/DFs in flue gas from crematory in Korea.

Profiles of homologues and 2,3,7,8-substituted PCDDs/DFs in flue gas are presented in Figure 1. The concentration of T4CDFs was the highest in the homologue pattern of PCDFs, and the concentration got low as the number of bonded chlorine atoms increased. Although the magnitude of PCDDs/Fs was not uniform, but for four times, the homologue patterns of PCDDs/Fs were identical. The homologue pattern in Figure 1 appeared to be the characteristic of crematories. This homologue pattern is similar to that of Japan[5]. The concentration of 2,3,4,7,8-P5CDF is the highest, looking at the patterns of 17 toxic congeners that include chlorine atoms at least at 2, 3, 7 and 8 positions.

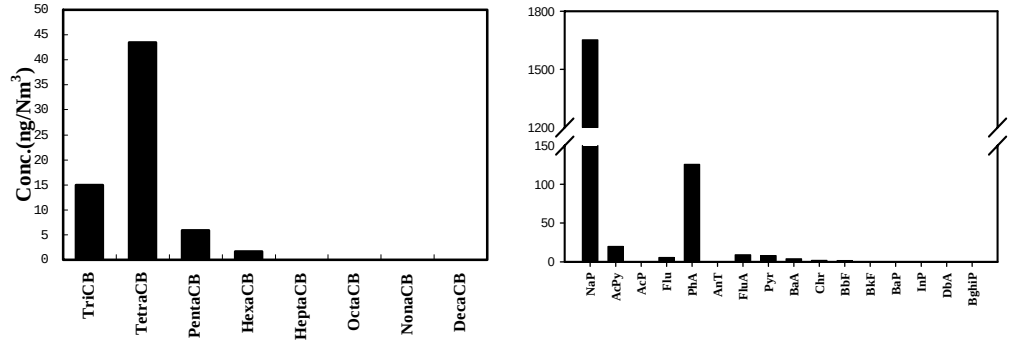

Figure 2. Average normalized compositions of PCBs and PAHs in flue gas from crematory in Korea.

TetraCBs was the most predominant among the homologue groups of PCB in flue gas from crematories in Korea. The high-chlorinated CBs were not detected in any of the crematory samples. As for PAHs, naphthalene (NaP) occupied very highest proportion amongst flue gas samples from crematories in Korea. Phenanthrene (PhA) showed relatively high contribution.

However, other compounds had similar contributions.

Estimated of emission of toxic contaminants from crematories

The released amount (R_{air}) of toxic organic contaminants from crematories can be calculated as below;

$$R_{air} = EF \times A$$

, where EF means an emission factor (ng-TEQ or ng/body) and A indicates an activity rate (cremated bodies/year)

In addition, the emission factor (EF) was derived from below calculation;

$$EF = C \times Vg \times T$$

where C is the concentration (ng TEQ or ng/Nm^3) of target contaminants, Vg means the dry gas volume measured (Nm^3/h), and T indicates cremation time (h/body). Therefore, the estimated amount of target compounds was summarized in Table 1.

Table 1. Summary of the PCDDs/DFs, PCBs and PAHs, emitted from crematories in Korea (2001).

Target compounds	EF (ng/body)	R_{air} (g/year)
PCDDs/DFs	540000	50
TEQ	8400	0.79
PCBs	450000	42
PAHs	12000000	1200

The annual emission amount of PCDDs/Fs and benzo(a)pyrene (BaP), the main substance of mutagenicity and carcinogen amount of PAHs compounds, from 1997 to 2001 was estimated by using the above given emission factors. The result is illustrated in Figure 3.

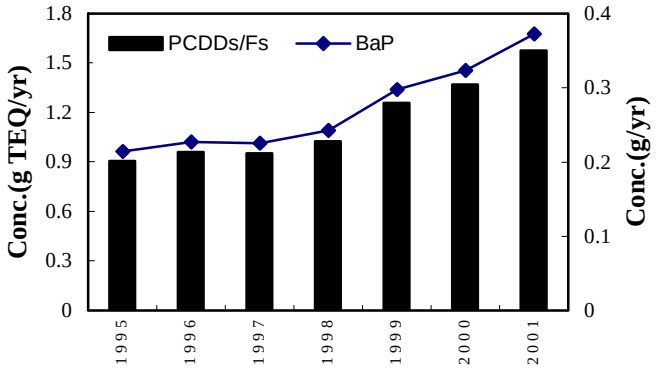

Figure 3. Trend of PCDDs/Fs and BaP amount from crematories in Korea.

In this result, PCDDs/Fs and BaP emission increased every year. The typical pattern of

crematories does not depend on the condition of the dead body, age, sex, funeral materials, and so on, but it depends on the crematory mechamism[5]. Furthermore, the emission amount of contaminants from crematories depends on the number of cremated bodies.
In the near future, crematories are predicted to become one of the important sources of PCDDs/Fs emission.

References

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