# DISTRIBUTION OF PCDD/Fs IN THE AMBIENT AIR AROUND A MUNICIPAL SOLID WASTE PLANT IN CHINA

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## Introduction

Polychlorinated dibenzo-p-dioxins and furans(PCDD/Fs) emitted from the municipal solid waste incinerators are released into the atmosphere and then transported over large distances before settlement. The atmosphere is the major pathway for PCDD/Fs transport and deposition. Recently, PCDD/Fs concentration in the atmosphere of the big city in China, such as Guangzhou, Shanghai and Beijing has been studied. However, the information of the PCDD/Fs distribution in the ambient air around the municipal solid waste incinerators is very limited. In this paper the PCDD/Fs concentration in the ambient air around a municipal solid waste plant was analyzed and the gas/particle partitioning characteristics of PCDD/Fs were also discussed.

## Material and methods

The municipal solid waste plant investigated consists of three fluidized bed incinerators which using MSW and coal as fuel. The capacity of the plant is 800 tonnes $MSWday^{-1}$ with three units and the weight ratio of MSW to coal of each incinerator is 80:20. Each incinerator has own air pollutant control devices which are composed of bag filter and semi-dry scrubber. Finally, all of the flue gases are emitted through a 60 m high stack.The sampling sites are shown in Fig.1. Five sites (A1 to A5) are about 200 m to 1.1 km to the MSW plant. The air samples were collected using a high volume air sample (SIBATA, Japan) complying with USEPA TO-9A. About 1000 $m^3$ ambient air was collected for each sample site. Samples' pretreatment and PCDD/Fs analysis were based on USEPA method 23 and 1613.

## Results and discussion

### *PCDD/Fs concentration and homologue distribution*

Fig.2. shows the PCDD/Fs concentration and homologue distribution in the five sites. The total PCDD/Fs concentration in the ambient air (A1 to A5) sampled around the MSW plant is 7050 fg $m^{-3}$(88fg I-TEQ $m^{-3}$), 12763 fg $m^{-3}$(161fg I-TEQ $m^{-3}$), 8859 fg $m^{-3}$(143fg I-TEQ $m^{-3}$), 8201 fg $m^{-3}$ (97fg I-TEQ $m^{-3}$), and 6707 fg $m^{-3}$(94fg I-TEQ $m^{-3}$), respectively. The results of PCDD/Fs concentration in the ambient air around a MWI in northern Taiwan showed the values were 101, 144, 208 and 194 fg I-TEQ $m^{-3}$, which were similar with this study[1]. In Japan[2], the PCDD/F concentration in ambient air close to MWIs ranged from 280 to 2500 fg I-TEQ $m^{-3}$. All of the PCDD/Fs concentration in this study were lower than the ambient air quality standard proposed in Japan (600 fg I-TEQ $m^{-3}$). Compared the study results with other reports in China, it was found I-TEQ of

PCDD/Fs in this study were all lower than those reported for atmosphere of big cities, such as Guangzhou and Beijing, with the mean I-TEQ values of 367fg I-TEQ m$^{-3}$, 268 fg I-TEQ m$^{-3}$ respectively[3-4].The PCDD/Fs homologue distribution of the five samples was similar. The concentration of PCDFs decreased with the increase of chlorine number and the concentration of PCDFs was larger than that of PCDDs, the distribution were also quite similar with the PCDD/Fs homologue distribution in the flue gas of the MSWIs[5].

*PCDD/Fs congener distribution*

Table 1 shows the percentage of PCDD/Fs congener in the ambient air.   OCDD, 1,2,3,4,6,7,8-HpCDD, OCDF and 1,2,3,4,6,7,8-HpCDF were the major congener, accounting for 56-74% of the total concentration. However, 2,3,4,7,8-PeCDF was the major contributor for 29-45% of the total I-TEQ. It is caused by the fact that the I-TEF of 2,3,4,7,8-PeCDF is 0.5. Other important contributors for I-TEQ were    1,2,3,4,7,8-HxCDF (7-9%), 1,2,3,6,7,8-HxCDF(8-11%), 2,3,4,6,7,8-HxCDF(7-9%) and 1,2,3,7,8-PeCDD (6-13%). 2,3,7,8-substitued PCDFs were the more important contributors than that of PCDDs. The study conducted by Chang et al. reported the similar results as this paper[6].

*Gas/particle phase distribution of PCDD/Fs in ambient air*

The PCDD/Fs concentration for gas/particle phase of the five air samples is summarized in Table 2. It was obvious that the PCDD/Fs total concentration and I-TEQ were dominant in the particle phase. Especially for the high chlorinated PCDD/Fs. The percentage of hepta- to octa-chlorinated PCDD/Fs   in the particle phase ranged from 83 to 99 %, with the majority > 90%. PCDDs tended to be more associated with the particle phase than that of PCDFs, which probably is due to the slightly lower vapor pressure of the PCDDs. In the meantime, the lower chlorinated PCDD/Fs congeners tended to distribute in the gas phase, while the higher chlorinated congeners were more associated with the particle phase. The characteristic of PCDD/Fs distribution for gas/particle phase was also found by Li et al and Lee et al[4,7].

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Fig.1.    Location of five sampling sites and M
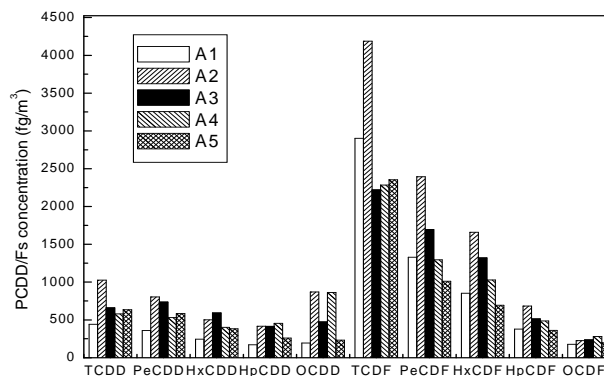(Black dot is the sampling site of soil.)



Fig.2. Concentration and distribution of PCDD/Fs in the five
air samples

Table 1 Percentage of PCDD/Fs congener in the five air samples

| Sampling sites | A1 | | A2 | | A3 | | A4 | | A5 | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Conc. (%) | I-TEQ (%) | Conc. (%) | I-TEQ (%) | Conc. (%) | I-TEQ (%) | Conc. (%) | I-TEQ (%) | Conc. (%) | I-TEQ (%) |
| **2,3,7,8-TCDF** | 8.0 | 11.5 | 4.0 | 6.9 | 3.5 | 5.0 | 2.4 | 5.6 | 5.7 | 8.1 |
| **1,2,3,7,8-PeCDF** | 8.3 | 5.9 | 6.9 | 6.0 | 5.4 | 3.9 | 3.8 | 4.5 | 5.0 | 3.6 |
| **2,3,4,7,8-PeCDF** | 4.1 | 29.2 | 3.5 | 30.9 | 6.4 | 45.3 | 2.8 | 33.6 | 5.4 | 38.9 |
| **1,2,3,4,7,8-HxCDF** | 4.7 | 6.7 | 5.0 | 8.8 | 6.0 | 8.6 | 2.9 | 6.8 | 5.0 | 7.2 |
| **1,2,3,6,7,8-HxCDF** | 5.7 | 8.2 | 6.5 | 11.2 | 4.6 | 6.5 | 3.9 | 9.4 | 6.0 | 8.5 |
| **2,3,4,6,7,8-HxCDF** | 5.3 | 7.6 | 4.8 | 8.3 | 5.1 | 7.3 | 4.0 | 9.5 | 5.6 | 8.0 |
| **1,2,3,7,8,9-HxCDF** | 2.1 | 3.1 | 1.8 | 3.2 | 1.9 | 2.6 | 1.5 | 3.5 | 2.0 | 2.9 |
| **1,2,3,4,6,7,8-HpCDF** | 20.3 | 2.9 | 16.4 | 2.9 | 15.8 | 2.2 | 14.9 | 3.5 | 18.4 | 2.6 |
| **1,2,3,4,7,8,9-HpCDF** | 1.7 | 0.2 | 1.6 | 0.3 | 2.4 | 0.4 | 1.3 | 0.3 | 1.7 | 0.2 |
| **OCDF** | 14.0 | 0.2 | 8.0 | 0.1 | 11.6 | 0.2 | 12.2 | 0.3 | 14.7 | 0.2 |
| **∑PCDF** | 74.2 | 75.5 | 58.5 | 78.4 | 62.7 | 81.9 | 49.5 | 76.9 | 69.4 | 74.2 |
| **2,3,7,8-TCDD** | 0.6 | 8.2 | 0.2 | 3.7 | 0.4 | 5.0 | 0.2 | 4.3 | 0.04 | 0.5 |
| **1,2,3,7,8-PeCDD** | 1.7 | 12.2 | 1.4 | 11.8 | 0.9 | 6.4 | 0.9 | 10.5 | 1.9 | 13.5 |
| **1,2,3,4,7,8-HxCDD** | 0.3 | 0.5 | 0.3 | 0.6 | 0.6 | 0.8 | 0.3 | 0.7 | 0.4 | 0.6 |
| **1,2,3,6,7,8-HxCDD** | 1.0 | 1.4 | 1.1 | 1.9 | 1.6 | 2.3 | 1.0 | 2.3 | 1.4 | 2.0 |
| **1,2,3,7,8,9-HxCDD** | 0.8 | 1.1 | 1.2 | 2.1 | 1.3 | 1.9 | 0.9 | 2.1 | 1.2 | 1.7 |
| **1,2,3,4,6,7,8-HpCDD** | 6.1 | 0.9 | 6.5 | 1.1 | 9.3 | 1.3 | 9.8 | 2.3 | 8.3 | 1.2 |
| **OCDD** | 15.4 | 0.2 | 30.9 | 0.5 | 23.3 | 0.3 | 37.4 | 0.9 | 17.3 | 0.3 |
| **∑PCDD** | 25.8 | 24.5 | 41.5 | 21.6 | 37.3 | 18.1 | 50.4 | 23.1 | 30.6 | 19.8 |

Table 2 PCDD/Fs concentration for gas/particle phase of the five air samples (fg/m$^3$)

| Sampling sites | A1 | | A2 | | A3 | | A4 | | A5 | |
|---|---|---|---|---|---|---|---|---|---|---|
| | gas | particle | gas | particle | gas | particle | gas | particle | gas | particle |
| **2,3,7,8-TCDF** | 55.6 | 45.7 | 71.2 | 39.7 | 30.6 | 41.1 | 26.2 | 28.5 | 41.74 | 34.8 |
| **1,2,3,7,8-PeCDF** | 39.4 | 65.5 | 64.5 | 128.2 | 32.4 | 78.4 | 26.2 | 60.6 | 18.04 | 49.5 |
| **2,3,4,7,8-PeCDF** | 8.2 | 43.5 | 27.9 | 71.7 | 23.1 | 106.9 | 14.9 | 50.6 | 15.53 | 57.6 |
| **1,2,3,4,7,8-HxCDF** | 16.9 | 42.7 | 20.3 | 120.9 | 20.5 | 102.1 | 12.7 | 53.2 | 8.26 | 59.1 |
| **1,2,3,6,7,8-HxCDF** | 13.6 | 58.8 | 16.6 | 164.5 | 19.4 | 74.3 | 13.2 | 77.8 | 6.33 | 73.8 |
| **2,3,4,6,7,8-HxCDF** | 7.5 | 59.6 | 8.7 | 124.8 | 14.5 | 90.1 | 8.2 | 83.9 | 5.23 | 69.8 |
| **1,2,3,7,8,9-HxCDF** | 2.9 | 24.3 | 2.9 | 48.4 | 6.1 | 31.5 | 3.0 | 30.9 | 2.32 | 25.2 |
| **1,2,3,4,6,7,8-HpCDF** | 27.7 | 229.1 | 20.7 | 440.7 | 57.2 | 264.0 | 29.0 | 314.5 | 12.53 | 234.4 |
| **1,2,3,4,7,8,9-HpCDF** | 1.9 | 19.7 | 3.2 | 41.6 | 9.3 | 40.2 | 3.2 | 26.4 | 1.82 | 20.7 |
| **OCDF** | 1.8 | 175.4 | 2.1 | 223.4 | 40.7 | 195.0 | 2.2 | 278.3 | 2.02 | 195.0 |
| **2,3,7,8-TCDD** | 3.0 | 4.3 | 4.6 | 1.4 | 2.8 | 4.5 | 2.6 | 1.6 | 0.26 | 0.2 |
| **1,2,3,7,8-PeCDD** | 7.4 | 14.1 | 4.9 | 33.1 | 0.4 | 18.1 | 0.6 | 19.7 | 5.28 | 20.1 |
| **1,2,3,4,7,8-HxCDD** | 0.8 | 3.4 | 0.4 | 9.2 | 1.7 | 10.0 | 1.0 | 5.3 | 0.38 | 5.4 |
| **1,2,3,6,7,8-HxCDD** | 1.8 | 10.8 | 2.2 | 27.9 | 6.5 | 26.4 | 2.6 | 20.2 | 1.92 | 17.2 |
| **1,2,3,7,8,9-HxCDD** | 0.7 | 9.0 | 1.7 | 31.3 | 4.7 | 22.5 | 2.0 | 18.7 | 1.04 | 15.2 |
| **1,2,3,4,6,7,8-HpCDD** | 5.7 | 71.7 | 5.2 | 176.3 | 30.5 | 157.9 | 14.8 | 212.3 | 4.33 | 106.8 |
| **OCDD** | 13.4 | 181.4 | 26.1 | 842.5 | 77.0 | 396.6 | 56.8 | 805.8 | 1.55 | 231.0 |
| **TCDF** | 1769.7 | 1133.5 | 3174.3 | 1013.7 | 1154.1 | 1065.4 | 1303.2 | 980.3 | 1547.42 | 805.2 |
| **PeCDF** | 608.8 | 721.3 | 1046.4 | 1347.2 | 417.2 | 1277.8 | 410.8 | 883.9 | 383.18 | 627.2 |
| **HxCDF** | 207.8 | 643.8 | 194.2 | 1464.7 | 260.2 | 1060.0 | 158.7 | 869.4 | 70.34 | 623.0 |
| **HpCDF** | 38.1 | 340.1 | 33.2 | 650.1 | 88.5 | 426.0 | 42.4 | 443.1 | 20.30 | 341.0 |
| **OCDF** | 1.8 | 175.4 | 2.1 | 223.4 | 40.7 | 195.0 | 2.2 | 278.3 | 2.02 | 195.0 |
| **TCDD** | 215.4 | 226.8 | 859.3 | 165.5 | 368.5 | 290.6 | 278.0 | 301.4 | 452.40 | 181.4 |
| **PeCDD** | 88.8 | 269.8 | 260.9 | 543.9 | 137.0 | 599.8 | 106.3 | 424.2 | 168.75 | 414.9 |
| **HxCDD** | 38.5 | 205.5 | 45.6 | 455.1 | 95.5 | 496.0 | 48.6 | 352.7 | 33.95 | 348.9 |
| **HpCDD** | 12.3 | 158.3 | 12.8 | 402.6 | 65.1 | 348.4 | 31.8 | 423.2 | 10.31 | 249.1 |
| **OCDD** | 13.4 | 181.4 | 26.1 | 842.5 | 77.0 | 396.6 | 56.8 | 805.8 | 1.55 | 231.0 |
| **Total(fg/m3)** | 4055.8 2994.6 | 5654.8 | 7108.6 | 2703.8 | 6155.5 | 2438.7 | 5762.3 | 2690.21 | 4016.6 | |
| **I-TEQ(fg-TEQ/m3)** | 23.1 | 65.3 | 36.9 | 124.5 | 27.5 | 115.9 | 19.1 | 78.2 | 18.48 | 75.6 |