# THE EVALUATION OF PCDD/Fs CONCENTRATION IN THE AMBIENT AIR AND SOIL OF CENTRAL TAIWAN

Hsu Yuan Cheng, Peng Jui Hwa, Lee Tzu Yi, Chen Yuan Wu
Environmental Analysis Laboratory (EAL), Environmental Protection Administration (EPA), Chung Li City, Taoyuan County, Taiwan 32024, R.O.C.

**Introduction**

Electric arc furnaces, steel rolling manufacturers and waste incinerators are the major pollution sources of polychlorinated dibenzo-p-dioxins and furans （PCDD/Fs）in Taiwan. PCDD/Fs can be released directly into the atmosphere from various sources that will then be transported to the terrestrial and aquatic ecosystems through dry or wet deposition. Most pollutants in the atmosphere are bounded to the suspended particles. With the help of wind, they can be transported to another places and eventually might be settled down at some water bodies or other kind of receptors in the environment. Atmospheric transportation and deposition are believed to be two of the major distribution pathways to carry PCDD/Fs of various emission sources into the environmental compartments[1]. It is well known that food chain is the essential path for PCDD/Fs to enter the human body. As livestock products have been playing an important role in most of the human diet, people will be immediately exposed to high risk in their health once the livestock products are contaminated by PCDD/Fs. Thus, the evaluation and monitoring of the PCDD/Fs levels in the pasturage areas and the study of interactions between the ambient air and the soil in industry discharge areas has become a critical issue.

It is believed that each of the PCDD/Fs congeners will more or less be depleted or transformed through certain kinds of chemical degradation mechanisms such as OH radical reactions[2-3]. As the dechlorination rate of each dioxin congener may vary from each other, therefore, the composition pattern of the dioxin congeners may offer some clues to disclose and help to track down the possible origins of pollution sources. This investigation has been focused on the central part of Taiwan and we have selected sampling spots covering industrial, pasturage and heavy traffic areas. Ambient air samples were collected and analyzed every six months. Locations of the sampling spots for the soil were determined based on the analyzed concentration of PCDD/Fs.

**Material and methods**

(1) Sample collection, extraction and clean-up

There are 19 sampling stations in this investigation covering various areas in five counties of the central Taiwan. They include ten industrial areas (I), six pasturage areas (P) and three heavy traffic areas (T). These sampling stations are demonstrated as shown in Figure 1. Samples were collected during October, 2006 and January, July of the year of 2007. Soil samples were collected only for those spots with high potential pollution based on the analysis results of the ambient air. Ambient samples including vapor phase and solid phase PCDD/Fs were collected with quartz filter paper (102~105mm diameter) and PUF (3 inch thickness, 630mm diameter) using the PS1 semi-volatile sampling trains. The total sampled air volume of a typical 5-6 days sampling [5] was generally larger than 2,000$m^3$. All samples have been spiked with $^{13}$C-isotopes labeled internal standards of each target compounds before their Soxhlet (ambient) or ASE (soil) extraction with toluene solvent. Extracted samples were concentrated into a volume of approximately 1 mL through rotary vacuum evaporation and then substitute the solvent with 5 mL of hexane for further cleanup steps including sulfuric acid silica gel and activated carbon column kits (CAPE).

(2) HRGC/HRMS analysis

PCDD/Fs were analyzed by the high-resolution mass spectrometer (HRMS) (JEMOL JMS-700) coupled with a gas chromatograph equipped with cooling injection system. PCDD/Fs were eluted with a J&W DB-5MS column (60m╳0.25mm╳0.25 μm). Compounds identification and quantitative analysis were done by isotope dilution following the USEPA Method 1613.

**Results and discussion**

Results of the investigation show that the range of PCDD/Fs in the ambient air samples are in the range of 0.015~0.261 pg-I-TEQ/Nm$^3$ with an average of 0.070 pg-I -TEQ/Nm$^3$. Soil in the hot spots judging from the data of ambient air are in the range of 0.464~18.1 ng-I-TEQ/Kg d.w. with an averageof 3.90 ng-I-TEQ/Kg d.w.. All data in this investigation have been summarized and illustrated as shown in Table 1and 2. All concentrations measured are significantly lower than the ambient air quality standards of Japan (600 fg-TEQ/m$^3$) [5] and show a trend of declining in the level of PCDD/Fs as we compare them with those data of previous studies in Taiwan[6] possibly due to the successful effort of environmental management works done by EPA Taiwan. Among the three kind of sampling sites for ambient air, the average concentration in the heavy traffic areas (0.075 pg-I-TEQ/Nm$^3$) is the highest, the industrial areas (0.071 pg-I-TEQ/Nm$^3$) is the next while the pasturage areas (0.065 pg-I-TEQ/Nm$^3$) is the lowest although the difference among these three are actually quite small. The high average value in the heavy traffic area is contributed mostly from the H3 sampling spot that is significantly higher than the other two stations.

As to the soil samples, average concentration of the industry areas (6.28 ng-I-TEQ/kg d.w.) is the highest, the pasturage areas (0.728 ng-I-TEQ/kg d.w.) is the next while the heavy traffic areas (0.075 ng-I-TEQ/kg d.w.) is the lowest. It is reasonable to propose that the contribution of PCDD/F in pasturage area might come from the industrial areas more than from the heavy traffic areas. PCDD/Fs result of soil samples is about in the same level comparing with data of agricultural soil investigation of Taiwan in the year of 2001(0.254~15.2 ng-I-TEQ/Kg d.w.)[7] except for the one in the sampling station I6 that is significantly higher than the others. Fig.2 and 3 shows the concentration distribution of congener of PCDD/Fs in ambient air collected in different time. In Fig.3, we have observed that the patterns of congeners in the industrial areas are very similar to those in the pasturage areas. However, it is not the case for the patterns shown in Fig.2. One possible explanation for this difference may be due to the strong northeastern season wind during the winter period. It will play an important role in the mixing and transportation of PCDD/Fs in the ambient air.

**Acknowledgments**

We would like to express our deep gratitude to all the kind assistances from both the Department of Air Quality Protection & Noise Control and the Department of Environmental Monitoring & Information Management, Taiwan EPA during the period of this investigation work.

**Reference**

1. Lohmann R, Green N J L and Jones K C. *Environ. Sci. Technol.;* 1999; 33, 4440.
2. Hippelein M, Kaupp H, Dörr G, McLachlan M and Hutzinger O. *Chemosphere* 1996; 32,1605.
3. Ogura I, Masunaga S and Nakanishi J. *Chemosphere* 2001; 44, 1473.
4. Environmental Analysis Laboratory, EPA Taiwan, Republic of China, *Sampling of polychlorinated dibenzo-p-dioxim and Dibenzofurans In Ambient Air* 2001, NIEA Method A 809.10B.
5. 平成 17 年度ダイオキシン類に係る環境調査結果について（お知らせ），日本環境省，2005.
6. Lee T Y. *Annul scientific report of EAL of EPA, ROC 2004.* 11:390.

7. Chung J C. *Annul scientific report of EAL of EPA, ROC 2004.* 11:382.

**Table 1 Summary of concentration in ambient air.**

| | Sampling station | Sample | Concentration range ($pg\ I\text{-}TEQ/Nm^3$) | Average ($pg\ I\text{-}TEQ/Nm^3$) |
|---|---|---|---|---|
| All areas | 19 | 46 | 0.015~0.261 | 0.070 |
| Industrial areas | 10 | 20 | 0.015~0.261 | 0.071 |
| Pasturage areas | 6 | 12 | 0.018~0.148 | 0.065 |
| Heavy traffic areas | 3 | 6 | 0.030~0.133 | 0.075 |

**Table 2 Summary of concentration in soil.**

| | Sampling station | Sample | Concentration range （ng I-TEQ/Kg d.w.） | Average （ng I-TEQ/Kg d.w.） |
|---|---|---|---|---|
| All areas | 7 | 7 | 0.464~18.1 | 3.90 |
| Industrial areas | 4 | 4 | 0.818~18.1 | 6.28 |
| Pasturage areas | 2 | 2 | 0.464~0.991 | 0.728 |
| Heavy traffic areas | 1 | 1 | 0.729 | 0.075 |

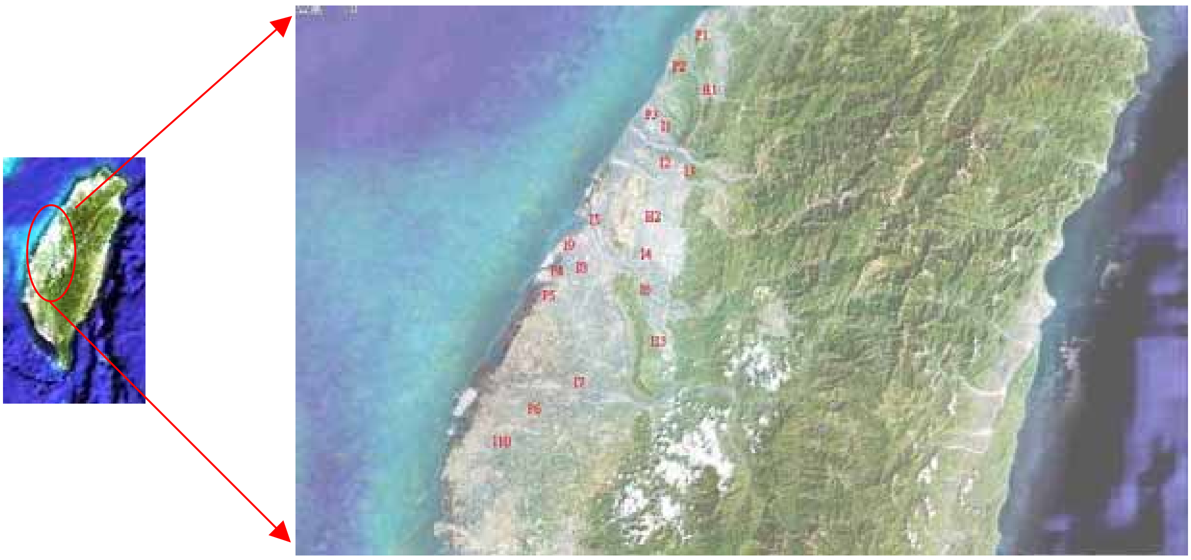

Figure 1 Location of sampling stations in central of Taiwan.

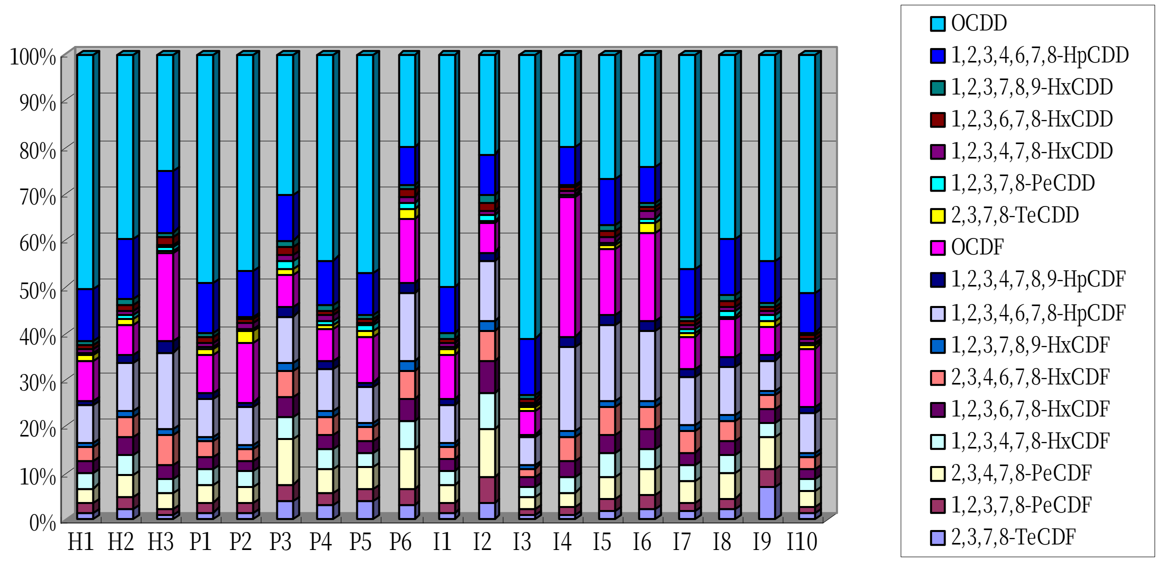


Figure 2 Concentration distribution of congener of PCDD/F in ambient air on October 2006.

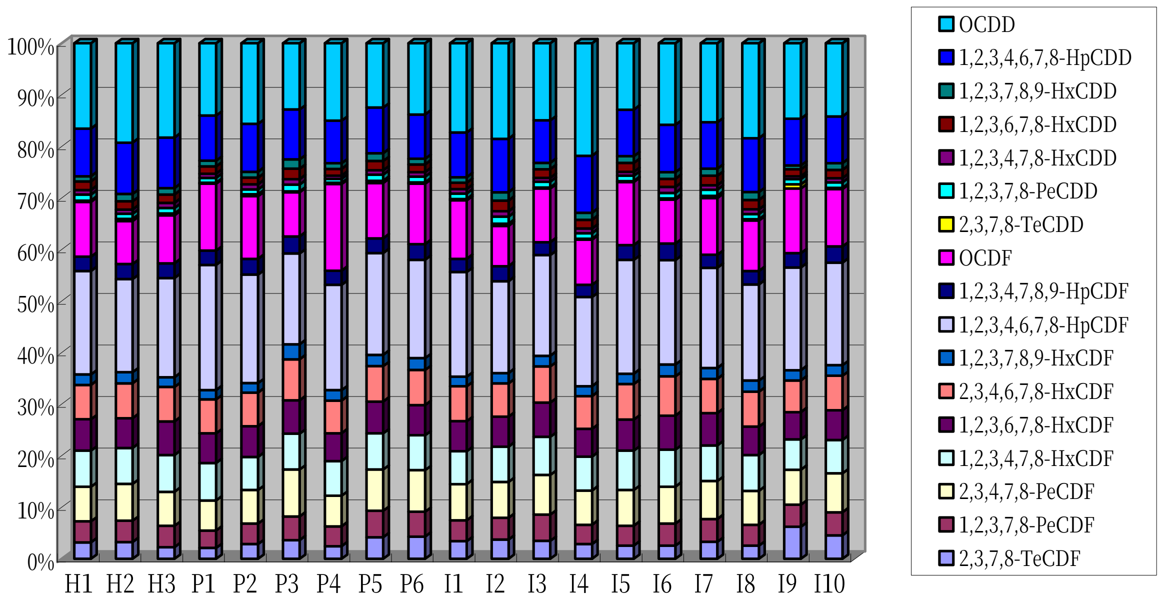


Figure 3 Concentration distribution of congener of PCDD/F in ambient air on January 2007.