

## THE NATIONWIDE SURVEY OF THE LEVEL OF PCDD/Fs IN AMBIENT AIR IN TAIWAN BETWEEN 2002 AND 2003

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### Introduction

Taiwan is a solitary island on the western edge of the Pacific Ocean. Incineration is the major way for waste treatment in Taiwan. EPA of the ROC government has planed to build 30 municipal solid waste incinerators MSWIs . Currently, there are 19 MSWIs in operation with a daily treatment capacity of 21,000 tons<sup>1</sup>. The emission of PCDD/Fs from MSWIs has been of great concern from the public. Therefore, large-scale surveys over the PCDD/Fs in ambient air were focused largely on the vicinity of MSWIs in the last three years<sup>2</sup>. There were only several small-scale projects for ordinary areas were implemented in northern and southern Taiwan<sup>3,4,5</sup>.

The EPA started to set up the Taiwan Air Quality Monitoring Network TAQMN in 1990. For now, there are 72 air quality monitoring stations, including 58 ordinary ambient air stations, 5 traffic pattern stations, 4 background pattern stations, 3 industrial pattern stations and 2 national park pattern stations<sup>6</sup>. The priority pollutants being monitored in TAQMN include PM10, sulfur dioxides, nitrogen oxides, carbon monoxide, ozone, and hydrocarbons. Besides, it also records several meteorological conditions. These stations were set up after proper evaluation and can well represent the air quality in the vicinity areas.

The most recent data for the concentration of PCDD/Fs in ambient air have shown a trend of deceasing level in many areas, but have not been reported in Taiwan. Therefore, in this study, EAL selected 16 TAQMN monitoring stations as sampling sites and launched this nationwide survey from 2002 to 2003.

### Materials and Methods

#### Sampling sites

There were 16 sampling sites in this study, including 13 ordinary ambient air stations that were highly concerned in this study, 2 industrial pattern stations and 1 national park pattern station that were considered as a reference site. Figure 1 showed the locations of 19 MSWIs in operation and our 16 sampling sites in this study. There is a huge mountain chain in Taiwan as we can observe from Figure 1. It stretches from north to south and divides Taiwan into east and west. The west half is more prosperous and owns over 90% of the population. Therefore, further divide this half into three monitoring areas, named northern, central and southern Taiwan. Combining with the eastern Taiwan area. We have four monitoring areas in all. We selected four sampling sites in each area

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and chose one of the sites for duplicate sampling to meet QA/QC requirement. We have done 8 samplings in each site during the period from August 2002 to November 2003.

### Sampling

All samples were collected according to NIEA 810.10B modified from USEPA method TO-9A, but the standards system followed USEPA method 23 with PS-1 high volume samplers at a flow rate of  $0.225 \pm 10\%$  m<sup>3</sup>/min. The sampling module included a quartz fiber filter QFF and a polyurethane foam PUF plug. Prior to sampling, QFF was pre-cleaned by baking at 400 for 5 hours and PUF was pre-cleaned by Soxhlet extraction with Toluene for 6 hours. Before sampling, <sup>13</sup>C<sub>12</sub>-labeled PCDD/Fs surrogate standard was spiked on PUF to monitor sampling efficiency. The total sampling time was about 72-96 hours and sampling volume was around 1000-1300 m<sup>3</sup>. After sampling, the modules were wrapped by aluminum foil in order to avoid degradation of PCDD/Fs due to sunlight, and were stored in a refrigerator until analyzed.

### Analysis

After spiking with <sup>13</sup>C<sub>12</sub>-labeled PCDD/Fs internal standard, QFF and PUF were extracted with toluene using Soxhlet apparatus for 24 hours. Before cleanup, <sup>13</sup>C<sub>12</sub>-labeled alternative standard was spiked into concentrated extracts to monitor efficiency of cleanup procedures. The cleanup procedures included sulfuric acid treatment, acidic silica gel column, alumina column and activated carbon column. <sup>13</sup>C<sub>12</sub>-labeled recovery standard was spiked before mass analysis. The analysis of samples was performed on the HRGC/HRMS JEOL JMS-700 using DB-5MS column. TEQ values were calculated by I-TEF.

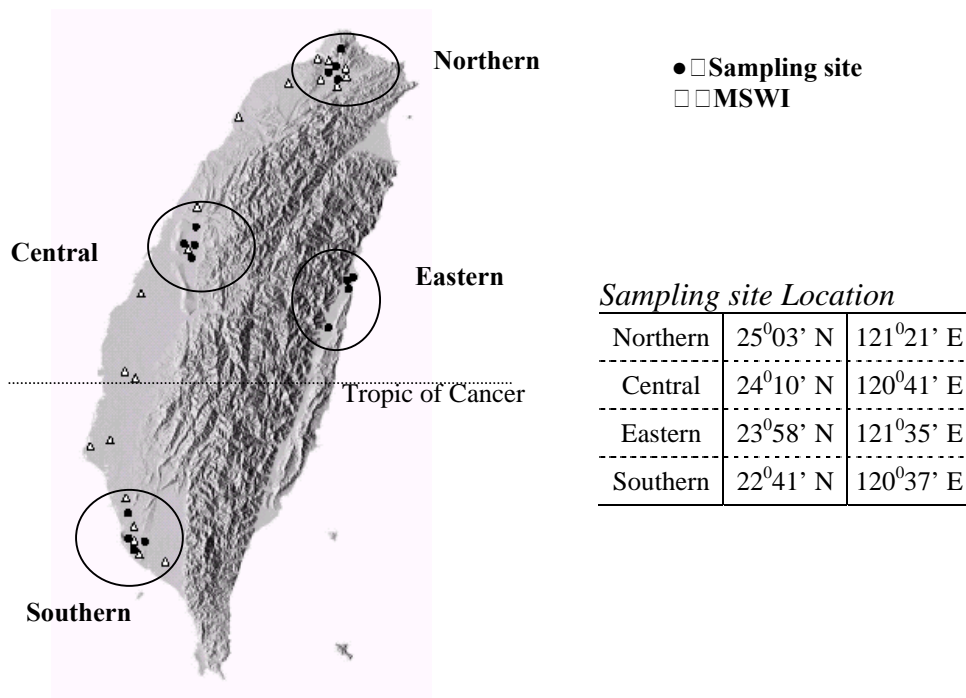


Figure 1 The corresponding locations of 19 MSWIs and 16 Sampling sites in Taiwan

## Results and Discussion

Table 1 listed the mean I-TEQ concentrations of PCDD/Fs at different sites pattern in Taiwan from August 2002 to November 2003. For ordinary ambient air sites, the range and mean of I-TEQ concentration were 0.013~0.353 pg I-TEQ/Nm<sup>3</sup> and 0.089 pg I-TEQ/Nm<sup>3</sup> respectively. For national park site, the range and mean of I-TEQ concentration were 0.010~0.033 pg I-TEQ/Nm<sup>3</sup> and 0.019 pg I-TEQ/Nm<sup>3</sup> respectively. And for Industrial pattern sites, the range and mean of I-TEQ concentration were 0.011~0.315 pg I-TEQ/Nm<sup>3</sup> and 0.095 pg I-TEQ/Nm<sup>3</sup> respectively. The mean I-TEQ concentration of all sites was 0.088 pg I-TEQ/Nm<sup>3</sup>.

Table 1 also showed the PCDD/Fs levels at different monitoring areas for the 13 ordinary ambient air sites. The mean I-TEQ concentrations was sequenced as following Central 0.128 pg I-TEQ/Nm<sup>3</sup> >Southern 0.094 pg I-TEQ/Nm<sup>3</sup> >Northern 0.045 pg I-TEQ/Nm<sup>3</sup> >Eastern 0.032 pg I-TEQ/Nm<sup>3</sup> .

**Table1 PCDD/Fs levels in ambient air at different sites pattern in Taiwan □2002 - 2003□**

Sites pattern □Area□		Sites	Samples	PCDD/Fs levels	Mean	
				(pg I-TEQ/Nm <sup>3</sup> )	(pg I-TEQ/Nm <sup>3</sup> )	
Ordinary ambient air	Northern	3	32	0.014~0.167	0.045	0.089
	Eastern	3	32	0.016~0.065	0.032	
	Central	4	40	0.049~0.353	0.128	
	Southern	3	32	0.013~0.225	0.094	
National park		1	8	0.010~0.033	0.019	
Industrial pattern		2	16	0.011~0.315	0.095	
All sites		16	160	0.010~0.353	0.088	

PCDD/Fs levels in 13 ordinary ambient air sites at different sampling date were shown in Table 2. The highest mean I-TEQ concentration occurred on May 2003 and the lowest one was on July 2003. The range of mean I-TEQ concentration was 0.062-0.130 pg I-TEQ/Nm<sup>3</sup>. The variation of mean I-TEQ concentration was very small in contrast to other countries, and the temperature effect was not significant here.

**Table2 PCDD/Fs levels in 13 ordinary ambient air sites at different sampling date in Taiwan**

Sampling date	Sites	Samples	PCDD/Fs levels	Mean	Temp	Weather
			(pg I-TEQ/Nm <sup>3</sup> )	(pg I-TEQ/Nm <sup>3</sup> )	□	
August 2002	13	17	0.021~0.180	<b>0.067</b>	<b>27.3-38.4</b>	<b>Sunny-Rainy</b>
October 2002	13	17	0.029~0.122	<b>0.071</b>	<b>18.3-34.2</b>	<b>Sunny-Rainy</b>
January 2003	13	17	0.014~0.270	<b>0.107</b>	<b>9.6-30.2</b>	<b>Sunny-Rainy</b>
March 2003	13	17	0.027~0.214	<b>0.088</b>	<b>11.1-28.7</b>	<b>Sunny-Rainy</b>
May 2003	13	17	0.029~0.353	<b>0.130</b>	<b>23.0-33.5</b>	<b>Sunny-Rainy</b>
July 2003	13	17	0.013~0.147	<b>0.062</b>	<b>26.1-37.0</b>	<b>Sunny</b>
September 2003	13	17	0.017~0.263	<b>0.085</b>	<b>24.7-34.4</b>	<b>Sunny</b>
November 2003	13	17	0.020~0.255	<b>0.109</b>	<b>12.6-33.4</b>	<b>Sunny-Rainy</b>

A few small-scale projects for ordinary ambient air sites were implemented in northern and southern Taiwan from 1999 to 2001<sup>3,4,5</sup>. We compared the mean levels of PCDD/Fs with our study and showed as Figure 2. The result showed a downward trend and the mean levels of 2002-2003 were much lower than that of 1999. EPA has endeavored on the reduction of emission of PCDD/Fs for many years. We strongly believe that it is the reason of decreasing trend of mean levels of PCDD/Fs in ambient air.

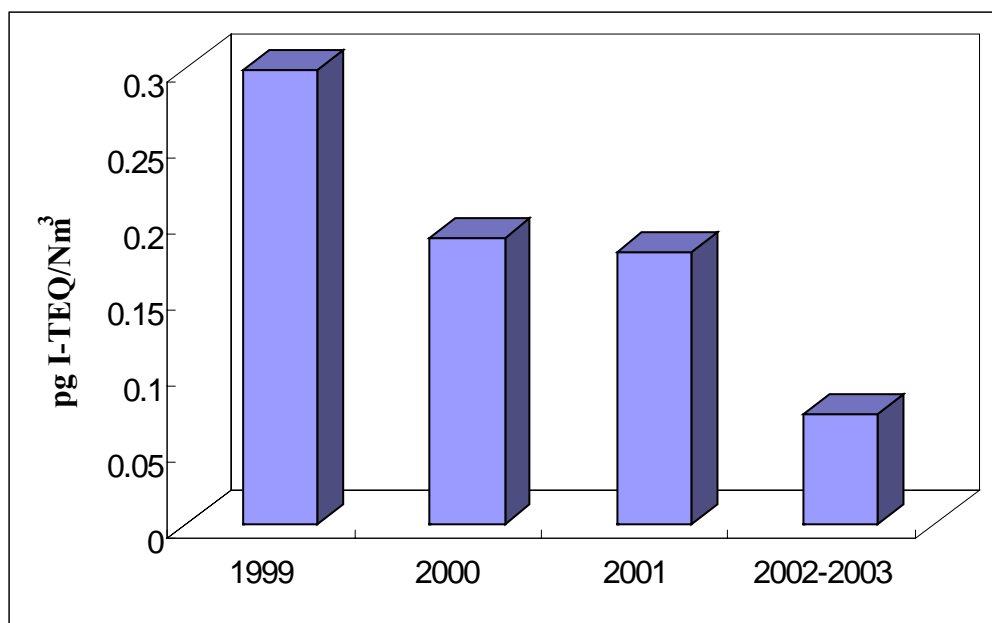
**Figure 2 The mean level of PCDD/PCDFs in Taiwan ambient air samples**

Figure 3 showed the distribution of 17-Congeners concentration at different monitoring areas. Few abnormal data that had significant different distribution with other sites at the same monitoring area were eliminated before drawing Figure 3. These data might have some strong donation of PCDD/Fs from other uncertain emission sources. In Figure 3, the distribution patterns of 17-Congeners concentration at different monitoring areas were much similar. We tried to find a typical 17-Congeners concentration profile of PCDD/Fs in Taiwan ambient air. A factor “  $F-D/D$  ” of the samples was selected for statistics. “F” was the total concentration of PCDFs and “D” was the total concentration of PCDDs. After calculation, the range of 95% confidence interval of normal distribution of this factor was found. We screened all the 160 data by using this interval, and 25 abnormal data out of this interval were found and eliminated. After that, new 95% confidence interval of normal distribution for the 135 normal data ranged from -0.32 to 1.11. Finally, the typical 17-Congeners concentration profile of PCDD/Fs for the 135 normal data in Taiwan ambient air was shown as Fig 4. If we use this interval to check other Taiwan ambient air data that we have got from 1999 to 2000, it also could be worked and easily found the abnormal data.

### Acknowledgments

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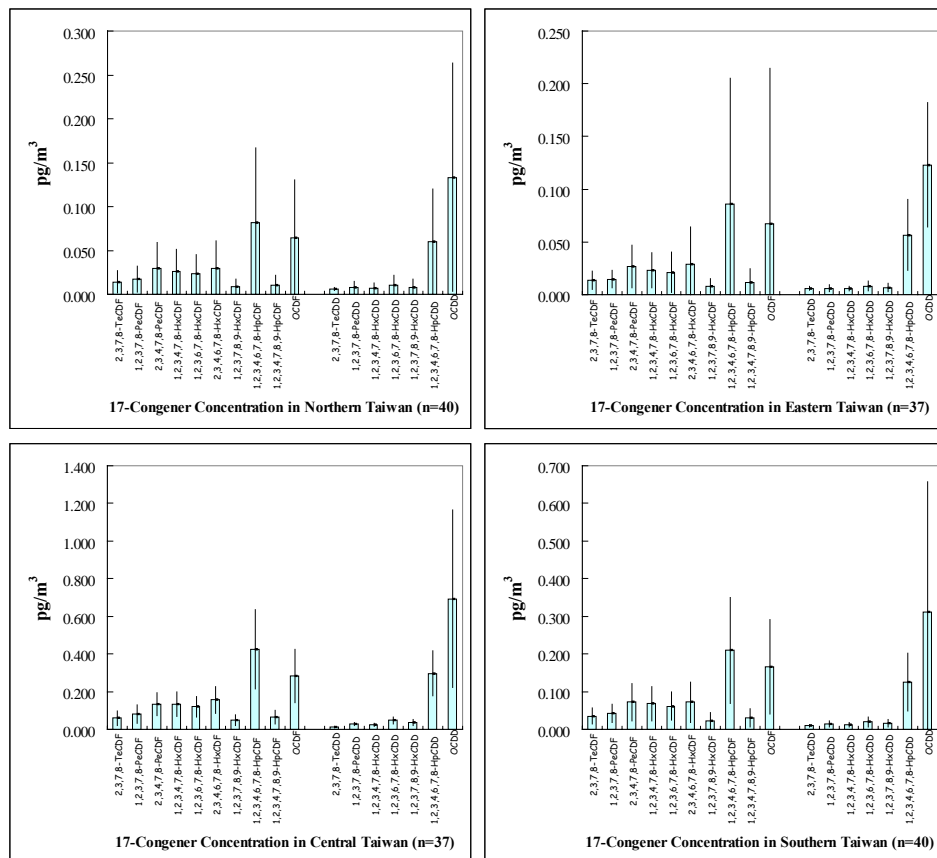


Figure 3 The distribution of 17-Congeners Concentration in Taiwan ambient air

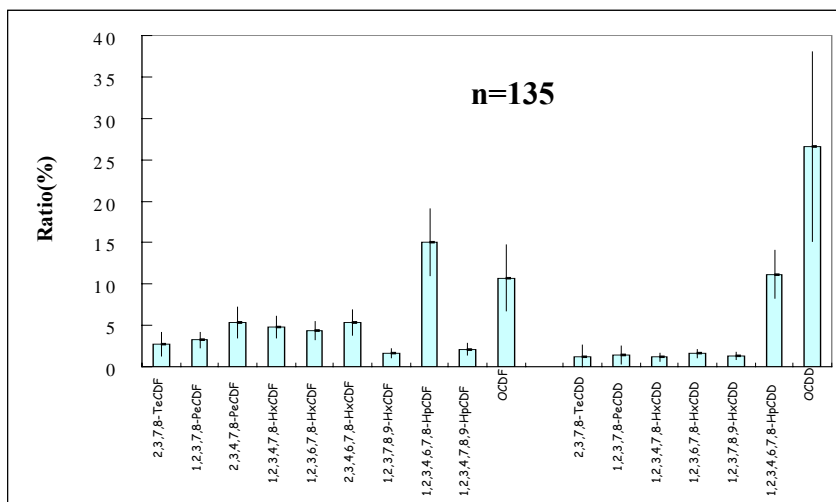


Figure 4 The typical 17-congeners profiles in Taiwan ambient air

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