

# Dioxin '97, Indianapolis, Indiana, USA

## Assessment of Air Pollution by PCDDs and PCDFs in Taiwan Using Banyan Tree Lief as a Biomonitoring Indicator

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### Abstract

Air pollution by PCDDs and PCDFs at 14 locations in Taiwan, Republic of China was evaluated by their accumulation levels in banyan tree lief as an indicator. Consequently, there was a remarkably regional difference in the atmospheric pollution with a level of 0.32 to 3.4 pgTEQ/g wet weight. On the other hand, the contamination levels of both chemicals were compared banyan tree lief with Japanese black pine needle from two locations in Taiwan, showing the level to be similar between the two plants. Therefore, a comparison study was done on this data from banyan tree lief in Taiwan and the data from black pine needle in Japan in order to evaluate a situation of air pollution by PCDDs and PCDFs in Taiwan.

### Introduction

In 1996, we confirmed that the indeciduous Japanese black pine tree (*Pinus thunbergii parlatore*) is one of the most suitable indicator for atmospheric pollution by polychlorinated dibenzo-p-dioxins (PCDDs), polychlorinated dibenzofuran (PCDFs) and non-ortho chlorine substituted coplanar PCBs (Co-PCBs)<sup>1</sup>. Therefore, the air pollution by the three chemicals in various locations in the whole of Japan was evaluated using black pine needle as an indicator<sup>1</sup>. However, no data concerning atmospheric contamination levels of PCDDs and PCDFs have been reported in Taiwan, Republic of China.

In Taiwan, the indeciduous banyan tree (*Ficus microcarpa* L.) grows in the whole

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Table 1 Details of sampling locations of banyan tree lief

Sample No.	Sampling location	Population	Traffic volume	Industrial activity	Sampling spot
1	Taipei District	+	+	-	Residential area
2	Keelung City	+	++	++	Industrial area
3	Taipei District	++	++	++	Residential area
4	Taipei City	++	+	-	Sight-seeing area
5	Taipei City	+++	+++	-	Government office area
6	Hsinchu City	++	+++	+	Commercial area
7	Taichung District		+++		Highway area
8	Taichung City	+++	+++	++	Commercial and industrial area
9	Vunlin District		++		Highway area
10	Chiayi City	++	++	+	Commercial area
11	Tainan District		++		Highway area
12	Tainan City	++	++	+	Residential area
13	Kaohsiung City	++	+++	+++	Industrial area
14	Pingtung City	-	+	-	Sight-seeing area

-: few/small    +: moderate    ++: many/large    +++: a great many/a great large

country. While Japanese black pine can be seen at a limited areas in Taiwan. In this study, we determined accumulation levels of PCDDs and PCDFs in leaf samples of the both plants, showing the contamination levels to be almost equal. From the result, we tried to survey the air pollution using banyan tree leaf as an indicator, and to compare the difference in the pollution magnitude between Taiwan and Japan.

## 2. Experiment

### 1) Sample

About 1 kg of banyan tree lief sample was respectively collected at 14 locations in the whole of Taiwan in November, 1966. The sampling point is illustrated in Fig. 2. In addition, the details of the sampling sites are described in Table 1. On the other hand, about 1 kg of Japanese black pine needle was respectively sampled at the sampling locations of No. 3 (Taipei City) and No. 6 (Taichung District) in Fig. 2 at the same time.

Each sample was cut into a length of ca. 3 cm and then stirred well up.

### 2) Analytical method

After spiking of internal standards (five  $^{13}\text{C}_{12}$ -PCDDs and five  $^{13}\text{C}_{12}$ -PCDFs, each 400 pg; three  $^{13}\text{C}_{12}$ -Co-PCBs, each 500 pg), 50 g of pine needle sample was homogenized with 250 ml of toluene by a ultramixture machine, and then extracted for 5 hrs. under reflux. After addition of silica gel (30 g), each extract was stirred and filtered for removing a bulk

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of chlorophyll. The filtrate was concentrated to less than 0.3 ml, followed by adjusting to a volume of 10 ml with n-hexane. The solution was cleaned up on a multi-layer column and alumina column according to our previous report<sup>1</sup>). The purified extract was dissolved in 20  $\mu$ l of n-decane and analyzed for PCDFs, PCDDs and Co-PCBs in EI-SIM mode at a resolution of 8000 using a Hewlett Packard 5890J gas chromatograph-JEOL SX-102 mass spectrometer according our report described elsewhere<sup>2</sup>).

## Results and discussion

### 1) Comparison on accumulation levels of PCDDs and PCDFs between Japanese black pine needle and banyan tree lief

As shown in Table 2, banyan tree lief and Japanese black pine needle from Taipei City at the same period gave similar accumulation levels of PCDDs and PCDFs. The total actual and TEQ concentrations were 11.4 and 1.15 pg/g wet weight for banyan tree and 7.60 and 1.27 pg/g wet weight for black pine. On the other hand, there was a 1.5 times difference in the total actual level in samples from Taichung District. However, the TEQ concentration was almost the same, showing the level to be 1.67 pg/g in banyan tree and 2.02 pg/g in pine.

Fig. 1 showed the actual concentrations of 2,3,7,8-PCDD and 2,3,7,8-PCDF congeners in both plants. In the samples from Taichung District, the accumulation patterns of both chemicals were remarkably resemble, indicating the major congener to be OCDD for PCDDs and PeCDF for PCDFs. While there was a slight discrepancy in the accumulation patterns of samples from Taipei City. The largest congeners (OCDD for PCDDs and PeCDF for PCDFs) of both chemicals, however, were same in both plants.

From above results, we concluded that the banyan tree lief has comparable accumulation levels of PCDDs and PCDFs to pine needle.

### 2) Whole country survey using banyan tree lief

Fig. 2 showed total TEQ concentrations of PCDFs and PCDDs in banyan tree lief from 14 areas in the whole of Taiwan. As shown in Fig. 2, the TEQ concentration was in a range of 0.5 to 3.4 pgTEQ/g wet weight. The ranges were 0.18 to 2.3 pgTEQ/g for PCDDs and 0.026 to 2.37 pgTEQ/g for PCDFs. The contamination level was remarkably high at urban area with large traffic volume, high industrial activity and/or large population such as Taipei District (No. 3), Hsinchu City (No. 6), Chiayi City (No. 10), Tainan City (No. 12) and Kaohsiung (No. 13). While Pingtung with the reverse conditions showed a low level of 0.5 pgTEQ/g.

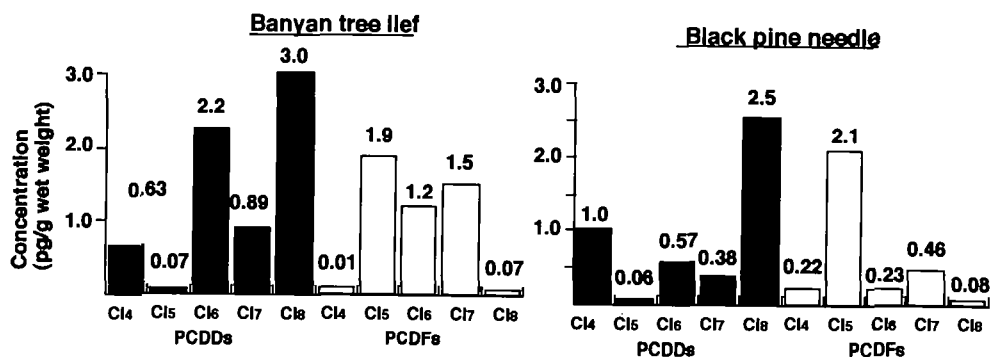
As illustrated in Fig. 2, there was a notable difference in contributions of PCDDs and PCDFs in the total TEQ among surveyed locations. In Kachsiung City with the most heavy pollution, 69% of the TEQ was derived from PCDFs. The region is the highest industrial activity in Taiwan. Therefore, the main contamination source is surmised to be industrial facilities. Thus contamination pattern was seen in Hsinchu City, Taichung City, Chiayi City and Tainan City, all of which have relatively higher industrial activity Table 1). However, such phenomenon was observed in Taipei District (No.1), Taipei City (No. 4) and Pingtung City (No. 14) with no industrial activity. This indicated the pollution source might be attributable to exhaust gas from cars, because leaded gasoline is used in

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Table 2 Comparison of actual and TEQ concentrations of PCDDs and PCDFs in banyan tree leaf and black pine needle samples from two locations

Sampling point	Actual concentration (pg/g wet weight)			TEQ concentration (pgTEQ/g wet weight)		
	PCDDs	PCDFs	Total	PCDDs	PCDFs	Total
<b>Taipei City</b>						
Banyan tree leaf	6.79	4.64	11.4	0.897	0.255	1.15
Black pine needle	4.51	3.09	7.60	1.09	0.177	1.27
<b>Taichung District</b>						
Banyan tree leaf	9.53	11.2	20.7	0.938	0.731	1.67
Black pine needle	12.6	18.6	31.3	0.817	1.20	2.02

## Sampling location: Taipei City



## Sampling location: Taichung District

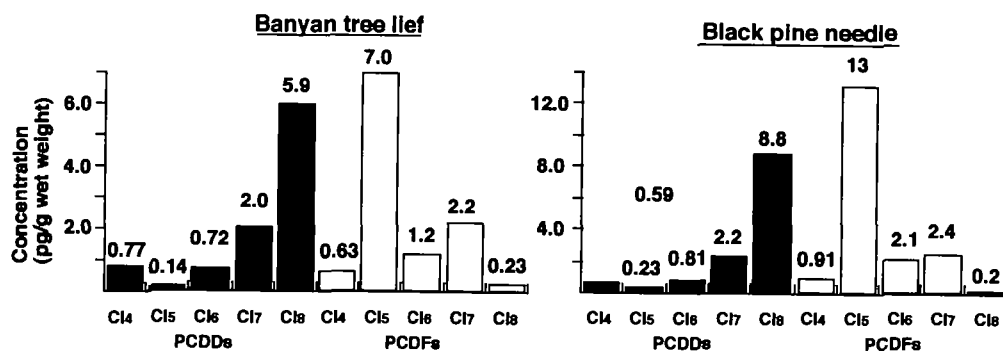
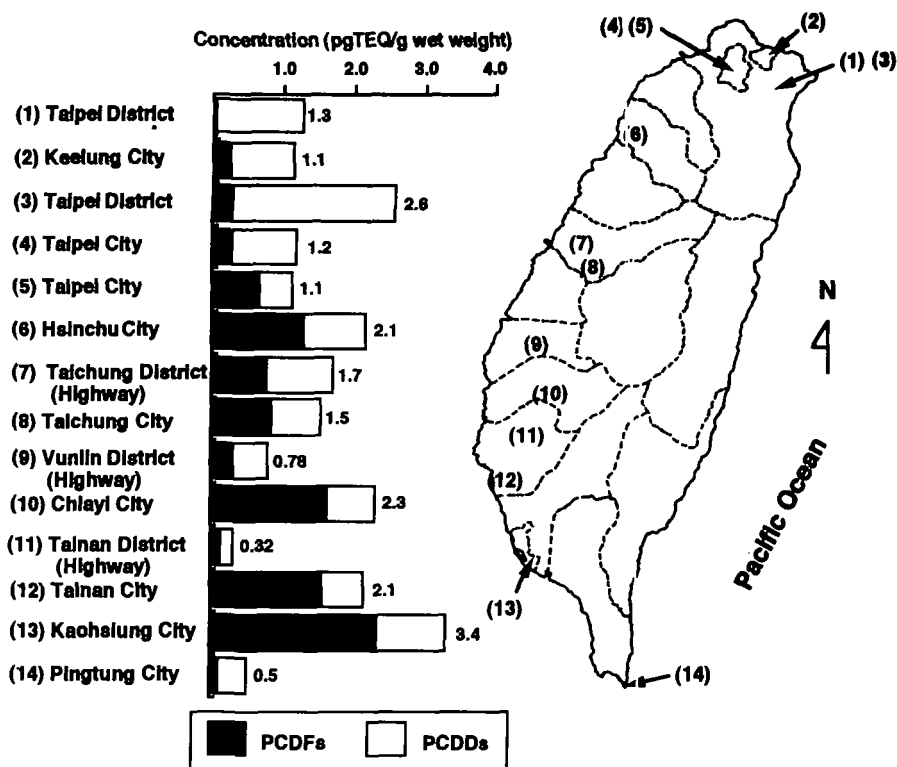


Fig. 1 Comparison of actual concentrations of 2,3,7,8-PCDDs and 2,3,7,8-PCDFs in broadleaf tree and pine needle samples from two locations

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**Fig. 2 Total TEQ concentrations of PCDDs and PCDFs in banyan tree leaf samples from various locations in Taiwan**

Taiwan. From this reason, the contamination was determined two locations in highway area. Consequently, Taichung District (No. 7) with a large traffic volume showed rather high pollution level of 1.7 pgTEQ/g, showing 56% of TEQ to be brought from PCDDs. In fact, thus larger emission of 2,3,7,8-PCDDs than 2,3,7,8-PCDFs was reported by Hagenmaier et al. (1994)<sup>2</sup>. Therefore, the exhaust gas of car is surmised to be main pollution source in the areas with a low industrial activity, due to only a small number of MSW incineration facility in Taiwan.

The accumulation level of PCDDs and PCDFs in black pine needle in Japan was in a range of 0.85 to 11.4 pgTEQ/g wet weight (Fig. 3)<sup>1</sup>. Taking the result into consideration, in general, the air pollution was considered lower in Taiwan than Japan. However, the high contaminated areas such as Taipei City, Hsinchu City, Chiayi City, Tainan City and Kaohsiung City showed remarkably higher pollution than that (0.44 to 1.4 pgTEQ/g wet weight) at local cities in Hokkaido, Iwate, Tottori, Fukuoka and Oita prefectures in Japan.

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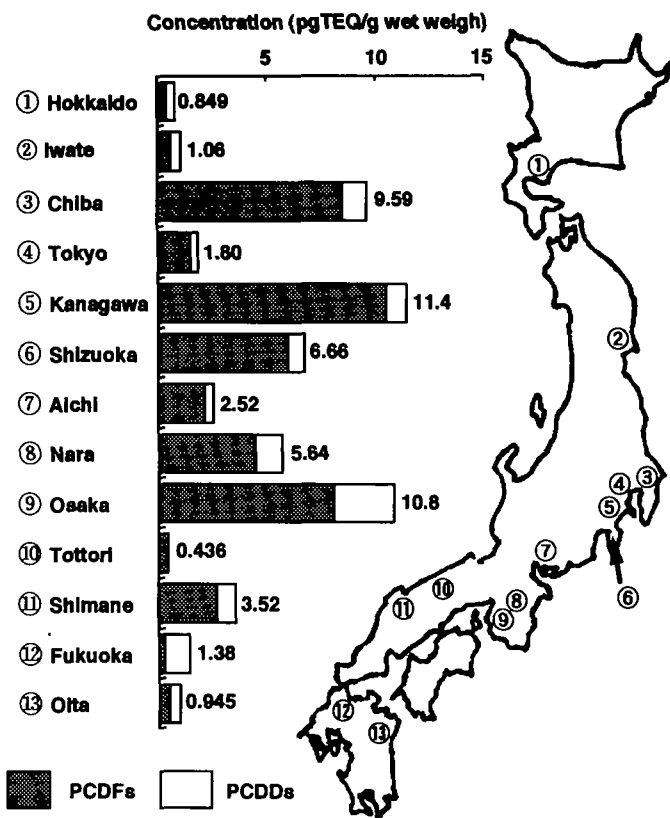


Fig. 3 Total TEQ concentrations (pgTEQ/g wet weight) of PCDDs and PCDFs in pine needle samples in Japan

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