

## The Assessment of PCDD/Fs Discharge from Wastewater of Incineration plant, Pulp and Paper Mill Factory, and Vinyl Chloride Manufactory in Taiwan

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### Abstract

In this study, the PCDD/Fs concentrations in the effluents of 9 representative factories in the incineration plant, pulp and paper mill factory and vinyl chloride manufactory were measured and were within the range from 0.06 to 5.88 pg I-TEQ/L, which were lower than the dioxin discharge regulation standard (10 pg TEQ/L) in Japan. Also, the PCDD/Fs concentrations in the 10 samples of raw wastewater were in the range from 0.13 to 1,292 pg I-TEQ/L. We may obtain: the amount of PCDD/Fs discharged from effluents of the Municipal solid waste incinerators (MSWIs) was 0.0008 g I-TEQ/year; the industrial waste incinerators (IWIs) was 0.0079 g I-TEQ/year; the pulp and paper mill factory was 0.0927 g I-TEQ/year; the vinyl chloride manufactory was 0.0030 g I-TEQ/year in Taiwan.

### Introduction

USEPA points out: there are two main ways that dioxins can enter the food chain and humans; one way is: sources air plants animals; the other way is: sources water/mud water-dwelling animals. The estimates of USEPA about releases of PCDD/Fs from urban runoff to surface water 142g WHO-TEQ<sub>DF</sub> and from rural soil erosion to surface water 2,500g WHO-TEQ<sub>DF</sub> in 2000.<sup>1</sup>

The emission inventory of dioxins was established in Japan, the total dioxins amount of 12.8 g-TEQ was discharged into surface water in 1997, the quantity of dioxins discharged into surface water showed a gradually decreasing pattern. After seven years of effort, the quantity of dioxins discharged into surface water in 2004 was greatly reduced to 2.0g-TEQ in Japan.<sup>2</sup>

In this study, the PCDD/Fs concentrations in the effluents of 9 representative factories in the incineration plant, pulp and paper mill factory and vinyl chloride manufactory were measured, and then the total amount of PCDD/Fs discharged from effluents of these industries was assessed.

### Methods and Materials

In 2006, in Taiwan, there were 22 MSWIs, 72 IWIs, 2 pulp factories, 79 paper mill factories, and 4 vinyl chloride manufactories. In this study, one MSWI, two IWIs, two pulp factories, three paper mill factories, and two vinyl chloride manufactory were chosen for the measurement of PCDD/Fs concentrations in their raw wastewater and effluents. In the gathering of the samples of raw wastewater, the samples were taken from the equalization tank of their wastewater treatment plant. In the gathering of the samples of effluents, the samples were from the discharge points or effluent tanks.

Water samples were collected in pre-cleaned sampling bottles with large volume (about 25L). The amount of water sampled was 25-50 L. After samples were carried back to the laboratory, the pre-treatment will follow the following procedure: water samples will first filter through the glass fiber membrane (Advantec GD-120), then the filtrate will pass through Polyurethane Foam (PUF) to adsorb the trace amount of PCDD/Fs in water with the trapping velocity less than 1.0 L/min, the PUF will put together with the glass fiber membrane in a clean area for air dry, and wait for analysis. Then, the samples were analyzed according to USEPA Method 1613. Samples were analyzed by Agilent 6890N /ThermoFinnigan MAT 95XL above 10000 resolution with 60m × 0.25mm × 0.25µm of DB-5MS. Toxic equivalents as 2,3,7,8-TCDD (TEQ) were calculated by using the international toxicity equivalency factors (I-TEFs). The concentrations of some congeners in some samples will be lower than limit of detection (LOD), the results of these congeners are ND, and TEQ were calculated by using ND = 0.

Due to the fact that it cannot obtain the PCDD/Fs concentrations of all effluents in each industry, the PCDD/Fs releasable coefficient was first determined for a certain industry from the limited data that were actually

measured and then the amount of the PCDD/Fs was discharged from effluents of the industry could be calculated.

### Results and Discussion

Table 1 bears the PCDD/Fs concentrations and treatment techniques in wastewater of the representative factories. Incinerator A was the only one MSWI owned wet scrubber facilities in Taiwan. The PCDD/Fs concentration of its raw wastewater reached 1,292 pg I-TEQ/L; however, the PCDD/Fs concentration of its effluent was substantially reduced to 5.88 pg I-TEQ/L. Incinerator B is a IWI, and its PCDD/Fs concentration in the raw wastewater was quite high (474 pg I-TEQ/L). Based on above findings, it indicates the PCDD/Fs discharges from the wastewater of incineration plants are remarkable. The PCDD/Fs concentrations of the effluents of the pulp and paper mill factories were lower than 10 pg TEQ/L. In the production of pulp, because chlorine-containing compounds were used for bleaching, the PCDD/Fs concentrations of the raw wastewater for the production of pulp were rather high (10.1 pg I-TEQ/L). In Table 1, we can see that the PCDD/Fs concentrations of the raw wastewater of Factory I and Factory J, which were in the production of vinyl chloride, were really high (710 and 648 pg I-TEQ/L, respectively); however, the PCDD/Fs concentrations of the effluents of them were greatly reduced to 0.66 and 0.59 pg I-TEQ/L, respectively. Therefore, we can see that the factories in the incineration plant, pulp and paper mill factory and vinyl chloride manufactory could effectively reduce the amount of PCDD/Fs discharged from effluents with their current wastewater treatment technology and facilities in Taiwan.

In this study, because limited data were actually measured, PCDD/Fs releasable coefficients were used to calculate the amount of PCDD/Fs discharged from each industry. Please refer to Table 2. The PCDD/Fs releasable coefficient for the MSWIs was derived from the measured data of incinerator A. The PCDD/Fs releasable coefficient for the IWIs was derived from the measured data of incinerator C. The PCDD/Fs releasable coefficient for the production of pulp was derived from the average value of the measured data of Factory D and Factory E. The PCDD/Fs releasable coefficient for the production of paper mill was derived from the average value of the measured data of Factory F, Factory G, and Factory H. The PCDD/Fs releasable coefficient for the production of vinyl chloride was derived from the measured data of Factory I. Table 3 illustrates PCDD/Fs discharge amounts were obtained from the PCDD/Fs releasable coefficients for several types of industries in Taiwan. In this study, in terms of amount of PCDD/Fs discharge, the production of paper mill and pulp ranked the top and second. Though PCDD/Fs concentrations of effluents for the production of paper mill and pulp were not relatively high, the amounts of wastewater and activity strength of them were rather high. After calculation, the amount of PCDD/Fs discharged from effluents for the production of the paper mill was 0.0846 g I-TEQ/year; the pulp was 0.0081 g I-TEQ/year; the IWIs was 0.0079 g I-TEQ/year; the vinyl chloride was 0.0030 g I-TEQ/year; the MSWIs was 0.0008 g I-TEQ/year. Compared with the estimated PCDD/Fs released to air about 144 g I-TEQ/year, it contributes very minor portion of PCDD/Fs discharges from effluents of the incineration plant, pulp and paper mill factory and vinyl chloride manufactory in Taiwan.<sup>3</sup>

### References

1. United State Environmental Protection Agency, "The inventory of sources and environmental releases of dioxin-like compounds in the United States: the year 2000 update", March 2005.
2. Japan Environment Agency, "The emission inventory of dioxins in Japan", November 2005.
3. Taiwan Environmental Protection Administration, "Establishing the dioxin emission inventories and its database from 2002-2004 in Taiwan", April 2005.

Table 1 The PCDD/Fs concentrations and treatment techniques in wastewater of the representative factories

No.	Type of industry	Type of production or process	Name of factory	Wastewater treatment technique	PCDD/Fs concentration of raw wastewater (pg I-TEQ/L)	PCDD/Fs concentration of effluent (pg I-TEQ/L)
1	Incineration	MSWI	Incinerator A	Coagulate settling	1,292	5.88
2	Incineration	IWI	Incinerator B	-	474	-
3	Incineration	IWI	Incinerator C	Coagulate settling	3.38	5.19
4	Pulp and paper mill	Pulp	Factory D	Coagulate settling & activate sludge process	10.1	0.42
5	Pulp and paper mill	Pulp	Factory E	Coagulate settling & activate sludge process	10.1	0.16
6	Pulp and paper mill	Sanitary paper	Factory F	Coagulate flotation & activate sludge process	4.57	0.51
7	Pulp and paper mill	Industrial paper	Factory G	Coagulate flotation & activate sludge process	0.13	0.06
8	Pulp and paper mill	Cultural paper	Factory H	Coagulate flotation & activate sludge process	0.79	0.32
9	Vinyl chloride	Vinyl chloride	Factory I	Biological treatment & coagulate settling	710	0.66
10	Vinyl chloride	Vinyl chloride	Factory J	Coagulate settling & biological treatment	648	0.59

Note : “-” means “no sample was sampled”

Table 2 PCDD/Fs releasable coefficients for several types of industries in Taiwan

No.	Type of production or process	Quantity of production or process (metric tons/month)	Quantity of wastewater (m <sup>3</sup> /month)	PCDD/Fs concentration of effluent (pg I-TEQ/L)	PCDD/Fs releasable coefficient (ng I-TEQ/ton)
1	MSWI	18,582	12,900	5.88	4.08
2	IWI	65	85	5.19	6.79
3	Pulp	32,466	2,340,000	0.29	20.90
4	Paper mill	8,017	525,900	0.30	19.68
5	Vinyl chloride	25,000	63,930	0.66	1.69

Table 3 The amount of PCDD/Fs discharged from effluents for several types of industries in Taiwan

No.	Type of production or process	PCDD/Fs releasable coefficient (ng I-TEQ/activity strength unit)	Activity strength (unit/year)	Unit	Amount of PCDD/Fs discharge (g I-TEQ /year)
1	MSWI	4.08	194,697	Per ton of Municipal solid waste	0.0008
2	IWI	6.79	1,166,443	Per ton of industrial waste	0.0079
3	Pulp	20.90	389,592	Per ton of pulp production	0.0081
4	Paper mill	19.68	4,300,000	Per ton of paper mill production	0.0846
5	Vinyl chloride	1.69	1,763,004	Per ton of vinyl chloride production	0.0030