PCDDs/PCDFs EMISSION FROM ENERGY UTILIZATION FACILITIES IN KOREA

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Introduction

After 2001, emission of polychlorinated dibenzo-*ρ*-dioxins/polychlorinated dibenzo-furans (PCDDs/PCDFs) was decreased steadily in Korea. At incineration facilities PCDDs/PCDFs emission decreased rapidly until 2010, but non-incineration facilities did not greatly influence the decrease in PCDDs/PCDFs emission. In Korea, laws to regulate waste management controlled PCDDs/PCDFs emission from incineration facilities were enacted about 20 years ago. However, PCDDs/PCDFs emission from non-incineration facilities has not been controlled since 2007, so increase in industrial activity has resulted in increase in the proportional contribution of non-incineration facilities to Korea's total PCDDs/PCDFs emission. Especially, the proportional contribution from energy utilization facilities (EUFs) has increased steadily, for example from 1% of the total in 2001 to 13% of the total in 2010. PCDDs/PCDFs emission from incineration facilities, steel industrial facilities, and non-metal industrial facilities in Korea are now controlled by the law of Persistent Organic Pollutants Management. PCDDs/PCDFs emission from EUFs is not controlled because it is very low, but despite this low concentration, the proportion of total PCDDs/PCDFs emission by EUFs has increased because in total they emit a huge volume of exhaust (flue) gas. The number of energy utilization facilities in Korea will increase in the future due to the governments'6th electricity supply plan (6-ESP). The base on the present increasing emission ratio and 6-ESP, the PCDDs/PCDFs emission ratio in 2023 will be approximately double that in 2011. Therefore, PCDDs/PCDFs emission from EUFs in Korea should be controlled and managed. In this study, the influence of the sort of fuel and air pollution control devices (APCDs) on PCDDs/PCDFs concentration and emission from EUFs were investigated.

Materials and methods

Facility

Nine EUFs were selected depending on the fuel and APCDs that they use (Table 1). The fuels were liquid nature gas (LNG), bunker C oil (B-C oil), and coal (anthracite, bituminous or both). Each EUF has APCDs of a type that depends on the stipulations of the Clean Air Conversion Act in Korea. EUFs that use LNG are exempt from the requirement to install APCDs. EUFs that use B-C oil have APCDs that remove dust and NO_X. EUFs that use coal have APCDs that remove dust, SO_X and NO_X. None of these EUFs has any special APCD to remove PCDDs/PCDFs, because emission of these chemicals by EUFs is not controlled in Korea

Table 1. Information of the fuel and APCDs in 9 facilities tested

Facility	*Fuel Type*	*APCDs*	*Fuel Use (ton/day)*	*Flue gas (m^3/day)*	*Power (MW/day)*
A	B-C oil	SNCR & SCR – Dry EP	186 (kl/day)	2349072	345
B	LNG	No	664	17719488	3140
C	LNG	Dry Low NOx Burner	819	35204592	3010
D	LNG	No	547	17197474	2610
E	LNG	No	200	5834235	799
F	bituminous	SCR – EP - FGD	4829	40423920	2633
G	bituminous +sewage sludge	SCR – EP - FGD	5067	6936400	12754
H	bituminous +wood pellet	SCR – EP - FGD	5482	51307004	13501
I	bituminous +anthracite	EP - FGD	1411	8319140	2923

Sampling and analysis

PCDDs/PCDFs concentration in flue gas were sampled and analyzed according to the Korean Standard Test Method for Dioxins and Furans (ES 10330.1; Official Method of PCDDs/PCDFs) using a Stationary Source Emissions-High Resolution Gas Chromatograph/High Resolution Mass Spectrometer (HRGC/HRMS). To sample the stack a sampler and gas probe were used and the samples were collected using a glass fiber filter, XAD-2 resin, and absorbed in impingers. To sample the particle phase, the iso-kinetic method (iso-kinetic factor of 95-105%) was used and the sampling amount was > 3 m^3 during 4 h. For analysis the samples were extracted using the soxhlet method and cleanup using a multi-silica gel and alumina column. The concentrated sample after cleanup was analyzed using HRGC/HRMS equipped with an SP-2331 column. Flue-gas constituents such as O_2, CO, CO_2, NO_X and SO_X were measured using electrochemical sensors of a portable gas analyzer every 5 min at the sampling point.

Results and discussion

PCDDs/PCDFs concentration and emission (Table 2) and proportion of 2,3,7,8-substituted congeners (Fig. 1) in flue gas varied among the EUFs, but showed no distinct effect of the type of fuel used. PCDDs/PCDFs concentration was higher in EUFs that use B-C oil than in EUFs that use LNG or coal, except facility G. PCDDs/PCDFs emission was lower from EUFs that use B-C oil than from EUFs that use LNG or coal. Usually, B-C oil is used in small EUFs or boilers; therefore these EUFs emitted less flue gas than did EUFs that use LNG or coal. The 2,3,7,8-substituted congeners in PCDDs/PCDFs emissions differed among the EUFs tests. Specifically, those in EUF A, which that uses B-C oil, were different some different those of EUFs that use LNG or coal. Normally, 2,3,4,7,8-PeCDF and 1,2,3,7,8-PeCDD are dominant compounds in EUFs that use combustion process. However, in the EUF that uses B-C oil 2,3,4,7,8-PeCDF and 2,3,7,8-TCDD were the dominant compounds. In the facilities that use LNG, PCDDs/PCDFs concentration was high in those that used much LNG or that had small capacity. In these LNG facilities, the relative proportions of 2,3,7,8-substituted congeners were similar; 2,3,4,7,8-PeCDF and 1,2,3,7,8-PeCDD were dominant compounds. However, the proportion of 2,3,7,8-TCDD in facility B was higher than in facilities D, E and F. In the EUFs that use coal, the effect of coal type on the relative concentrations could not be compared, but the relative proportions of 2,3,7,8-substituted congeners were similar; 2,3,4,7,8-PeCDF and 1,2,3,7,8-PeCDD were dominant compounds. The presence of selective catalytic reduction (SCR) increased PCDDs/PCDFs emission. Facility I does not have an SCR; this facility had the lowest PCDDs/PCDFs emission but the highest NO_X emissions. These results occur because the SCR removes NO_X but not PCDDs/PCDFs. Although the facilities F, G and H use the same APCDs, PCDDs/PCDFs concentration was lower in facility H was than in facilities F and G. Also, the CO concentration in flue gas was zero from facility I, but 10.2 ppm from facility F and 38.5 ppm from facility G; these results suggest that that the combustion conditions in facilities F and G are not good. Moreover, it could be guess that the sewage sludge using as fuel in facility G was affected on the combustion conditions. In 2001, PCDDs/PCDFs emisssion from EUFs totaled 8.5 g I-TEQ/y (<1% that of incineration facilities) but in 2011, PCDDs/PCDFs emisssion from EUFs totaled 12.2 g I-TEQ/y (~29% that of incineration facilities). Therefore, although PCDDs/PCDFs concentrations of EUFs are very low, a method to remove PCDDs/PCDFs from the emission of EUFs should be considered. If PCDDs/PCDFs can be controlled as hazardous air pollutants in the Clean Air Conversion Act, PCDDs/PCDFs emission from non-incineration facilities such as EUFs can be decreased greatly in Korea.

Table 2. PCDDs/PCDFs concentration and emission of the facilities tested

		Facility								
		A	B	C	D	E	F	G	H	I
Conc.	pg/m^3	7.07	2.42	4.71	3.94	5.02	6.75	13.25	2.30	3.75
	pg I-TEQ/m^3	0.63	0.36	0.46	0.30	0.97	0.96	1.83	0.23	0.24
Emission	μg/day	16.62	42.85	165.78	69.85	29.30	272.98	754.52	69.30	31.23
	μg I-TEQ/day	1.48	6.29	16.27	5.26	5.64	38.69	104.36	6.92	2.01

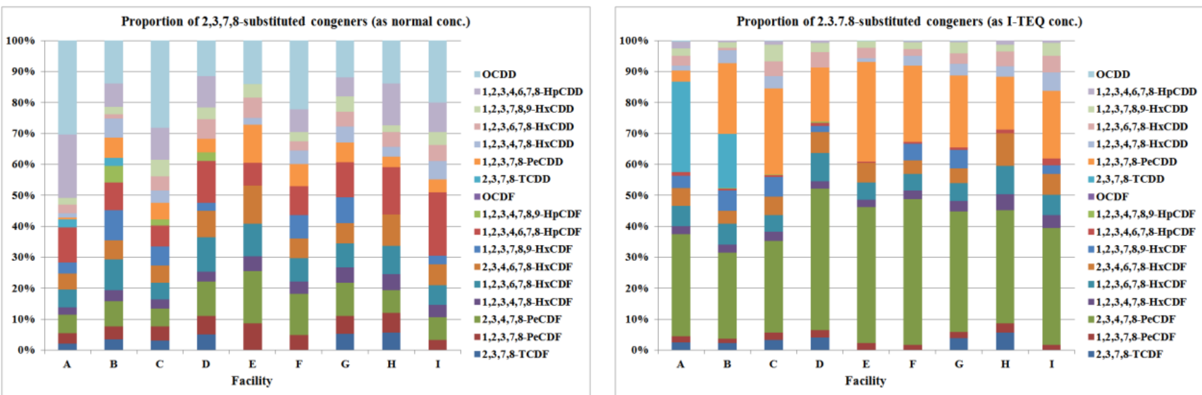

Fig. 1. Proportions of 2,3,7,8-substituted congeners in the facilities tested.

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