Estimation of emission factors for PCDD/Fs and Co-PCBs emitted from uncontrolled incineration of waste wood (construction/demolition) and domestic waste

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Introduction

POPs including PCDDs, PCDFs and Co-PCBs are emitted to environment as unintentional by-products formed by various industrial activities according to development of technology. POPs have high toxicity, and they persist for long periods of time in the environment and can bio-accumulate from one species to the next through food chain. They can be transported to long distance, so they can affect far from where they are used and released.
Movement to reduce the amount of POPs emitted and to control them with an international co-management system has been engaged in many countries since "Stochholm Convention for Persistent Organic Pollutants" has been adopted on 2001.
In many countries including Korea, there are enough researches about emission factors(EFs) and activity factors(AFs) on 'point sources' such as waste incineration, ferrous and non-ferrous metal production, power generation/heating and etc. However, there is no sufficient data for establishment of EFs and AFs about non-point sources such as small combustion facilities, accidental fires, and uncontrolled combustions.
For non-point sources, EFs of PCDD/Fs and Co-PCBs into air are difficult to estimate because variable factors like sample composition, quality for incineration, combustion conditions, and sampling method make it hard to determine objectively.
From the results of previous studies about these problems, several methods - for examples, sampling of ambient air around fires, direct sampling of emission gas, and sampling by simulation facilities - are suggested to estimate the amount of PCDD/Fs and Co-PCBs in open-burning system. In this study, Sampling method by simulation facilities is selected among them because it was possible to control conditions of incineration and measurement, and expected to bring an appropriate comparison between each result.
Therefore, in this study, a flux chamber was set to simulate an open-burning of waste wood(for construction/demolition) and domestic waste by incineration. And using the results, PCDD/Fs and Co-PCBs isomer patterns of open-burning would be compared with those of three MSWIs, and the effective emission factors should be suggested.

Table 1. The characteristics of test samples in this study

Classification	Sample name	Composition	Start Mass Kg	Final Mass Kg	Mass burned %	Volume of Inlet air Sm^3
Waste Wood (Construction/ Demolition)	A-1	Lumber 60%, Others 40%	22.0	0.7	96.8	718.0
	A-2		22.0	0.6	97.2	772.8
	A-3		22.0	0.6	97.2	1397.1
Household Waste	B-1	Paper 85%, Plastics 10%, Others (Wood, Lubber, Garbage and etc) 5%	20.0	4.7	76.5	1426.2
	B-2		20.0	4.7	76.5	1759.0
	B-3		20.0	3.0	85.0	1742.9

Material and Methods

For the simulation test for open-burning, we selected two samples; household waste and waste wood from construction/demolition. The open-burning simulation facility (OBSF) was a chamber with a 3.5 x 2.5 m floor area and a sloping roof with a min. height of 1.9 m and a max. height 2.2 m. The combustion air was supplied into the chamber through right and left side of floor, and the 180 L steel barrel which has holes at the base of it for air located in the center of chamber. The canopy hood was installed over the drum for regulation of air flow.
The characteristics of samples and experimental conditions were summarized in <Table 1> and the diagram of OBSF was shown in <Fig. 1>.
Prior to burning, approximately 20Kg of waste was weighed and set alight using a propane touch which is reported on dioxin-free. During incineration, PCDD/Fs and Co-PCBs were sampled using a Low Volume Air Sampler which was

designed to comply with EPA's ambient sampling method TO-9. We operated this sampler at approximately 40L/min and the sampling was done for about 1.5 hours.
The GF filter and PUFs removed from LVAS were wrapped with aluminum hoil, kept in cold and dark storage box, and carried to a laboratory. For PCDD/Fs and Co-PCBs analysis, they were extracted with Methylene Chloride by soxhlet apparatus, and cleaned-up by multi-layer silica-gel, alumina oxide(basic), and activated carbon-impregnated silica-gel in order. Cleaned-up samples were analyzed using HRGC/HRMS(Autospec Ultima. U.K).

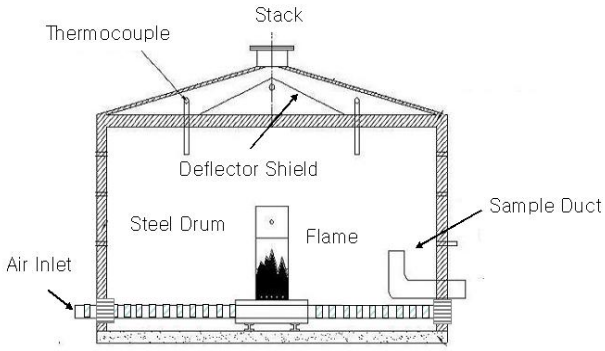

Fig. 1. Diagram of Open-burning simulation

Results and Discussion

<Table 2> illustrated the results of the PCDD/Fs and Co-PCB TEQ values which were collected by simulation test of open-burning of Waste Wood and Domestic Waste. For waste wood, Average value of PCDD/Fs and Co-PCBs was 0.215 ng WHO-TEQ/m^3 and 0.026ng WHO-TEQ/Sm^3 respectively. Also, for domestic waste, average value of PCDD/Fs was 0.091 ng WHO-TEQ/m^3 and that of Co-PCB was 0.004 ng WHO-TEQ/m^3. This result shows that average TEQ value of waste wood was higher than that of domestic waste
The isomer pattern of 2,3,7,8-Cl substituted PCDD/Fs and Co-PCBs in open-burning was compared with general MSW incineration. As shown in <Fig. 2>, the value of TeCDF and PeCDF isomers from open-burning was relatively higher than that from MSWIs with air pollutants control system.
This study was conducted by 3 times in each sample, so it was difficult to generalize the pattern of the 2,3,7,8-Cl substituted congeners from open burning, however, the results from same category were reflected the similer isomer patterns as shown in <Fig. 2>. The reason of the isomer pattern's charicteristic may be assumed that the case of open burning is sampled directly without the reducing mechanism in the pollution control facilities.
In the result of Standardized TOOLKIT[4] reported by UNEP, they were used that an EF from uncontrolled domestic waste burning is 300 ng TEQ/kg, and an EF from open burning of wood (construction/demolition) is 60 ng TEQ/kg . M Lemieux[1] was reported that the EFs for PCDD/Fs and Co-PCBs of uncontrolled domestic waste burning be 76.8 ng-TEQ/kg and 1.34 ng-TEQ/kg, respectively. And also, Brian Gullett[3] was reported that the range of EFs for PCDD/Fs was 14-47 ng-TEQ/kg and 1-56 ng-TEQ/kg from biomass open burned. In generally, EFs can be calculated in terms of

Table 2. PCDD/Fs and Co-PCBs concentration of air and estimated emission factors

Classification	Sample name	Concentration ng WHO-TEQ/Sm^3			Emission Factors kg WHO-TEQ/kg waste		
		PCDD/Fs	Co-PCBs	PCDD/Fs + Co-PCBs	PCDD/Fs	Co-PCBs	PCDD/Fs + Co-PCBs
Waste Wood (Construction/ Demolition)	A-1	0.176	0.048	0.224	5.74	1.57	7.31
	A-2	0.205	0.020	0.225	7.17	0.70	7.87
	A-3	0.264	0.010	0.274	16.77	0.76	17.53
	average	**0.215**	**0.026**	**0.241**	**9.89**	**1.01**	**10.90**
Household Waste	B-1	0.120	0.007	0.126	8.56	0.50	9.06
	B-2	0.067	0.003	0.070	5.89	0.26	6.17
	B-3	0.087	0.002	0.089	7.58	0.17	7.76
	average	**0.091**	**0.004**	**0.095**	**7.34**	**0.31**	**7.66**

pollutant mass, Volume of inlet air and biomass burned as followed;

$EF = C_{sample} \times V_{inlet} \div m_{burned}$

where, EF : Emission Factor (ng-TEQ/kg)
C_{sample} : TEQ Concentration (ng-TEQ/m^3)
V_{inlet} : Volume of inlet air (m^3)
m_{burned} : Weight of burned material (kg)

<Table 2> showed the estimated EFs for PCDD/Fs and Co-PCBs which can be expected by calculation. The average EFs for waste wood and domestic waste were estimated to 10.90 ng TEQ/kg and 7.66 ng TEQ/kg, respectively. When comparing these EFs with those from other researchers', the EFs of PCDD/Fs and Co-PCBs could be different between each other by the variation of waste composition, waste quality as well as sampling method.
In addition, we should acquire relatively low EFs in this study because the combustion efficiency and conditions of samples would be better than that of actual open-burning. For objective generation of EFs, it has been suggested that the detached sampling method be offered for comparison between data acquired from various ones, and that waste composition and combustion conditions be summarized with EFs

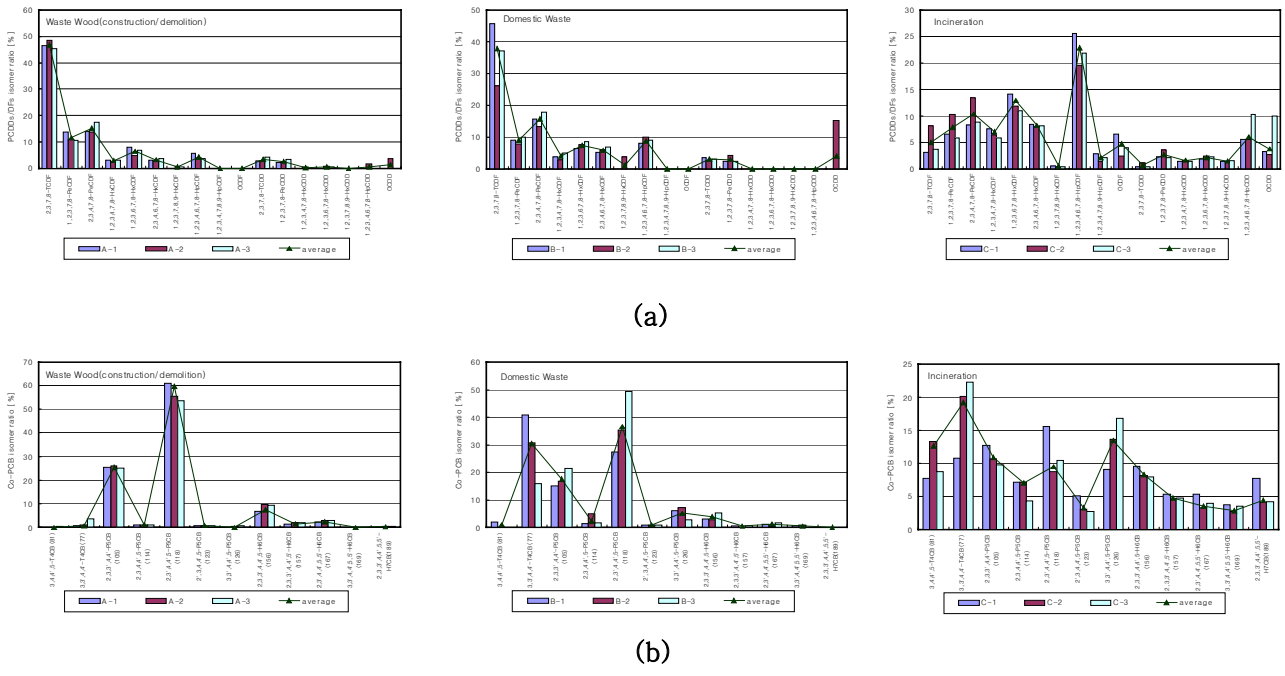

Fig. 2. The comparison of isomer specific patterns of PCDD/Fs and Co-PCBs between samples from open-burning and MSWIs : (a) PCDD/Fs, (b) Co-PCBs (left – waste wood, center – Domestic waste, right – emission gas)

References

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