Evaluation of an industrial waste incinerator on the PCDD/Fs levels by measured and modeled data

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Introduction

The influence of emissions of polychlorinated dibenzo-*p*-dioxins and dibenzofurans (PCDD/Fs) from waste incinerators is a hot environmental issue in Korea. Mainly due to the limit of landfill sites, the Korean government has increased the contribution of incineration from 5.5% in 1996 to 14.5% in 2003.[1]The first national survey of PCDD/Fs emissions from incinerators was launched in 1997[2], and only a few studies have been conducted on PCDD/Fs levels in the environment near the incinerators.

In our previous study[3], we measured PCDD/Fs in various environmental samples such as stack gas, ambient air, soil, water, pine needle, and rice plant near an industrial waste incinerator. Additionally, another research group in Korea also measured PCDD/Fs concentrations in 47 soil samples at the same area.[4]These two research groups concluded respectively that the influence of the incinerator was clearly shown from the comparison of congener patterns of PCDD/Fs. However, these studies focused only on the levels and patterns of PCDD/Fs in soil or air with distance from the incinerator to elucidate the source effect, and there was no in-depth consideration of atmospheric dispersion and multimedia environmental effects for the quantitative evaluation of the incinerator to the total PCDD/Fs levels in various environmental media. Therefore, in this study, we compared the level of PCDD/Fs between measured and modeled data. With these results, the influence of the incinerator could better be assessed in the quantitative aspect.

Methods and Materials

Study area

The industrial waste incinerator was located in a rural area of Pyongtaek, Korea. Our study area was within 5 Km from the incinerator (Figure 1). Actually, there were two waste incinerators in the study area: One incinerator with a capacity of 0.8 ton/h was operated between 1998 and 2001, and the other with a capacity of 3 ton/h started its operation in 2001. Accordingly we focused on the current emission state from the second incinerator.

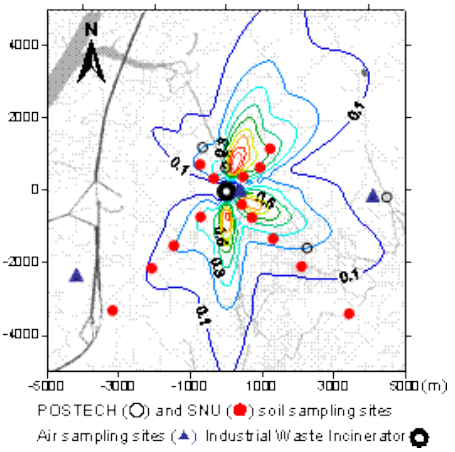
PCDD/Fs modeling

To examine the spatial distribution of PCDD/Fs in air, which are emitted from the incinerator, and its relation to the levels of PCDD/Fs in soil, the industrial source complex (ISC3) dispersion model, steady-state Gaussian plume model, was used. Data for stack (emission rate, height, exit temperature, exit speed, diameter) and meteorology (wind speed, wind direction, temperature, atmospheric stability, mixing height) for 2002 were used as input parameters.

For the comprehensive understanding of overall fates of PCDD/Fs in the study area, a fugacity-based multimedia environmental model (level III model, Trent University) was applied. The model assumes the steady state distribution of PCDD/Fs in a closed environment. Therefore, the most important factor affecting the fate of chemical is the emissions. As a model chemical for a preliminary study, octachlorinated dibenzo-*p*-dioxin (OCDD) was selected for the model calculation. A more detailed description of the model can be found in the website of the Canadian Environmental Modeling Center: http://www.trentu.ca/cemc/models/L3280.html.

Results and Discussion

The previous study mentioned the use of ISC3 for the determination of soil sampling sites[4], however there was no detailed information on the model results and the comparison between measured and modeled data. According to our simulation, northeastern, southeastern, and southern areas from the incinerator could be major receptors of PCDD/Fs (Figure 1). The influence of incinerator seems to be high within 2 Km. We compared the measured PCDD/Fs data in soil (pg/g)[4] with the modeled ones in air (pg/m^3) as shown in Figure 2. There is a bimodal pattern of total PCDD/Fs in modeled air concentrations, while large variations in soil concentrations are observed, resulting in a difficulty to find a decreasing pattern of total PCDD/Fs with distance from the incinerator. All sampling sites in Figure 1 were not open fields but rice fields after harvesting. Therefore, they probably did not directly reflect the short-term deposition pattern of PCDD/Fs. In addition, the reason for unexpectedly high levels of PCDD/Fs may be due to the local contamination by agricultural activities such as open burning and the past use of pentachlorophenol pesticide.[4]



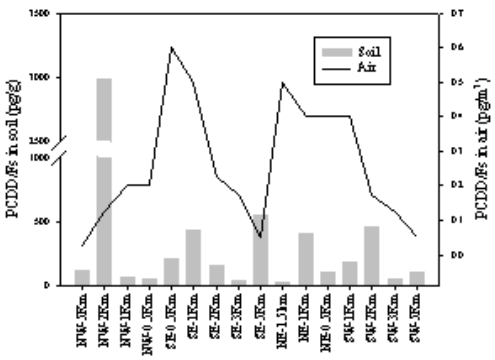


Figure 1. Sampling sites and result of dispersion model (ISC3) for 2002

Figure 2. Measured PCDD/Fs levels in soil[4] and modeled ones in air by ISC3

The results of multimedia environmental modeling for OCDD are shown in Figure 3. There are four environmental compartments (air, soil, water, and sediment), but only air and soil are our concerns considering both the number of samples and measured levels of PCDD/Fs.

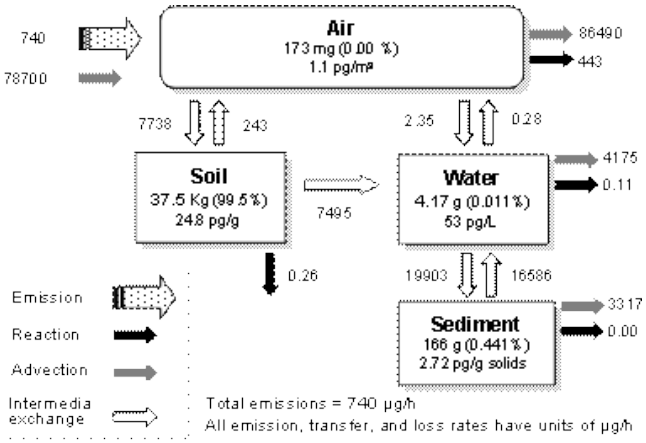


Figure 3. Diagram of the fate of OCDD in the multimedia environment

We assumed that there were no PCDD/Fs emissions to soil, water, and sediment. The emission sources to air in

this study area were the incinerator and advective inflow. In the first modeling, the emission rate into air from the incinerator (740 µg/h) was only considered. However, the modeled levels of OCDD in air and soil were two orders of magnitude lower than the measured ones, implying that the incinerator was not a sole PCDD/Fs source. After the average OCDD levels in air was used as the input value of advective inflow, comparable modeled data to measured ones could be obtained (Table 1).

Table 1. Comparison between measured and modeled OCDD ( ) average

	Measurement (2002)	ISC3 (2002)	Level III
Air[3]	0.6-1.5 (1.0) pg/m^3	0-0.19 (0.03) pg/m^3	0.01-1.1 pg/m^3
Soil[3,4]	8.1-220.0 (76.9) pg/g	-	0.2-24.8 pg/g
Water[3]	4.9 pg/L	-	0.0-53.0 pg/L

Our results from two different models indicate that there might be other PCDD/Fs sources near the study area and the inflow of polluted air from other regions is likely to be a more significant factor than this incinerator for the total levels of PCDD/Fs in air and soil. Even though the influence of the incinerator in the study area was suggested by previous studies[3,4], its quantitative effect could be much smaller than the former expectation. For the more reliable evaluation, additional modeling for all 2,3,7,8-substituted congeners along with uncertainty analysis will be followed.

Acknowledgements

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