Monitoring of Polychlorinated Divenzo-p-Dioxins and Dibenzofurans in soil in the proximity of incineration plants

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Introduction

Incineration is a frequently used technology for the final disposal of municipal or industrial solid waste. At the same time, the incinerators are major source for dioxins into the environment. Among these, polychlorinated dibenzo-p-dioxins (PCDDs) and polychlorinated dibenzofurans (PCDFs) are of special concern because of its toxicity to living organisms. PCDDs/Fs emitted from these sources are entering into the environmental boundaries, and then distributed in soil, vegetation, water, biota, etc. As a result, human health can be affected through different pathways. In Korea, the interest on the PCDDs/Fs by the scientific community has been increased a great deal over the several years, and survey for making inventory of the emission level is also in progress. This study is a part of the investigation of environmental level of PCDDs/Fs under the support of National Institute of Environmental Research (NIER). In the present study, soil was selected to monitor the level of PCDDs/Fs, because the concentration and the congener profiles of PCDDs/Fs in soil are almost not much fluctuated with day-to-day changes. In order to assess the potential impact of these chemicals on the environment, the soil samples were collected in the vicinity of large sized incinerators (~200 Ton/day) and analyzed for PCDDs/Fs.

Methods and Materials

A total number of 157 soil samples were collected at 25 locations from the 6 selected incinerator area as shown in Figure .1 Sampling points were selected according to considerations on the prediction of the time-averaged emission plume behavior obtained from a Gaussian model (Industrial Source Complex, ISC 3). The samples were air-dried and manually ground before the Soxhlet extraction (for 20hr with distilled toluene). The crude extracts obtained were then subjected to cleaned-up procedures in order to remove the impurities as follows; H_2SO_4 treatment, silica gel column, alumina column and activated carbon column. The final concentrated samples were spiked with ^{13}C-labeled recovery standard before HRGC/HRMS analysis. Purified PCDDs/Fs extracts were separated using DB-5 column (60 m × 0.25 mm ID, 0.25 μm).

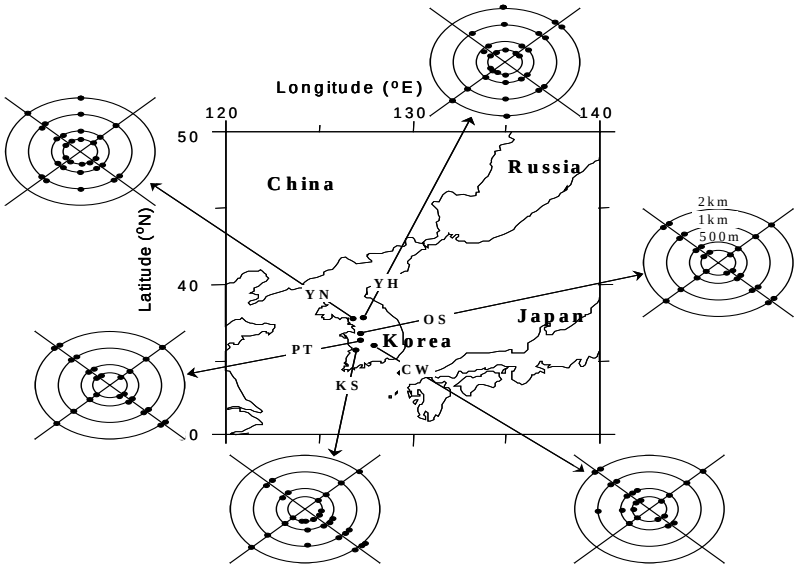

Figure 1. Diagrammatic view of Korean peninsula and the location of sampling points at each city. (Large size incinerators are located in center of each circle).

Results and Discussion

The study presents the result of seventeen most toxic congeners of PCDDs/Fs present in the soil. The total concentration of PCDDs/Fs was estimated about 7803~3.0pg/g dry weight(dw) with a very large fluctuation. The mean concentration of total PCDD/Fs in the 157 samples was 705pg/g (dw) and the median value was 126pg/g dw. The mean total concentration of PCDDs/Fs in the 6 area (YH, YN, PT, CW, GS, OS), were 1711, 260, 606, 25, 199, and 1211pg/g (dw), respectively. The toxic equivalent (TEQ) calculated based on the international toxic equivalent factor (I-TEF) ranged about 35.4~0.1pg I-TEQ/g (dw) with an average concentration of 3.7pg I-TEQ/g (dw). Although a large fluctuation of total PCDDs/Fs were observed, the profiles of the isomer were very similar in the all samples. The most abundant congener observed in the study was OCDD and it was accounted about 71% of the total PCDD/Fs. In addition, 1,2,3,4,6,7,8-HpCDD, 1,2,3,4,6,7,8-HpCDF, OCDF were also predominantly present in the soil (Fig. 2b).

It was also reported that MSWI, industrial oil fired boilers, use of unleaded gasoline, and diesel fuel combustion contributes higher amount of OCDD than other congeners[2,3]. Alcock et al.(1999) reported that congener profiles of different incinerators including MSWI, chemical waste, cement kilns, sinter pant and sewage sludge were quite similar and OCDD, 1,2,3,4,6,7,8-HpCDD dominated followed by 1,2,3,4,6,7,8-HpCDF and OCDF.

Table 1. Concentration of PCDDs/Fs in each area (pg/g, dry weight basis)

PCDD/Fs	YH(n=30)	YN(n=28)	PT (n=24)	CW (n=24)	GS(n=27)	OS(n=24)	Overall(n=157)
Range	7258~42	1740~14	3844~30	73~3.0	774~9.3	7803~12	7803~3.0
Mean (Std.devi.)	1771(2231)	260(465)	606(884)	25(18)	199(210)	1211(1831)	705(1410)
Median	618	58	261	24	102	295	126
I-TEQ PCDD/Fs							
Range	35~1.0	5.6~0.1	7.5~0.3	1.5~0.1	17~0.2	18~0.1	35~0.1
Mean (Std.devi.)	8.4(7.7)	1.5(1.4)	2.8(2.1)	0.6(0.5)	3.2(4.2)	4.5(4.5)	3.7(5.0)
Median	5.8	0.9	2	0.4	2.1	2.8	1.6

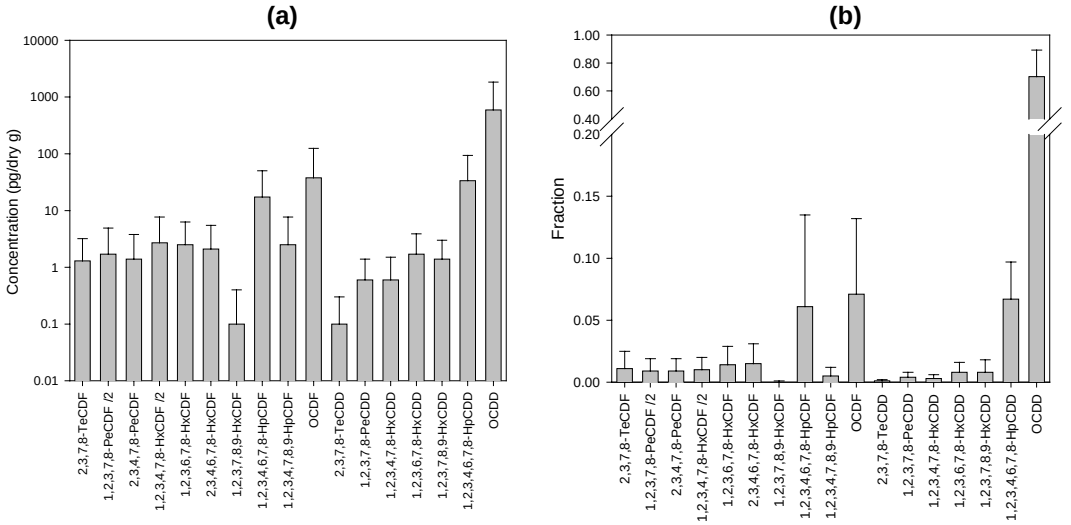

Figure 2**. (a) The average concentration and (b) congener profiles of PCDD/Fs in soil samples collected near the large size incinerators**

Figure 3 illustrates the results of correlation analysis of different congeners. The degree of Pearson correlation coefficient was indicated with varying symbol size. The spatial distribution of total PCDD/Fs concentration was either not related with predominant wind direction or the distance with the incinerator. Possible reason for these low-correlation between sampling site and the concentration could be due to the effect of sporadically available small size incinerators or from any other emission sources. Result in correlation analysis, less chlorinated congeners correlated with less chlorinated congeners and highly chlorinated congeners correlated with highly chlorinated congeners.

In summary, the results of the present investigation showed that incineration is responsible for the presence of chlorinated PCDDs/Fs congeners in soil. The finding of the study also reveals that there should be some unidentified sources that may also contribute few chlorinated PCDDs/Fs in the soil. Hence, the emissions from the large size incinerators not only responsible for the presence of PCDDs/Fs in soil but the sporadically available small size incinerators also contributes significant amount of PCDDs/Fs in soils.

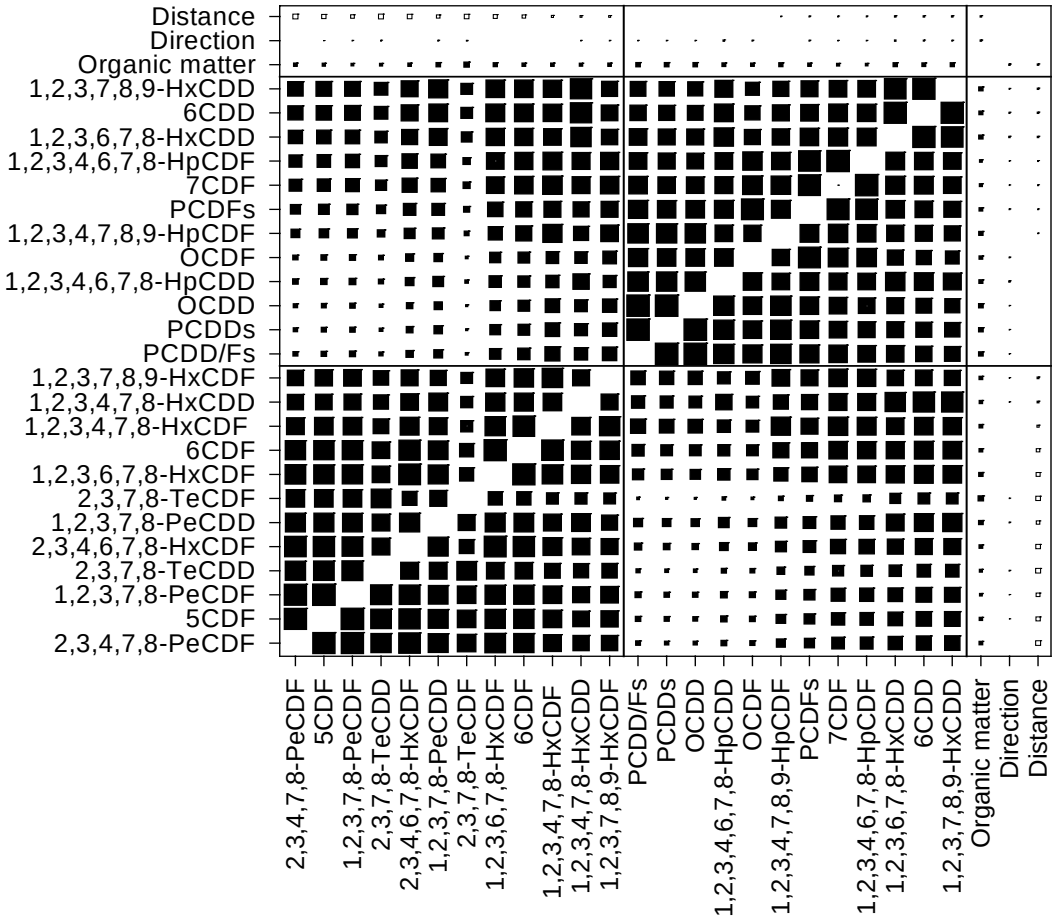

Figure 3. Result of correlation analysis between congeners and spatial parameter. The sizes of symbols are proportional to the Pearson correlation coefficient. Solid symbols denote a positive correlation and open symbols denote a negative correlation.

References

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