Patterns of dioxin in blood for the residents and workers of the MSWI, Korea

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Introduction

Polychlorinated dibenzo-p-dioxin (PCDDs) and polychlorinated dibenzofurans (PCDFs) are toxic chemicals that persist in the environment (Yang et al., 2002; Schecter et al., 1998; Patandin et al., 1999). Moreover, because human beings are at the top of food chain, a relatively high level of these compounds can be found in human adipose tissues, blood lipids, and breast milk fat (Yang et al., 2002; Iida et al., 1999; Noren and Meironyte, 2000).

The main pathway of PCDD/PCDFs into the environment is via the combustion processes (Domingo et al., 2000). PCDD/PCDFs are transported from incinerator emission to environmental media such as air, soil, and water, and then into exposure media such as drinking water, food, and vegetation. Monitoring PCDD/F levels and congener distribution patterns in various environments has attracted much attention from environmental researchers, who have established methods for evaluating the exposures of humans and the environment (Schecter et al., 1991; Schuhmacher et al., 1999; Thomas et al., 2002). Different sources of PCDD/Fs can be usually characterized by their different congener patterns (Lohmann and Jones, 1998; Wehrmeier et al., 1998). Principal components analysis (PCA) is a technique for forming new variables, which are linear composites of the original variables. The maximum number of new variables that can be formed is equal to the number of original variables, and the new variables are uncorrelated among themselves (Oh et al., 2002).

In Korea, the number of municipal and hazardous waste incinerators have increased since 1980. In addition, municipal waste incinerators are almost always located in residential areas. Therefore, the human health risks caused by dioxin is become an increasing public concern in Korea. The aim of this study was to assessed and compared the patterns and sources of PCDDs/PCDFs in blood from individuals living in the vicinity area of the MSWI (Municipal Solid Waste Incinerator), workers at the MSWI and general population living in the urban area not including the MSWI using Principal Component Analysis (PCA).

Materials and Methods

The blood samples were obtained between 2002 and 2004 from volunteer workers of the MSWI and residents living near to the MSWI in urban area of Korea. The MSWI worker group was 31 employees (average 4.7 years of working durations) at the MSWI in urban area and the residents group was 68 vicinity residents living at distance < 300m from the MSWI for at least 5 years. For background exposure, the general group was 11 adults living in the urban area not including the MSWI. The participants answered a detailed questionnaire regarding the sociodemographic variables, lifestyle, possible exposure through occupational and non-occupational contact the locations of their former and present residences, and their food intake patterns.

About 150ml of Blood was collected without anticoagulant, centrifuged to remove cells, and frozen. The quantitative assessment of the dioxin levels in blood was analyzed by high-resolution gas chromatography and high-resolution mass spectrometry (HRGC-HRMS) according to the US EPA 1613 method. The School of Environmental Engineering, Pohang University, conducted the instrumental analysis and the Fisheries & Oceans Laboratory of Canada collaborated with our teams in the quality assurance/quality control (QA/QC) program. PCDDs/PCDFs concentrations were reported as picograms TEQ/g lipid (pg TEQ/g lipid). Toxic equivalents (TEQ) were calculated using the toxic equivalent factors (TEFs) established by WHO in 1998.

In order to evaluated the dioxin sources in blood of the subjects, we was gathered data from known sources, such as stack gas and flay ash, dust and bottom ash of MSWI, ambient air and ground soil, and foods. This study cited papers as well as technical reports on the dioxin concentrations in the environmental media and foods in Korea to estimate the dioxin levels in the environmental media and foods.

To evaluate similarities or differences of PCDD/PCDFs congener pattern in eachsample, all data were normalized to the total sum of 'PCDDs + PCDFs = 1'. Data matrices were evaluated through principal component analysis (PCA), which is a multivariate analysis technique for dimension reduction (Simca, 7.0). PCA was used to examine similarities and differences in the multivariate mixture of PCDD/Fs in the samples. The correlation matrix tests were performed on calculated statistical software (SAS 8.0 for Windows) at a 95% confidence levels.

Results and Discussions

The average ages of the subjects were 40 years old, 49 years old and 37 years old, respectively, the MSWI workers, the vicinity residents of the MSWI, and general population. The percentages of smoker were 58%, 13%, and 18%, respectively, in the MSWI workers, the vicinity residents, and general population. There was no significant difference in weekly food consumption patterns. The detection ranges of dioxin in blood were 2.09–66.67 pg/g lipid, 1.00–29.33 pg/g lipid, and 5.29–35.93 pg/g lipid for workers, vicinity residents and general population, respectively. In blood of workers and residents, 2,3,4,7,8-pentachlorinated dibenzofuran (2,3,4,7,8-PeCDF) was approximately 50% to PCDDs/PCDFs TEQ concentration and was most predominant among the PCDDs/PCDFs congeners followed by 1,2,3,6,7,8- hexachlorinateddibenzo-p-dioxin (1,2,3,6,7,8-HxCDD) and 1,2,3,7,8-pentachlorinated dibenzo-p-dioxin (1,2,3,7,8-PeCDD). The PCDDs/PCDFs levels in blood from subjects classified according to gender, age, smoking habit and specific place of residence are given in Table 1. The average PCDDs/PCDFs concentrations were found to be similar to men (12.55 pg TEQ/g lipid) and women (11.72 pg TEQ/g lipid) and to be higher in non-smokers (11.57 pg TEQ/g lipid) than in smokers (13.68 pg TEQ/g lipid).

The average levels of PCDDs/PCDFs in the stack gas, fly ash, dust and bottom ash at the MSWI were 0.998 ng -TEQ/m^3, 5.502 ng -TEQ/g, 2.013 ng -TEQ/g, and 0.098 ng -TEQ/g, respectively. The average levels of PCDDs/PCDFs in ambient air and ground soil at the vicinity of the MSWI were 0.255 pg -TEQ/m^3, and 22.671 pg -TEQ/g, respectively. The average dioxin concentration in ambient air and ground soil at the urban areas was 0.23 pg-TEQ/m^3 and 1.57 pg-TEQ/g, respectively. The data for 11 food groups including 94 food samples were collected randomly from markets in several cities in Korea. The dioxin concentrations in the 11 food groups were 0.015 pg-TEQ/g, 0.016 pg-TEQ/g, 0.015 pg-TEQ/g, 0.006 pg-TEQ/g, 0.153 pg-TEQ/g, 0.288 pg-TEQ/g, 0.013 pg-TEQ/g, 0.023 pg-TEQ/g, 0.008 pg-TEQ/g, 0.028 pg-TEQ/g, and 0.055 pg-TEQ/g for cereals, beans, vegetables, fruit, fish, shellfish, dairy products, beef, pork, chicken, and eggs, respectively.

The relationships between the blood samples, ambient air, ground soil, incinerator samples, and foods were analyzed by PCA. The first principal component (PC1) accounted for 54.8% of the variance, and the second principal component (PC2) accounted for 20.3% of the variance. PC1 is affected by Penta-CDF, and PC2 is affected by OCDD. As shown in Figure 1, two distinct clusters of samples were identified by the PCA. Group I consisted of the blood for the vicinity residents, environmental samples of MSWI area and foods such as meat, fish and shellfish. Group II consisted of the blood samples for smokers. These results indicate that the PCDDs/PCDFs levels in blood for the vicinity residents were affected by the dioxin levels of environments at the MSWI and foods such as meat, fish and shellfish.

Reference

Domingo, J.L., Schuhmacher, M., Muller, L., et al., 2000. J. Hazard. Mater. 76, 1–12.

Hoover, S.M., 1999. Risk Analysis 19(4), 527-545

Iida, T., Hirakawa, H., Matsueda, T., et al., 1999. Chemosphere 38(11), 2461-2466

Jimenez, B., Hernandez, L.M., Eljarrat, E., et al., 1996. Chemosphere 33, 2403-2410

Newsome, W.H., Davies, D.D. and Doucet, J., 1995. Chemosphere 30(11), 2143-2153

Noren, K. and Meironyte, D., 2000. Chemosphere 40, 1111-1123

Oh, J.E., Chang, Y.S., Kim, E.J., et al., 2002. J. Air Waste Manage. 52, 174–180.

Papke, O., Ball, M., and Lis, A., 1996. Chemosphere 29, 2355-2360

Patandin, S., Dagnelie, P.C., Mulder, P.G.H., et al., 1999. Environ. Health Persp. 107(1), 45-51

Schecter, A., Ryan, J.J, and Papke, O., 1998. Chemosphere 37(9-12), 1807-1816.

Schecter, et al., Papke, O., Furst, P., et al., 1997 Organohalogen Compounds 33, 473-478

Schuhmacher, M., Domingo, J.L., Llobet, J.M., et al., 1999. Chemosphere 38(5), 1123-1133

Somogyi, A. and Beck, H., 1993. Environ. Health Persp. 101(Suppl. 2), 45-52

Thomas, G.O., Jones, J.L., Jones, K.C., 2002. Environ. Sci. Technol. 36, 2372–2378.

Yang, J.Y., Shin, D.C., Park S.E., et al., 2002. Chemosphere 46, 419-428

Table 1. Concentration of PCDDs/PCDFs in blood from subjects living in the urban area of Korea according to sociodemographic characteristics

	N[1)]	Mean	SD[2)]	Minimum	Maximum
Proximity					
Workers	31	12.34	11.46	2.09	66.67
<300m	68	11.63	6.68	1.00	29.33
(vicinity residents)					
> 10km	11	14.57	9.83	5.29	35.93
(general population)					
Gender					
Male	54	12.55	9.86	1.06	66.67
Female	56	11.72	7.14	1.00	35.93
Smoker habits					
Non-smokers	81	11.57	7.22	1.00	35.93
Smokers	29	13.68	11.52	5.29	66.67

1) N : number of samples
2) SD : Standard deviation
3) MSWI : Municipal solid waste incinerator

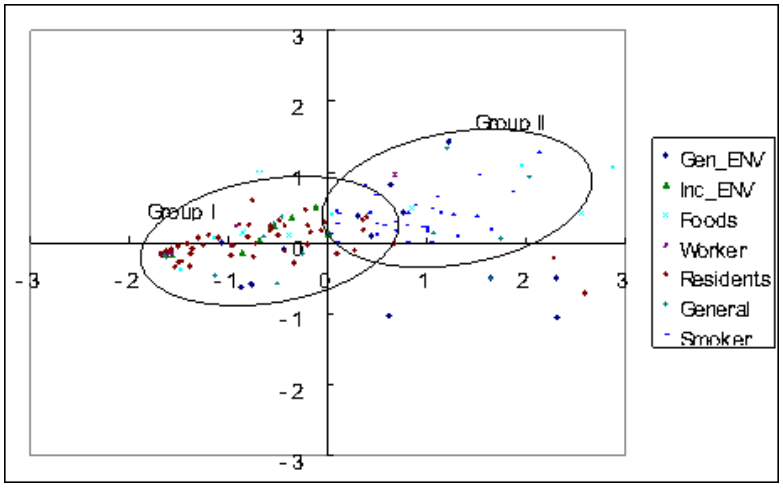

Figure 1. PCA plot for general environments samples, incinerator samples, foods, and human blood samples.