Exposure of t-PCDDs/Fs and Oxidative Damage on Workers and Residents near the Waste Incinerators in Korea.

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Introduction; Many incinerators have been constructed since the early 1990s in Korea due to the lack of available land fill sites. In 1993, the incineration rate of municipal solid waste (MSW) in Korea was about 2.4%. It will be increased up to 30% by the year 2011. But without proper technical strategies for emission reduction of dioxins and furans, this incineration-favored policy continue to face the dioxin-emission problem as the construction activities of further commercial-scale incineration facilities are increased. Since toxic substances, such as Polychlorinated dibenzo-p-dioxins (PCDDs) and polychlorinated dibenzofurans (PCDFs) have been detected in MSW and industrial waste incinerators in various countries, much public concern has been attached to the problem of environmental pollution and health effects by dioxin analogues. In 1996, the dioxin issues raise its head in relation to MSW incinerators though mass media. Local residents resist the construction and operation of MSW incinerators. In 1997, the control of PCDD/Fs emission from MSW incinerators was implemented in the Republic of Korea.

The emission concentrations of the MSW incinerators have been decreased below 0.005 ng-TEQ/Nm^3 by dioxin-control policy, but those of industrial waste incinerators have remained high in Korea.

Dioxin is an unwanted by-product of incineration, uncontrolled burning and certain industrial processes. The term "dioxin" refers to a large family of compounds that includes 17 compounds of particular interest because it is thought that these compounds have similar mechanisms of toxicity. Nevertheless, the toxicities of dioxins vary greatly, with the least toxic compound estimated to be 10,000 less potent than the most toxic. Dioxins occur as complex mixtures of these 17 family member compounds. The higher chlorinated PCDD/F like TCDD appear to be highly persistent in humans with half-lives ranging between 4 and 12 yr. PCDD/Fs persistent in environment, bioaccumulate though the food web, and pose a risk of causing adverse effects to human health and environment.

There are many studies concerning the exposure, toxicities and health effects of PCDDs/Fs. But there are a few studies to investigate whether even low body burden of PCDDs/Fs, such as 10 ng TEQ/kg bw, can have the adverse health effects on human, such as oxidative damage and enzyme inductions.

Objectives; In this study, we estimated the exposure status of the hazardous substances from incinerators,

such as polychlorinated dibenzo-p-dioxins (PCDDs) and polychlorinated dibenzofurans (PCDFs), and investigate the relationship between the exposure of these hazardous substances and their heath effects in workers and residents near the municipal solid waste (MSW) incinerators and residents near an industrial incinerator.

Methods; From July 2001 to June 2002, we interviewed 13 workers at two MSW incinerators, 16 residents from the area around two MSW incinerators, 6 residents from the control area, and further 10 residents near an industrial incinerator, which is estimated to emit higher level of hazardous substances. We collected information including sociodemographic information, personal habits, work history, detailed gynecologic and other medical history through interview. Blood samples from 45 subjects were collected for analysis of PCDDs and PCDFs, which were analyzed by HRGC-HRMS (high resolution gas chromatography - high resolution mass spectrometer) using US EPA 1613 method. In addition to a questionnaire survey, urinary concentrations of 8-hydroxydeoxyguanosine (8-OH-dG) and malondialdehyde (MDA) were measured as oxidative injury biomarkers. Urinary concentrations of 8-OH-dG were determined by in vitro ELISA. MDA were determined by HPLC using adduct with thiobarbituric acid.

The data from the 45 persons were encoded, entered, and analyzed with the assistance of the Statistical Analysis System(SAS) PC software Package and Data III Plus. We used χ^2 -test , Kruskal Wallis ANOVA and Multivariate logistic regression to test the differences of the exposure of PCDDs/Fs and health effects between exposure groups.

Results & Discussions; The PCDDs/Fs concentrations in residents near the industrial incinerator were higher than those in controls, workers and residents near the MSW incinerators. The average TEQ (Toxic Equivalencies) concentrations of PCDDs/Fs in residents near the industrial incinerator were 53.4 pg I-TEQs/g lipid, while those in controls, workers and residents near the MSW were 7.6 , 10.4, and 13.7 pg I-TEQs/g lipid. . In only 30% to the total residents near the industrial incinerator, the estimated daily intakes were within tolerable daily intake range (1-4 pg I-TEQ/kg bw/day) suggested by WHO (1997). Animal study already proved that even low body burden of PCDDs/Fs, such as 10 ng TEQ/kg bw, could make oxidative damage in laboratory animals. Our study also showed that the same levels of body burden of PCDDs/Fs could make oxidative damage to human.

Because lower body burden of PCDDs/Fs, such as 10 ng TEQ/kg bw, can oxidative damage, the tolerable daily intake range should be more restrictedly limited to 1 pg I-TEQ/kg bw/day. Proper protection strategies against PCDDs/Fs are needed.

Table 1. Distribution of PCDDs/Fs homologue in workers, residents near incinerators, and control residents

: Mean ± SD

PCDDs/Fs[1] congeners	I-TEFs[2]	Workers at the MSW[3] incinerators (n=13)	Residents near the MSW incinerators (n=16)	Residents near the industrial incinerator (n=10)	Control residents (n=6)	P-value*
		Mean ± SD	Mean ± SD	Mean ± SD	Mean ± SD	
2,3,7,8-TCDD[5]	1	n.c.[4]	n.c.	n.c.	0.233 ± 0.570	-
1,2,3,7,8-PeCDD[6]	0.5	0.744 ± 1.09	1.678± 2.146	14.074±11.709	0.758 ± 1.188	0.025
1,2,3,4,7,8-HxCDD[7]	0.1	0.119 ± 0.263	0.230 ± 0.290	n.c.	0.051 ± 0.124	-
1,2,3,6,7,8-HxCDD	0.1	1.588 ± 1.164	2.724 ± 1.412	n.c.	1.290 ± 0.997	-
1,2,3,7,8,9-HxCDD	0.1	0.301 ± 0.433	0.418 ± 0.480	n.c.	n.c.	-
1,2,3,4,6,7,8-HpCDD[8]	0.01	0.211 ± 0.251	0.316 ± 0.238	0.587 ± 0.252	0.157 ± 0.133	0.001
OCDD[9]	0.001	0.341 ± 0.475	0.915 ± 1.236	0.252 ± 0.181	0.264 ± 0.170	0.058
2,3,7,8-TCDF[10]	0.1	0.410 ± 0.914	0.015 ± 0.059	1.344 ± 1.029	n.c.	0.000
1,2,3,7,8-PeCDF[11]	0.05	0.056 ± 0.144	n.c.	1.262 ± 1.106	n.c.	0.000
2,3,4,7,8-PeCDF	0.5	4.812 ± 3.300	5.999 ± 3.392	18.239 ± 9.906	3.761 ± 2.189	0.000
1,2,3,4,7,8-HxCDF[12]	0.1	0.800 ± 0.641	0.589 ± 0.487	4.349 ± 2.429	0.466 ± 0.405	0.000
1,2,3,6,7,8-HxCDF	0.1	0.476 ± 0.488	0.546 ± 0.468	4.033 ± 1.339	0.466 ± 0.535	0.000
2,3,4,6,7,8-HxCDF	0.1	0.306 ± 0.681	0.169 ± 0.205	3.947 ± 2.615	0.061 ± 0.149	0.000
1,2,3,7,8,9-HxCDF	0.1	n.c.	n.c.	3.628 ± 2.127	n.c.	-
1,2,3,4,6,7,8-HpCDF[13]	0.01	0.214 ± 0.265	0.112 ± 0.049	0.740 ± 0.379	0.075 ± 0.065	0.000
1,2,3,4,7,8,9-HpCDF	0.01	0.004 ± 0.014	n.c.	0.183 ± 0.123	n.c.	0.000
OCDF[14]	0.001	0.003 ± 0.009	0.001 ± 0.004	0.025 ± 0.334	0.001 ± 0.002	0.029
t-PCDDs/Fs		10.395 ± 6.768	13.711± 8.443	53.420 ± 23.96	7.584 ± 4.196	0.000
Body burden of t-PCDDs/Fs (ng TEQ†/kg bw)		1.740 ± 1.381	3.160±2.196	12.161 ± 6.849	1.638 ± 0.722	0.000
Daily intake of t-PCDDs/DFs (pg I-TEQ‡/kg bw/day)		0.881 ± 0.699	1.600 ±1.112	6.260 ± 3.638	0.830 ± 0.366	0.000

nit: pg /g lipid

1) Polychlorinated dibenzo-p-dioxins and polychlorinated dibenzofurans

2) International-toxic equivalency factors

3) Municipal solid waste

4) Non countable

5) Tetrachlorinated dibenzodioxin, 6) Penta chlorinated dibenzodioxin, 7) Hexa-chlorinated dibenzodioxin,

8) Hepta-chlorinated dibenzodioxin 9) Octa-chlorinated dibenzodioxin 10) Tetrachlorinated dibenzofuran,

11) Penta chlorinated dibenzofuran, 12) Hexa-chlorinated dibenzofuran, 13) Hepta-chlorinated dibenzofuran,

14) Octa-chlorinated dibenzofuran

*Statistical analysis by Kruskal-Wallis one-way ANOVA, comparison between exposure groups

†ng TEQs: 10^{-9} g Toxic Equivalencies

‡ pg TEQs: 10^{-12} g Toxic Equivalencies

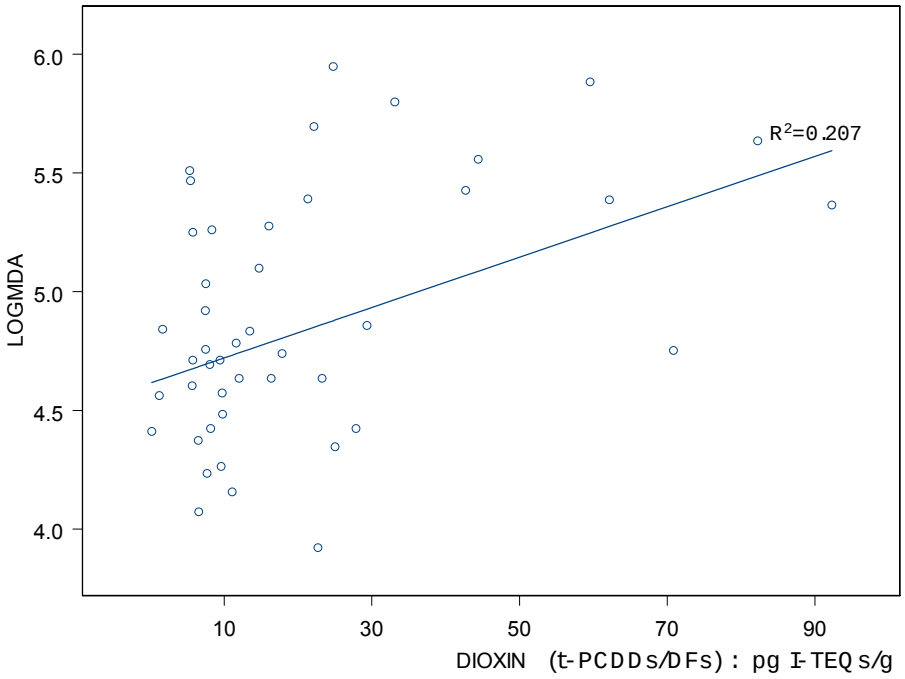

Figure 1 Dose-response relationship of blood t-PCDDs/Fs and log(MDA)

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