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Serum PCDDs/PCDFs Levels for the Residents Living in the Vicinity and Workers of the Municipal Waste Incinerators in Seoul, Korea

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자원회수시설 근로자 및 인근 거주 주민의 혈중 다이옥신 농도 분포

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요 약

이 연구의 목적은 자원회수시설 근로자 및 인근 지역 거주 주민의 혈중 다이옥신류 농도를 평가하고, 혈중 다이옥신류 농도에 영향을 미치는 요인을 평가하는 것이다. 2002~2004년까지 대상 자원회수시설에 3년 이상 근무하 근로자 31명과 시설로부터 300 m 이내 지역에서 3년 이상 거주한 주민 68명을 선정하여 혈액을 채취하였다. 참고 자료로 대상 자원회수시설에 영향을 받지 않는 도시 지역에 거주하는 일반 주민 11명을 함께 평가하였다. 혈액 채취시 개인 특성에 대한 설문조사도 함께 실시하였다. 시설 근로자의 혈중 다이옥신류 농도는 평균 2.09~66.67 pg/g lipid, 인근 거주 주민은 1.00~29.33 pg/g lipid, 일반 도시 주민은 5.29~35.93 pg/g lipid로 측정되었다. 시설 인근 지역 거주 주민 및 일반 도시 주민 중 비흡연자의 인체 부하량은 각각 3.0 ng TEQ/g lipid와 4.5 ng TEQ/g lipid로 평가되었다. 대상군의 특성에 따른 혈중 다이옥신류 농도 차이는 관찰되지 않았으며, 연령과 유의한 양의 상관성이 있었다.

Key words : PCDDs, PCDFs, blood, human exposure, municipal solid waste incinerator, body burden

INTRODUCTION

Polychlorinated dibenzo-p-dioxin (PCDDs) and polychlorinated dibenzofurans (PCDFs) are toxic chemicals that persist in the environment (Krathacker *et al.*, 1998; Patandin *et al.*, 1998; Schecter *et al.*, 1998; Weisglas-Kuperus, 1998; Patandin *et al.*, 1999; Yang *et al.*, 2002). PCDDs and PCDFs are a by-product of other chemical processes and are formed in various combustion processes (Rappe, 1994; Abraham *et al.*, 1996; Yang *et al.*, 2002). PCDDs and PCDFs are detected routinely, as they are widely

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distributed in the environment and accumulate in the food chain (Dewailly *et al.*, 1992; Somogyi and Beck, 1993; Newsome *et al.*, 1995; Korric and Altshul, 1998; Hoover, 1999; Iida *et al.*, 1999; Yang, *et al.*, 2002). 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 (Iida *et al.*, 1999; Noren and Meironyte, 2000; Yang *et al.*, 2002).

Many toxicological studies on dioxin, including the acute, subchronic, chronic, immuno-, developmental and reproductive toxicity, as well as the carcinogenicity, have been reported. These reports suggest that in order to assess the human risk of dioxin, it is essential to focus not only on cancer but also on several non-cancer endpoints (Yoshida *et al.*, 2000).

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 present study is one of a series of reports describing the results of monitoring program for the environmental impact and health risk assessment on community residents of the municipal solid waste incinerator (MSWI). The program was designed to baseline concentration of metals and odor related chemicals in ambient air, and to determine background levels for human exposure to metals and PCDDs/PCDFs in the vicinity of the MSWI. The aim of this study was to determine the concentrations of PCDDs/PCDFs in blood from individuals living in the vicinity area of the MSWI, and to compare PCDDs/PCDFs levels in blood for residents living near the MSWI, workers at the MSWI and general population living in the urban area not including the MSWI. Analysis of the results was made in terms of sociodemogtaphic characteristics such as age, sex, smoking habit, food consumption patters, and proximity to the MSWI.

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 < 300 m 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 150 mL of Blood was collected without anticoagulant, centrifuged to remove cells, and frozen. The serum samples were extracted with a mixture of acetone and hexane (2 : 1, v/v) after the addition of $^{13}C_{12}$-labeled internal standards (Andover, MA). The organic layer was washed with sodium oxalate saturated water, dried using an evaporator and then re-suspended in dichloromethane/hexane (1 : 1, v/v). The re-suspended layer was purified by gel permeation, silica gel, alumina and carbon fiber chromatography. Details on the sample clean-up and fractionation methodologies have been described previously (Rantalainen and Ikonomou, 1998). 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.

Calculation of PCDDs/PCDFs body burden was made according to a subject's body weight and percentage of body fat (Schecter *et al.*, 1998; Yang *et al.*,

2002). The equation used for calculating body burden was :

Body Burden (TEQ ng)
$=C_{blood}$ (TEQ ng/kg lipid) * $BW_{subject}$ (kg) * fl
where C_{blood} (TEQ ng/kg fat) : Concentration in blood
$BW_{subject}$ (kg) : Body weight of subject
fl : Proportion of subject's body fat (Knapik *et al.*, 1983)

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. The EXCEL package was used for data management and SAS package was used for statistical analysis. PCDD/F concentrations were reported as picograms Toxic-Equivalent per grams lipid (pg TEQ/g lipid). Toxic equivalents (TEQ) were calculated using the toxic equivalent factors (TEFs) established by WHO in 1998. The EXCEL package was used for data management and SAS package was used for statistical analysis. The simple correlation test was used to assess the relationship between age and serum PCDDs /PCDFs levels of subjects. T-test was used to assess the differences in serum PCDDs/PCDFs levels from gender and smoking habit. The ANOVA (analysis of variance) test was used to examine the differences in serum PCDDs/PCDFs levels among proximity to MSWI, age groups, or groups by weekly food consumption types.

RESULTS AND DISCUSSIONS

Table 1 shows the characteristics of the subjects such as their ages, body weights, lifestyles, and food consumption patterns. 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 (Table 2). In workers and residents, PCDFs levels (above 65% to PCDDs /PCDFs TEQ concentration) were higher than PCDDs levels in blood. 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- hexachlorinated dibenzo-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 other hand, PCDFs levels in blood were similar to PCDFs levels, and 2, 3, 4, 7, 8-pentachlorinated dibenzofuran (2, 3, 4, 7, 8-PeCDF) and 1, 2, 3, 7, 8-pentachlorinated dibenzo-p-dioxin (1, 2, 3, 7, 8-PeCDD) were about 35% and 30%, respectively, to PCDDs/PCDFs TEQ concentration in general population. The proportion of 2, 3, 7, 8-tetrachlorinated dibenzo-p-dioxin (2, 3, 7, 8-TCDD) was less than 0.01% to PCDDs/PCDFs TEQ concentration in all samples.

The PCDDs/PCDFs levels in blood from subjects classified according to gender, age, smoking habit and specific place of residence are given in Table 3. 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). Higher levels of PCDDs/PCDFs in blood were observed in older subjects than in younger subjects except 20~29 years old including heavy smoker (66.67 pg TEQ/g lipid) : 30~39 years old, 9.91 pg TEQ/g lipid; 40~49 years old, 10.87 pg TEQ/g lipid; above 50 years old, 13.84 pg TEQ/g lipid. The average levels of dioxin were 12.34 pg TEQ/g lipid, 11.63 pg TEQ/g lipid, and 14.57 pg TEQ/g lipid for workers, vicinity residents and general population, respectively. There were not significantly difference between the group living at distances <300 m from the MSWI and those living at

Table 1. Sociodemographic characteristics of the subjects in this study

Variables	MSWI[1)]		General population (n=11)
	Workers (n=31)	Vicinity residents (n=68)	
Age (years)	40 (28~67)	49 (23~63)	37 (21~57)
Gender (persons) (%)			
Male	29 (94)	22 (32)	3 (27)
Female	2 (6)	46 (68)	8 (73)
Body weight (kg)	69 (50~106)	63 (47~82)	64 (47~79)
Smoking habit (persons) (%)			
Non-smokers	13 (42)	59 (87)	9 (82)
Smokers 18 (58)	9 (13)	2 (18)	
Occupational contact with dioxin-like compounds (persons) (%)			
Yea	31 (100)	-	-
No	-	68 (100)	11 (100)
Weekly food consumption (persons) (%)			
Meat			
No	1 (3)	1 (1)	0 (0)
1 times/week	17 (55)	33 (49)	5 (45)
2~3 times/week	11 (35)	19 (28)	5 (45)
>4 times/week	2 (7)	15 (22)	1 (10)
Fish			
No	1 (4)	0 (0)	0 (0)
1 times/week	15 (48)	50 (75)	5 (45)
2~3 times/week	15 (48)	16 (24)	5 (45)
>4 times/week	0 (0)	2 (3)	1 (10)
Milk and dairy			
No	1 (4)	1 (1)	0 (0)
1 times/week	18 (58)	35 (52)	5 (45)
2~3 times/week	10 (32)	24 (35)	5 (45)
>4 times/week	2 (6)	8 (12)	1 (10)

[1)]MSWI : Municipal Solid Waste Incinerator

greater distances. Germany investigations of PCDDs /PCDFs concentrations showed PCDDs/ PCDFs values ranging from 5.2 to 34.5 pg TEQ/g lipid in subjects who lived in the vicinity of a waste incinerator, and 11.2~113.6 pg TEQ/g lipid in the general population (Deml *et al.*, 1996; Ewers *et al.*, 1996). For the subjects who lived who lived in the vicinity of a MSWI in Spain, significant differences were not found in relation to the specific residential area, while a significant correlation between the age of the subjects and the levels of PCDDs/PCDFs in blood could be observed (Schuhmacher *et al.*, 1999). Mari *et al.* (2006) was reported that the concentration of PCDDs/PCDFs in blood of 19 workers employed at a hazardous waste incinerator, 6 years after regulator operations, in Spain. The average level of PCDDs/ PCDFs (10.4 pg TEQ/g lipid) in blood was similar or even lower than those recently reported for various non-exposed population in Spain (Mari *et al.*, 2006). These results are consistent with our results. The levels of dioxin in blood were not significantly different between the groups, gender, and smoking habit, whereas a significant correlation between the age of the subjects and the levels of dioxin in blood could be observed.

The correlation coefficients between age and PCDDs/PCDFs levels in blood found were 0.32 ($p=0.004$) and 0.22 ($p=0.014$) in non-smokers and smo-

Table 2. PCDDs/PCDFs concentrations in blood of the subjects

Dioxin Congeners (pg TEQ/g lipid)	MSWI[1]						General population (n=11)		
	Workers (n=31)			Vicinity residents (n=68)					
	Mean	SD[2]	Range (Min.~Max.)	Mean	SD	Range (Min.~Max.)	Mean	SD	Range (Min.~Max.)
2,3,7,8-TCDD	0.05	0.26	0.00~1.45	0.00	0.00	0.00~0.00	0.00	0.00	0.00~0.00
1,2,3,7,8,-PeCDD	0.84	1.30	0.00~4.55	1.10	1.46	0.00~5.93	4.31	7.64	0.00~26.08
1,2,3,4,7,8-HxCDD	0.38	1.57	0.00~8.76	0.23	0.78	0.00~5.71	0.20	0.58	0.00~1.94
1,2,3,6,7,8-HxCDD	1.26	1.13	0.00~4.29	1.52	1.34	0.00~4.64	1.79	1.08	0.00~3.55
1,2,3,7,8,9-HxCDD	0.33	0.61	0.00~2.92	0.28	0.44	0.00~1.99	0.08	0.25	0.00~0.83
1,2,3,4,6,7,8-HpCDD	0.62	1.37	0.00~6.78	0.33	0.34	0.00~2.03	0.35	0.23	0.00~0.70
OCDD	0.36	0.41	0.09~1.90	0.47	0.48	0.05~2.41	0.40	0.26	0.15~1.06
2,3,7,8-TCDF	0.49	1.30	0.00~6.20	0.07	0.37	0.00~2.66	0.31	0.54	0.00~1.24
1,2,3,7,8,-PeCDF	0.03	0.10	0.00~0.47	0.01	0.05	0.00~0.31	0.00	0.00	0.00~0.00
2,3,4,7,8,-PeCDF	6.04	5.95	0.00~31.50	5.81	3.47	0.00~15.88	5.19	2.40	0.00~9.38
1,2,3,4,7,8-HxCDF	0.67	0.56	0.00~2.54	0.75	0.57	0.00~2.50	0.74	0.67	0.00~2.34
1,2,3,6,7,8-HxCDF	0.46	0.45	0.00~1.57	0.62	0.49	0.00~2.05	0.84	0.70	0.00~2.10
2,3,4,6,7,8-HxCDF	0.26	0.54	0.00~2.39	0.18	0.47	0.00~3.60	0.14	0.27	0.00~0.82
1,2,3,7,8,9-HxCDF	0.29	1.37	0.00~7.66	0.10	0.39	0.00~2.34	0.08	0.28	0.00~0.92
1,2,3,4,6,7,8-HpCDF	0.25	0.31	0.00~1.50	0.16	0.23	0.00~1.67	0.12	0.11	0.00~0.34
1,2,3,4,7,8,9-HpCDF	0.00	0.02	0.00~0.10	0.00	0.02	0.00~0.17	0.00	0.01	0.00~0.03
OCDF	0.01	0.05	0.00~0.24	0.00	0.01	0.00~0.04	0.00	0.00	0.00~0.01
Total PCDDs	3.83	3.70	0.27~19.58	3.93	3.24	0.05~13.77	7.13	7.86	0.32~28.80
Total PCDFs	8.50	8.52	0.02~47.09	7.70	4.29	0.38~19.82	7.44	4.04	1.15~15.38
Total PCDDs/Fs	12.34	11.46	2.09~66.67	11.63	6.68	1.00~29.33	14.57	9.83	5.29~35.93

[1]MSWI : Municipal Solid Waste Incinerator
[2]SD : Standard deviation

Table 3. 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
< 300 m (vicinity residents)	68	11.63	6.68	1.00	29.33
> 10 km (general population)	11	14.57	9.83	5.29	35.93
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

kers, respectively (Fig. 1). The correlation between age and blood dioxin level was reported by Jimenes *et al.* (1996) and Schumacher *et al.* (1999) for a population in Spain, and Chen *et al.* (2003) for residents living near the incinerators in Taiwanese. On the other hand, Deml *et al.* (1996) found the highest

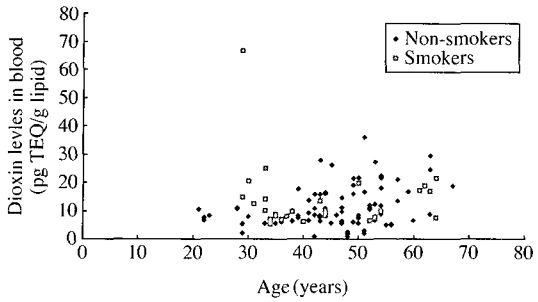

Fig. 1. Relationship between age and PCDDs/PCDFs levels in blood of the subjects.

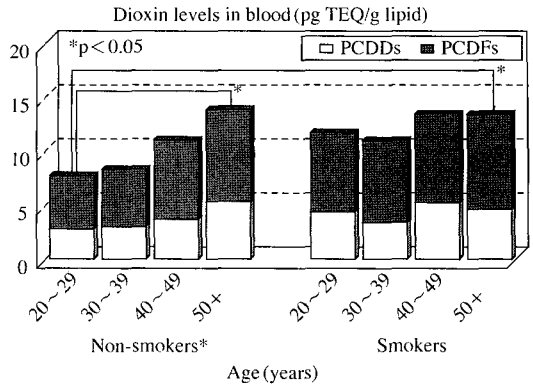

Fig. 2. Comparison of PCDDs/PCDFs levels in blood by smoking habit of the subjects except MSWI workers.

blood PCDDs/PCDFs levels in age groups between 40 and 60 years, indicating an age-dependent increase of the body burden for residents living vicinity the MSWI in Germany. However, significant correlation between age and PCDDs/PCDFs concentrations in blood were not found, possibly due to large inter-individual variations (Schumacher *et al.*, 1999).

To assess the interaction of age and smoking habit associated with subject's PCDDs/PCDFs levels in blood, the subjects except MSWI workers were grouped into 6 categories: group1, 20~29 years old and non-smoker; group 2, 30~39 years old and non-smoker; group 3, 40~49 years old and non-smoker; group 4, above 50 years old and non-smoker; group5, 20~29 years old and smoker; group 6, 30~39 years old and smoker; group 7, 40~49 years old and smoker; group 8, above 50 years old and smoker. For the non-smokers (group1, group2, group3, and group4), they show an increase with the age (Fig. 2). Significantly higher PCDDs/Fs concentrations in blood were found in older (50+years old) and smoker subjects (13.20 pg TEQ/g lipid) than younger (20~29 years old) and non-smoker subjects (7.75 pg TEQ/g lipid) in the residents living vicinity of the MSWI and general population except MSWI workers (Fig. 2).

To examine how dietary patterns were associated with subject's PCDDs/PCDFs levels in blood, the non-smoker subjects except MSWI workers were grouped into 3 categories according to their weekly dietary preferences for dioxin-rich foods consumption such as meat, fish and shellfish, dairy products, and fast foods: lower consumer group, below 1 time/week as consumption frequency of dioxin-rich foods; moderate consumer group, average 2~3 times/week as consumption frequency of dioxin-rich foods; higher consumer group, above 4 times/week as consumption frequency of dioxin-rich foods. PCDDs/PCDFs levels in blood of the higher consumer group (19.39 pg TEQ/g lipid) were significantly higher ($p=0.048$) than those of the lower consumer group (9.64 pg TEQ/g lipid) (Fig. 3). This result is partly consistent with previous findings that seafood, meat, and high-fat food are the main contributors to blood dioxin concentrations (Jimenez *et al.*, 1996; Ryan *et al.*, 1997; Zuccato *et al.*, 1999). Furthermore, Chen *et al.* (2003) were reported that dioxin levels in blood were significantly different among those subjects with different consumption frequencies of poultry ($p=0.048$) and dairy products ($p=0.011$).

The strongest evidence that exposure to TCDD leads to an increased risk of generalized cancers at multiple organ sites, including lung cancer, comes from the four occupational cohort studies (Zober *et al.*, 1990; Fingerhut *et al.*, 1991; Manz *et al.*, 1991; Bueno de Mesquita *et al.*, 1993; Flesch-Janys *et al.*, 1995, 1998, 1999; Becher *et al.*, 1996; Hooiveld *et al.*, 1996, 1998; Ott *et al.*, 1996; Steenland *et al.*,

Table 4. Summary of recent studies on PCDD/F levels (pg TEQ/g lipid) in human blood from general population living in a number of different places

Place	Number of samples	Dioxin levels in blood (pg TEQ/g lipid)	References
Germany (Schwandorf)	39	17.0	Deml *et al.*, 1996
Germany (Different places)	134	19.1	Papke *et al.*, 1996
Southern Germany (Children)	15	18.4	Wuthe *et al.*, 1996
Norway (Frierfjord area)	10	21.1	Johansen *et al.*, 1996
Spain (Madrid)	11	14.4	Jimenez *et al.*, 1996
Germany (Different places)	180	16.5	Papke *et al.*, 1997
USA (Binghamton, NY)	100	26.7	Schecter *et al.*, 1997
Israel and Gaza	109	8.4~26.6	Schecter *et al.*, 1997
Canada (Ontario)	14	20.8~41.2	Cole *et al.*, 1997
This study (South Korea)	81	11.57	-

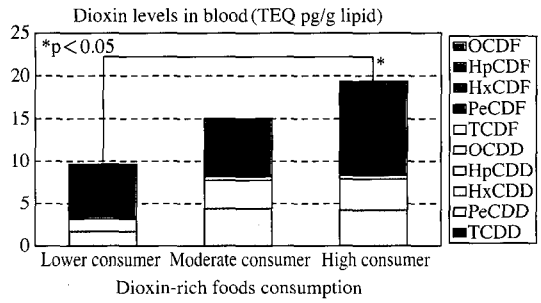

Fig. 3. Comparison of PCDDs/PCDFs levels in blood by consumption pattern for dioxin-rich foods of the non-smoker subjects except MSWI workers.

1999). These studies provide evidence of in vivo exposure to TCDD, with actual measurements of TCDD serum levels in exposed individuals or their surrogates positively correlated with significantly increased risks of cancer mortality of between 40% and 100% (SMRs range generally from 1.4 to 2.0). The range of average serum TCDD levels in those occupational exposed less than 1 year was 233~20,200 pg/g (lipid adjusted). Although it is clear that congeners of the PCDDs/PCDFs are also present in the blood serum of exposed subjects, TCDD predominates.

There are two epidemiologic studies in general population, the victims of the 1976 Seveso accident in Italy (Caramaschi *et al.*, 1981; Bertazzi *et al.*, 1989a,b, 1992, 1993, 1997, 1998, 2001a; Pesatori *et al.*, 1993, 1999; Landi *et al.*, 1996, 1998) and contaminated rice oil poisonings (Koda and Masuda, 1975; Kuratsune *et al.*, 1975; Chen *et al.*, 1980; Okumura, 1984; Kuratsune *et al.*, 1996; Todaka *et al.*, 2006). Residents of Seveso, Italy, were exposed to TCDD in a chemical accident in 1976. Nearly 200 cases of chloracne reported (Caramaschi *et al.*, 1981). The 1990 analysis, based on tissue specimens taken in 1976, found that the highest detected levels were recorded just after the accident. Six children at the time who subsequently developed severe chloracne had serum TCDD levels ranging from 12,100 pg/g to 56,000 pg/g. Four other persons with slightly less severe chloracne exhibited levels ranging from 828 pg/g to 17,300 pg/g of serum TCDD levels (Mocarelli *et al.*, 1991). Bertazzi *et al.* (2001a) were estimated exposure levels in the blood of random samples of residents of zones A (highest potential exposure) and B (intermediate exposure) at different time intervals. During the 16- to 18-year lapse from the initial blood lipid measurements in 1976~1977 (447.0 pg/g at zone A and 94.0 pg/g at zone B) until 1993~1994 (73.3 pg/g at zone A and 12.4 pg/g at zone B), there appears to have been a near 7-fold drop in blood levels of TCDD. Two accidents involving ingestion of food contaminated with PCBs and dibenzofurans, in Yusho (Japan) and Yu-Cheng (Taiwan), have been reported. In patients with Yusho and Yu-Cheng, following the onset of nonspecific symptoms such as

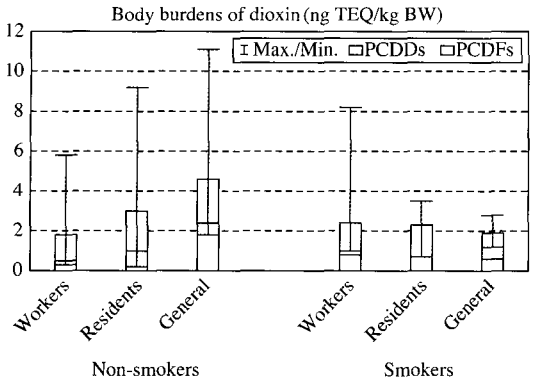

Fig. 4. Comparison of body burden of PCDDs/PCDFs based on subject's concentration in blood.

general malaise, loss of appetite and headache, several characteristic symptoms of Yusho gradually appeared, including acneform eruptions, darkbrownish nail pigmentation, increased discharge from the eyes with swelling of eyelids, pigmentation of oral mucosa, peripheral neuropathy, irregular menstruation in women, and growth retardation in infants and children (Okumura, 1984; Kuratsune *et al.*, 1996). The average level of PCBs in blood of the Yusho patients was 5.9 ppb and the blood concentration residues of Yu-Cheng ranges from 11 ppb to 720 ppb (mean level : 49 ppb) (Koda and Masuda, 1975; Chen *et al.*, 1980). A more recent follow-up (Todaka *et al.*, 2006) of the Yusho patients was reported that average level of dioxin-like compounds (PCDDs/ PCFDs/ co-planar PCBs) in blood was 212.5 pg TEQ/g lipid in 2001 and 161.4 pg TEQ/g lipid in 2002. The levels of dioxin in blood for epidemiological studies are ranged from several scores to scores of thousands of times higher than that of normal population including this study.

Fig. 4 shows the body burden levels based on the concentration of PCDDs/PCDFs in blood of subjects. For the non-smokers, the average body burdens of dioxin were 3.0 ng TEQ/g lipid and 4.5 ng TEQ/g lipid for vicinity residents and general population, respectively. The average levels of body burden were found to be lower than those of adult in the USA (about 9 ng TEQ/kg) (Birnbaum *et al.*, 1997).

CONCLUSIONS

We determined the concentrations of PCDDs/ PCDFs in blood from residents living near a MSWI of urban area in Korea. The average PCDDs/PCDFs levels in blood was 11.57 pg TEQ/g lipid with range from 1.00 to 35.93 pg TEQ/g lipid in non-smoker and residents. PCDDs/PCDFs levels in blood between 10 and 48 pg TEQ/g lipid were previously found in people without any occupational exposure to these compounds (Deml *et al*, 1996; Jimenez *et al.*, 1996; Papke *et al*, 1996; Schuhmacher *et al.*, 1999). These levels were considered as possible background concentrations. Significant differences were not found in relation to the specific residential area and gender, while significantly higher PCDDs/Fs concentrations in blood were found in older and smoker subjects than younger and non-smoker subjects. An analysis between the consumption frequency of dioxin-rich foods and PCDDs/PCDFs levels in blood showed that PCDDs/PCDFs levels of the higher consumer group were significantly higher than those of the lower consumer group.

We conclude that the distances from a MSWI to resident area may not be the main contributor to the levels of PCDDs/PCDFs in blood. While the individual factors such as age and food consumption patterns are associated with the levels of PCDDs/ PCDFs in blood.

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