REGIONAL HUMAN HEALTH RISK ASSESSMENT BY PCDDs/PCDFs EXPOSURE IN AMBIENT AIR

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Introduction

PCDDs/PCDFs are highly toxic and ubiquitous occurrence in the environment. These compounds may be produced through the incineration of waste, released into the atmosphere and transported at great distances before being transferred to other environmental matrices. PCDDs/PCDFs whose decomposition moved slowly in the environment have also influenced human beings and environments[1]. Being aware that persistent organic pollutants including dioxins(PCDDs/PCDFs) pose a major threats to human health and the environment, Stockholm Convention on Persistent Organic Pollutants(POPs) was adopted on 22 May 2001 by UNEP(United Nations Environment Program) and entered into force on 17 May 2004[2]. POPs including PCDDs/PCDFs have various characteristics such as toxicity, persistence, bio-accumulation and long-range transport. POPs can also cause cancer, allergies and hypersensitivity, damage to the central and peripheral nervous systems, reproductive disorders and disruption of the immune system. Some POPs are considered to be endocrine disrupters that alter the hormonal system[3].

Modern society is exposed to various environmental harmful toxic materials due to develop the scientific technique and diversify the industrial structure. So the quantitative assessment about the influence of these toxic materials to human is being required. Risk assessment is the tool that can reasonably respond to these requirement and can also quantitatively assess the influence of toxic materials on both human beings and ecology. Risk assessment is generally performed in four steps such as hazard identification, exposure assessment, dose-response assessment and risk characteristics.

The object of great interest in PCDDs/PCDFs has become whether or not those concentration exceed either allowable exhaust standard or environmental standard for a long time. However, quantitative information about possible human influence by being exposed to PCDDs/PCDFs is required recently. So based on the results of regional PCDDs/PCDFs distribution in ambient air, regional human health risk by PCDDs/PCDFs exposure in ambient air was assessed in this study.

Materials and methods

Ambient air samples used in this study were collected quarterly from 2009 to 2013 using high volume air sampler according to Korean standard method. The sampling was carried out for 48 hours by 0.5 m^3/min. The locations where ambient air were sampled, were four sites ; one industrial area(IA), one commercial area(CA) and two resident area(RA-1 and RA-2). Based on the the results of this research, we assessed the regional health risk by PCDDs/PCDFs exposure in ambient air. We used CTE(central tendency exposure) value, mean exposure value and 95% UCL(upper confidence level) value in single risk assessment. In a similar to Yukie et al's[4] and Bansidhar et al's[5], we also made use of Crystal ball 11.1.2.1 to carry out monte-carlo simulation. We repeated probabilistic risk assessment a hundred thousand by monte-carlo simulation.

There are four steps in risk assessment such as hazard identification, exposure assessment, dose-response assessment and risk characteristics. We used both the carcinogenic classification of IARC and US-EPA in the first step. Dioxins were classified into Group 1 of IARC and A group of US-EPA. The second step of risk assessment is human exposure assessment expressed as LADD(Lifetime Average Daily Dose). The calculation formular and exposure factor for exposure amount assessment were presented in Table 1 and 2[6]. The third was expressed in cancer potency factor(CPF). Cancer potency factor used in this study was 1.56×10^{-4} (pg-TEQ/kg/day)$^{-1}$ that was suggested by US-EPA in 1985 and has mainly applied to risk assessment of

PCDDs/PCDFs[7]. Risk characteristics, the last step of risk assessment is in the process of considering all the information of preceding three steps. So cancer risk(CR) in the last step is measured as LADD calculated in the second step times CPF suggested in the third step. In this study we compared single risk assessment with probabilistic risk assessment. To assess the probabilistic risk, Monte-carlo simulation was carried out using Crystallball 11.1.2.11.

Table 1. The formula for exposure amount assessment

Matrix	Contact	Fomular	Note
Ambient air	Inhalation	$LADD = \frac{Cair \times IR \times EF \times EP}{BW \times LE \times 365}$	

LADD : Lifetime average daily dose (pg-TEQ/kg/day)
C_{air} : Concentration in air (pg-TEQ/Sm^3)
IR : Inhalation rate (m^3/day)
EF : Exposure frequency(day/year)
EP : Exposure period(year)
BW : Body weight (kg)
LE : Life expectancy(year)

Table 2. Exposure factor for exposure assessment

Variable	Distribution form	Factors
Concentration	depend on TEQ values	-
Daily respiratory amount	normal distribution	mean 13 ㎥/day (S.D 0.9)
Exposure frequency	point	365 day
Exposure period	point	25 year
Body weight	normal distribution	mean 62 ㎏ (S.D 8.8)
Life expectation	Point	total 75, carcinogen 70

Results and discussion

The average regional distribution of PCDDs/PCDFs concentration in ambient air for five years was lognormal distribution in all regions that tend to be leftward bias, as presented in Fig. 1. Table 3 showed the maximum, minimum and mean concentration of PCDDs/PCDFs by region. Based on these results, the regional life average daily dose(LADD) of PCDDs/PCDFs by both single-estimated value and probabilistic exposure amount assessment were presented in table 4. In the case of single-estimated exposure amount assessment, LADD by CTE and RME at industrial area(IA) was 7.3E-03 and 3.9E-02 pg-TEQ/kg/day, respectively. These values were 3.3 ~ 4.6 and 3.9 ~ 13.4 times higher than other region's. LADD in industrial area by Monte-carlo simulation was in the range from 8.3E-04 to 1.2E-01 pg-TEQ/kg/day and had the highest value among all areas. LADD in industrial area by 50^{th} percentile was 9.2E-03 pg-TEQ/kg/day and higher than that of any other area having value of 1.5E-03 ~ 2.7E-03 pg-TEQ/kg/day. It was judged that these results were caused by various stationary emission sources of dioxin such as incinerator, chemical products manufacturer, nonferrous metal factory, etc in industrial area.

Based on above results, regional cancer risk by both single-estimated exposure and probabilistic exposure was presented by Fig. 2 and table 5. In the case of industrial area having the highest concentration of PCDDs/PCDFs, cancer risk by CTE and RME exposure was 1.1E-06 and 6.6E-06, respectively. These values exceeded natural risk, 1.0E-06, but didn't exceed environmental risk, 1.0E-05. Cancer risk in other regions was much lower than that in industrial area. The results of probabilistic risk assessment by monte-carlo simulation were as follows. Cancer risk in CA and RA-2 exceeded the natural risk from 90^{th} percentile, while that in RA-1 didn't exceed the natural risk. Cancer risk in IA having the most PCDDs/PCDFs emission sources exceeded the natural risk from 40^{th} percentile and exceeded the environmental risk in 100^{th} percentile. As I mentioned above, these results were caused by various stationary emission sources in industrial area.

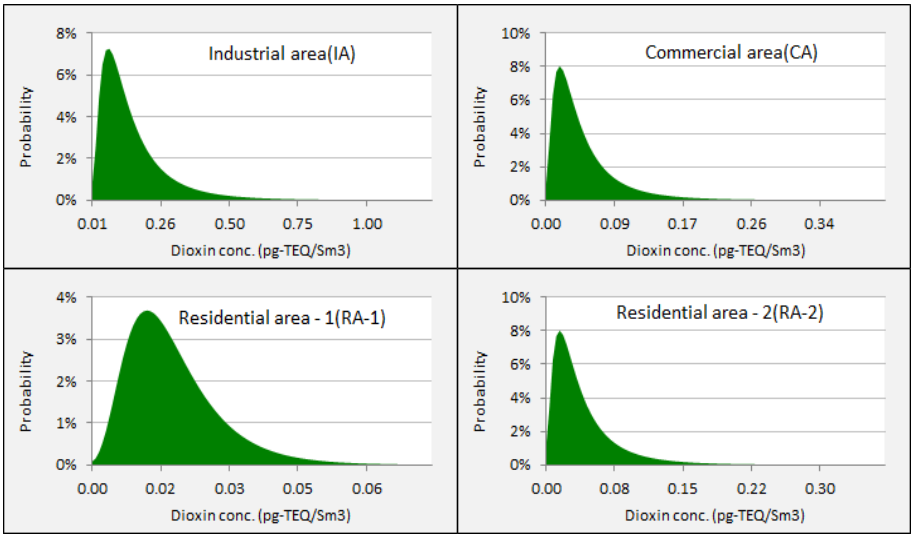

Fig. 1. The lognormal distribution of PCDDs/PCDFs concentration in ambient air according to the region.

Table 3. The regional concentration distribution of PCDDs/PCDFs in ambient air

	PCDDs/PCDFs concentration (pg-TEQ/Sm^3)			
	min.	max.	mean	S.D.
IA	0.044	0.520	0.181	0.159
CA	0.008	0.196	0.050	0.047
RA-1	0.006	0.041	0.022	0.010
RA-2	0.006	0.136	0.043	0.040

Table 4. Regional LADD of PCDDs/PCDFs by both single-estimated value and probabilistic exposure

(unit : pg-TEQ/kg/day)

		IA	CA	RA-1	RA-2
Single-Estimated value	CTE[1)]	7.3E-03	2.2E-03	1.6E-03	2.0E-03
	Mean	1.2E-03	3.7E-03	1.6E-03	3.2E-03
	RME[2)]	3.9E-02	9.0E-03	2.9E03	1.0E-02
Probabilistic exposure	0 %	8.3E-04	2.7E-04	2.5E-04	1.9E-04
	10 %	3.3E-03	9.6E-04	7.9E-04	8.9E-04
	20 %	4.7E-03	1.3E-03	1.0E-03	1.2E-03
	30 %	6.1E-03	1.7E-03	1.2E-03	1.6E-03
	40 %	7.6E-03	2.2E-03	1.3E-03	1.9E-03
	50 %	9.2E-03	2.7E-03	1.5E-03	2.4E-03
	60 %	1.1E-02	3.4E-03	1.7E-03	3.0E-03
	70 %	1.3E-02	4.2E-03	1.9E-03	3.6E-03
	80 %	1.7E-02	5.7E-03	2.2E-03	4.6E-03
	90 %	2.4E-02	8.7E-03	2.8E-03	6.7E-03
	100 %	1.2E-01	2.4E-02	5.5E-03	2.5E-02

1) CTE : Central tendency exposure
2) RME : Reasonable maximum exposure

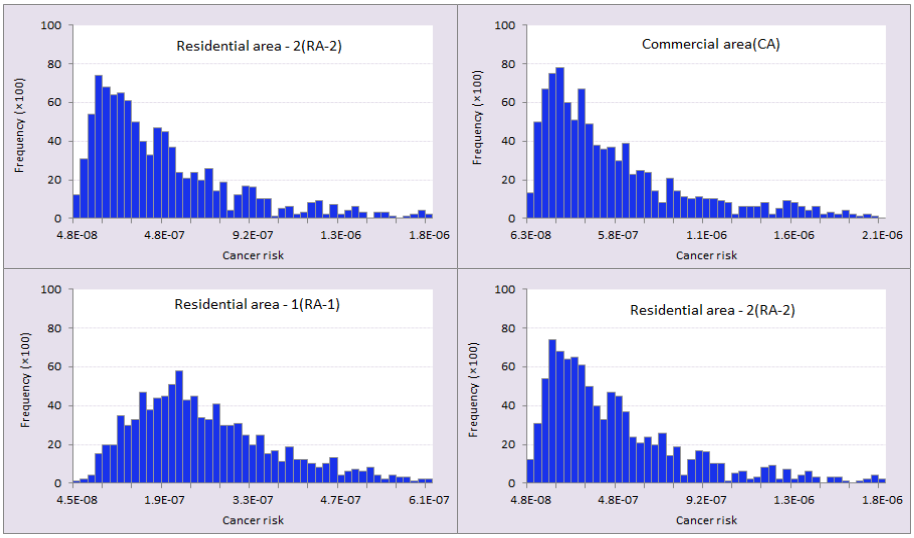

Fig. 2. Regional cancer risk of PCDDs/PCDFs

Table 5. Cancer risk by both single-estimated value and probabilistic exposure according to the region.

		IA	CA	RA-1	RA-2
Single-Estimated point	CTE[1)]	1.1E-06	3.5E-07	2.6E-07	3.2E-07
	Mean	1.9E-06	5.8E-07	2.6E-07	5.0E-07
	RME[2)]	6.0E-06	1.4E-06	4.6E-07	1.6E-06
Monte Carlo Simulation	0 %	1.3E-07	4.2E-08	3.9E-08	3.0E-08
	10 %	5.1E-07	1.5E-07	1.2E-07	1.4E-07
	20 %	7.3E-07	2.1E-07	1.6E-07	1.9E-07
	30 %	9.5E-07	2.7E-07	1.8E-07	2.4E-07
	40 %	1.2E-06	3.5E-07	2.1E-07	3.0E-07
	50 %	1.4E-06	4.2E-07	2.3E-07	3.8E-07
	60 %	1.7E-06	5.4E-07	2.7E-07	4.6E-07
	70 %	2.1E-06	6.6E-07	3.0E-07	5.6E-07
	80 %	2.6E-06	8.8E-07	3.5E-07	7.2E-07
	90 %	3.7E-06	1.4E-06	4.4E-07	1.0E-06
	100 %	1.9E-05	3.7E-06	8.6E-07	3.8E-06

1) CTE : Central tendency exposure
2) RME : Reasonable maximum exposure

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