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

Tae-uk Jeong,[1]*, Bok-ju Song[1], Dong-min Kwon[1], Kyeong-sim Lee[1], Pyung-jong Yoo[1], Gi-gon Kim[1], Dong-Cheol Seo[2], Jong-Hwan Park[3], Jong-Soo Heo[3]

[1]Busan Institution of Health & Environment, 140 Bungil, Hambakbong-ro, Buk-gu, Busan, 616-842, Rep. of Korea ; [2]Department of Bio-Environmental Sciences, Sunchon National University, Seokhyeon-dong, Suncheon, 540-742, Rep.of Korea ; [3]Division of Applied Life Science (BK21 Program) & Institute of Agriculture and Life Science, Gyeongsang National University, Gajwa-dong. Jinju, 660-701, Rep.of Korea

## Introduction

Being aware that persistent organic pollutants including dioxins(PCDDs/PCDFs) pose major and increasing threats to human health and the environment, Stockholm Convention on Persistent Organic Pollutants(POPs) by UNEP(United Nations Environment Program) was adopted on 22 May 2001 and entered into force on 17 May 2004[1]. POPs including PCDDs/PCDFs have a 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. So these materials can damage the reproductive and immune systems of exposed both individuals and their offspring[2]. Especially, PCDDs/PCDFs of all POPs are known to be highly toxic regardless of a small amount and have been of interest to researcher.

Modern society is exposed to a 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 and ecology. There are two types of risk assessment according to the acceptor : health risk assessment and ecological risk assessment. Risk assessment is generally performed in four steps such as hazard identification, exposure assessment, dose-response assessment and risk characteristics.

For a long time, the object of great interest in PCDDs/PCDFs has become whether those concentration exceed both allowable exhaust standard and environmental standard or not. Howerever, quantitatively information about possible human influence by being exposed to dioxin is required recently. So based on the results of seasonal PCDDs/PCDFs distribution in ambient air, seasonal 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 by season in four sites from 2009 to 2013 using high volume air sampler according to Korean standard method. The sampler consisted of a quartz fiber filter followed by a sorbent trap made of polyuretan form(PUF). The sampling was carried out for 48 hours by 0.5 $m^3$/min. The locations where ambient air were sampled, were one industrial area(IA-1), one commercial area(CA-1) and two resident area(RA-1 and RA-2). Based on this research, we assessed the seasonal health risk by PCDDs/PCDFs exposure in ambient air. CTE(central tendency exposure) exposure value, mean exposure value and 95% UCL(upper confidence level) exposure value were used in single risk assessment, while concentration range and variation by Monte-carlo simulation were used in probabilistic risk assessment. We used the same method used to carried out Yukie et al[3] and Bansidhar et al[4]. Monte-carlo simulation was repeated a hundred thousand times using Crystal ball 11.1.2.1.

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, hazard identification. PCDDs/PCDFs were classified into Group 1 of IARC and A group of US-EPA. The second step is human exposure assessment. Exposure amount assessment and exposure factor for exposure assessment were presented in Table 1 and 2[5]. The third step is dose-respond assessment. This step was expressed in cancer potency factor(CPF). Cancer potent factor used in this study was $1.56\times10^{-4}$ (pg-TEQ/kg/day)$^{-1}$ that was

suggested by US-EPA in 1985 and has mainly applied to risk assessment of PCDDs/PCDFs in our nation[6]. Risk characteristics is the last step of risk assessment and in the process of considering all the information of preceding three steps. So risk characteristics was expressed in cancer risk(CR) that is measured as LADD(Lifetime Average Daily Dose) calculated in the second step times CPF(cancer potency factor) suggested in the third step. In this study, we compared single risk assessment and 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 seasonal distribution of PCDDs/PCDFs concentration in ambient air for five years at four sites was lognormal distribution in all seasons that tend to be leftward bias, as presented in Fig. 1. Table 3 showed the maximum, minimum and mean concentration of PCDDs/PCDFs by season. Based on these results, the seasonal 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 in winter was 6.7E-03 and 3.9E-02 pg-TEQ/kg/day, respectively. These values were 2.2 ~ 4.2 and 2.6 ~ 5.3 times higher than other season's. LADD in winter by Monte-carlo simulation was in the range from 2.6E-04 to 1.2E-01 pg-TEQ/kg/day and had the highest value of all seasons. LADD in winter by $50^{th}$ percentile was 8.7E-03 pg-TEQ/kg/day and higher than that of any other season that has the value of 2.2E-03 ~ 3.2E-03 pg-TEQ/kg/day. These results were caused by increasing dioxin emissions from increasing heating fuel consumption and atmosphere inversion appearance in winter. It was judged that decreasing dioxin emissions by photolysis and $OH^-$ radical reaction in summer have also an influence on seasonal dioxin distribution of ambient air[7, 8].

Based on above results, seasonal cancer risk by single-estimated exposure and probabilistic exposure was presented by Fig. 2 and table 5. In the case of winter having the highest concentration of PCDDs/PCDFs, cancer risk by CTE and RME exposure was 1.1E-06 and 6.0E-06, respectively. These values exceeded natural risk, 1.0E-06, but didn't exceed environmental risk, 1.0E-05. Cancer risk in other seasons was much lower than that in winter. The results probabilistic exposure were as follows. Cancer risk in spring and fall didn't exceed the natural risk until $80^{th}$ percentile, while that in summer until $90^{th}$ percentile didn't exceed the natural risk. Cancer risk in winter having the most PCDDs/PCDFs emissions 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 increasing heating fuel consumption and atmosphere inversion appearance in winter.

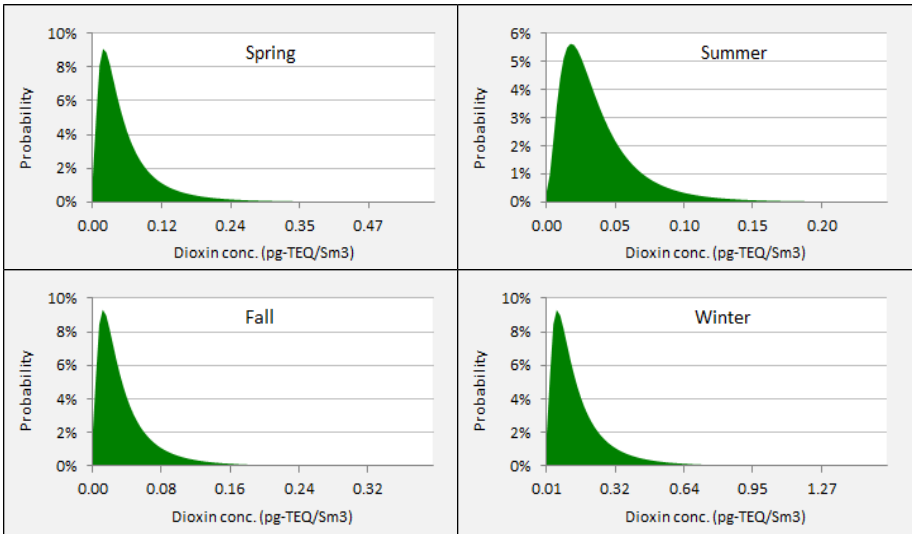


Fig. 1. The lognormal distribution of PCDDs/PCDFs concentration in ambient air.

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

| | PCDDs/PCDFs concentration (pg-TEQ/Sm$^3$) | | | |
|---|---|---|---|---|
| | min. | max. | mean | S.D. |
| Spring | 0.011 | 0.209 | 0.062 | 0.063 |
| Summer | 0.003 | 0.010 | 0.042 | 0.030 |
| Fall | 0.010 | 0.160 | 0.041 | 0.043 |
| Winter | 0.023 | 0.520 | 0.163 | 0.168 |

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

(unit : pg-TEQ/kg/day)

| | | Spring | Summer | Fall | Winter |
|---|---|---|---|---|---|
| Single-Estimated value | CTE[1)] | 2.5E-03 | 3.1E-03 | 1.6E-03 | 6.7E-03 |
| | Mean | 4.6E-03 | 3.1E-03 | 3.1E-03 | 1.2E-02 |
| | RME[2)] | 1.5E-02 | 7.3E-03 | 1.0E-02 | 3.9E-02 |
| Probabilistic exposure | 0 % | 2.7E-04 | 3.4E-04 | 2.1E-04 | 2.6E-04 |
| | 10 % | 1.1E-03 | 1.1E-03 | 7.2E-04 | 2.9E-03 |
| | 20 % | 1.5E-03 | 1.4E-03 | 1.0E-03 | 4.3E-03 |
| | 30 % | 2.1E-03 | 1.8E-03 | 1.4E-03 | 5.4E-03 |
| | 40 % | 2.6E-03 | 2.2E-03 | 1.8E-03 | 6.9E-03 |
| | 50 % | 3.2E-03 | 2.6E-03 | 2.2E-03 | 8.7E-03 |
| | 60 % | 4.0E-03 | 3.1E-03 | 2.7E-03 | 1.0E-02 |
| | 70 % | 5.0E-03 | 3.6E-03 | 3.4E-03 | 1.3E-02 |
| | 80 % | 6.4E-03 | 4.5E-03 | 4.4E-03 | 1.8E-02 |
| | 90 % | 9.5E-03 | 6.1E-03 | 6.5E-03 | 2.5E-02 |
| | 100 % | 5.0E-02 | 1.7E-02 | 3.3E-02 | 1.2E-01 |

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

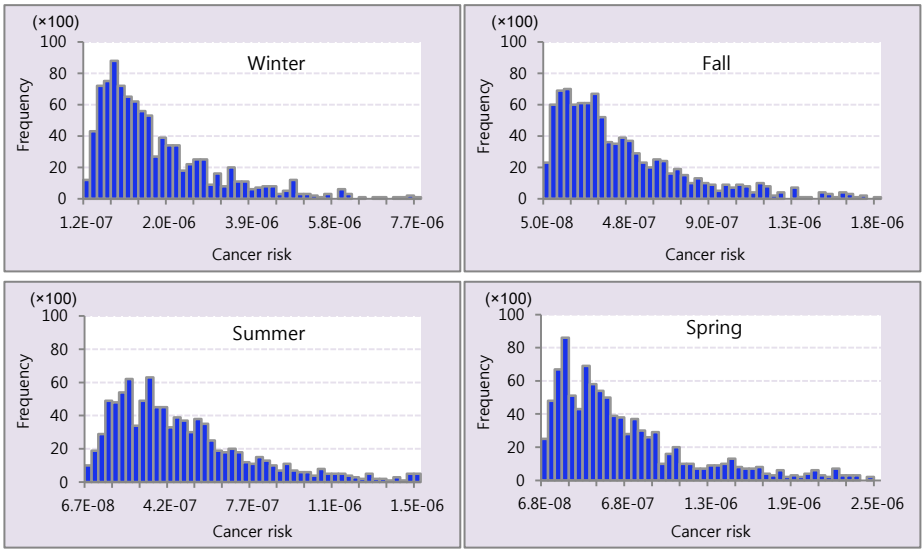


Fig. 2. Seasonal cancer risk of PCDDs/PCDFs

Table 5. Cancer risk by both single-estimated value and probabilistic exposure

| | | Spring | Summer | Fall | Winter |
|---|---|---|---|---|---|
| Single-Estimated value | CTE[1)] | 3.9E-07 | 4.8E-07 | 2.6E-07 | 1.1E-06 |
| | Mean | 7.2E-07 | 4.8E-07 | 4.8E-07 | 1.9E-06 |
| | RME[2)] | 2.4E-06 | 1.1E-06 | 1.6E-06 | 6.0E-06 |
| Probabilistic exposure | 0 % | 4.3E-08 | 5.2E-08 | 3.3.E-08 | 4.0E-08 |
| | 10 % | 1.6E-07 | 1.6E-07 | 1.1E-07 | 4.5E-07 |
| | 20 % | 2.3E-07 | 2.2E-07 | 1.6E-07 | 6.7E-07 |
| | 30 % | 3.3E-07 | 2.8E-07 | 2.2E-07 | 8.5E-07 |
| | 40 % | 4.1E-07 | 3.4E-07 | 2.8E-07 | 1.1E-06 |
| | 50 % | 5.0E-07 | 4.0E-07 | 3.4E-07 | 1.4E-06 |
| | 60 % | 6.2E-07 | 4.8E-07 | 4.3E-07 | 1.6E-06 |
| | 70 % | 7.8E-07 | 5.6E-07 | 5.3E-07 | 2.1E-06 |
| | 80 % | 9.9E-07 | 7.0E-07 | 6.9E-07 | 2.7E-06 |
| | 90 % | 1.5E-06 | 9.5E-07 | 1.0E-06 | 4.0E-06 |
| | 100 % | 7.9E-06 | 2.6E-06 | 5.1E-06 | 1.9E-05 |

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

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