ESTIMATING DIETARY EXPOSURE BASED ON AGRICULTURAL SOIL PCDDs/Fs LEVELS

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Introduction

The two mechanisms related in atmospheric distribution of PCDDs/Fs were long-range transport and soil deposition[1]. PCDDs/Fs adsorb tightly to particulates and as a consequence undergo slow migration through soils. Terrestrially deposition PCDDs/Fs adsorbed to particulates may be transferred into aquatic systems. Depending on locale, soil samples have been reported to contain up to several micrograms of PCDDs/Fs per kilogram of soil [2]. Rural soil samples have generally been reported to contain less, on the order of a few hundred nanograms of PCDDs/Fs per kilogram of soil. Such spatial trends reflect the importance of proximity to point sources[1,2].

On PCDDs/Fs persistence in soil, it was reported that 2,3,7,8-TCDD probably has a half-life of 25 to 100years in subsurface soil and 9 to 15 years at the soil surface (i.e., the top 0.1cm)[3].

MEPAS (Multimedia Environmental Pollutant Assessment System) [4] as model for simulating multimedia-based risk resulting from contaminant release from a single source to multiple environmental media can be used to predict site-specific exposure and risk.

This study was to estimate transported PCDDs/Fs levels from agricultural soil to plant like vegetable, cereal and fruit and to quantify daily dietary PCDDs/Fs exposure by ingestion of tainted food.

PCDDs/Fs Levels in Agricultural Soil

PCDDs/Fs levels in agricultural soil were presented in Table 1 with terms of means, range and sample sizes. Estimates for PCDDs/Fs levels in soil were based on a variety of investigation conducted at different location in Korea. TEQs in this study was computed by assuming that nondetects equaled zero.

Table 1. PCDDs/Fs levels in soil samples collected in agricultural area[5]

		(MOE, 1999)	
Detection limit :	4~5 Cl (0.2pg/L),	6~7 Cl (0.4pg/L),	8 Cl (1pg/L)

Exposure Calculation Method

The relationship between concentration of PCDDs/Fs in soil and transfer factor for leafy vegetable, fruit and cereal was determined with soil-vegetable partition coefficient as 5.06E-03 (g-soil/g-dry plant) suggested by MEPAS 4.1[4]. This parameter is the ratio of plant chemical concentration (dry weight) for leafy vegetables to the soil chemical concentration (based on dry soil). The soil-to-plant concentration ratio accounts for the uptake from soil and transport through roots to the edible plant parts.

For estimation of dietary exposure, the first step was to calculate PCDDs/Fs levels in foods by assuming that vegetable and fruit will be produced from field with 0.287pg-TEQ/g as mean and cereal will be produced from paddy field with 0.019pg-TEQ/g as mean.

The second step was to calculate dietary PCDDs/Fs exposure by ingestion of vegetable, fruit and cereal transported from contaminated soil.

Moisture contents in food (moisture weight / total weight) to convert from transported PCDDs/Fs in food producing as dry basis to wet basis as really edible condition were regarded for quantification of dietary exposure.

Table 2. Estimation for dietary exposure of PCDDs/Fs
Mean (range)

Foods	Transported PCDDs/Fs* (pg-TEQ/g-dry plant)	Ingestion Rate** (g-wet/day)	Moisture Content in Food (w/w)	Dietary Exposure (pg-TEQ/kg/day)
Vegetable	1. 45E-3 (0~6.05E-3)	283.5	0.9	8.01E-4 (0~3.34E-3)
Fruit	1. 45E-3 (0~6.05E-3)	197.5	0.9	5.01E-4 (0~2.09E-3)
Cereal (only rice)	9.65E-5 (0~3.69E-4)	246.1	0.15	3.61E-4 (0~1.38E-3)
Total	**1.66E-3 pg-TEQ/kg/day** (0~6.80E-3)			

* PCDDs/Fs mean level transported from soil to the edible plant parts
**Adult mean in 20-64yrs supported by Report on 1998 National Health and Nutrition Survey[6]

$$\text{Dietary Exposure} = \sum_{i=1}^{n} \frac{C_i \times IR_i \times (1\text{-}MC_i) \times P_{soil}}{BW}$$

Dietary Exposure : Daily dietary PCDDs/Fs exposure by intake of vegetable, fruit and cereal (pg-TEQ/kg/day)
C_i : Concentration of PCDDs/Fs in food *i*, (pg-TEQ/g-dry)
IR_i : Ingestion rate of food *i* (g-wet /day, Ministry of Health and Welfare, 1999)[6]
MC_i : Moisture content in food $_i$ (w/w)
P_{soil} : Soil to plant partition coefficients of TCDD (0.00506 g-soil/g-dry plant, MEPAS)
BW: Body weight (60kg, adult mean, Korea Research Institute of Standard and Science, 1998)[7]

In this study consumption rate of cereal was considered as rice which is mainly produced in domestic paddy field. For estimation of dietary PCDDs/Fs exposure, the general Korean adult group with 60kg as mean of man and woman was regarded as the target population and National Health and Nutrition Survey (MHW, 1999)[6] was used as mean consumption data for the food groups.

PCDDs/Fs levels as mean in vegetable and rice predicted using soil-vegetable partition coefficient was approximately 10 fold lower levels than food monitored data which was previously reported (KFDA, 2000)[8].

The estimated daily dietary PCDDs/Fs exposure by ingestion of vegetable, grain and cereal was 1.66E-3 pg-TEQ/kg/day as mean value (Table 2). PCDDs/Fs intake of the high-risk group exposed with foods which can be produced at upper levels of agricultural soil (Table 1) may be increased to 4 fold higher level than the mean as 6.80E-3 pg-TEQ/kg/day.

The feature of Korean food consumption pattern is the ingestion rate of vegetable and cereals is higher than that of meat and dairy product.

This data will be used as basic information for management of agricultural soil.

Discussion and Conclusion

Assuming transported PCDDs/Fs level were 1.45E-3 pg-TEQ/g for vegetables and fruits, and 9.65E-5 pg-TEQ/kg/day for the cereals from soil-vegetable partition coefficient and PCDDs/Fs levels in agricultural soil.

The estimated daily dietary PCDDs/Fs exposure by ingestion of vegetable, fruit and cereal was 1.66E-3 pg-TEQ/kg/day as mean value.

PCDDs/Fs intake of the high risk group who can be exposed at upper soil levels may be increased to 4 fold higher than the mean.

If maximum contaminated level goals of PCDDs/Fs to the vegetable, fruit and cereal are decided by consideration of dietary exposure pattern and TCDD TDI (Tolerable Daily Intake), this study can be used for establishment of PCDDs/Fs limit in agricultural soil.

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