# DIOXIN REGULATION AND RESEARCH ACTION IN JAPAN

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ABSTRACT

The levels of polychlorinated dibenzo-p-dioxins (PCDDs) and dibenzofurans (PCDFs) in Japanese environmental samples are calculated to the levels of 2,3,7,8-tetrachlorodibenzo-p-dioxin (TCDD) equivalent and the Japanese pollution condition is evaluated by comparing the calculated levels of TCDD equivalent in the daily intakes of samples to the acceptable daily intakes (ADI) of some nations. The smallest daily intake of TCDD equivalent for causing Yusho was calculated to be 28 ng/kg/day. Therefore, intake of 100 pg/kg/day would not cause any Yusho like symptoms. When the toxicities of coplanar polychlorinated biphenyls (PCBs) are converted to TCDD equivalent, toxic contribution of the PCBs is higher than those of PCDDs and PCDFs in the adipose tissue of normal persons.

## Evaluation of environmental pollution by TCDD equivalents

Many American and European countries have adopted the acceptable daily intakes (ADI) from 1 to 10 pg/kg/day for controlling the level of PCDDs and PCDFs in the environment (1). Japan has not set the ADI but has used the Evaluating Indicator, 100 pg/kg/day, for assessing municipal incinerators (2). When the quantities of ADI and Evaluating Indicator are assumed to be contained in air, water, fish and breast milk of daily intake, allowable concentrations of TCDD toxic equivalent in the samples are estimated as listed in Table 1. The concentrations of PCDDs and PCDFs in Japanese environmental samples analyzed are shown in Table 2. Concentrations of PCDDs and PCDFs in air of Kobe were measured as 8.6 and 8.8 pg/$m^3$ (3), calculating 0.4 pg/$m^3$ of TCDD equivalent. Flue gas from a municipal incinerator is assumed to be dispersed 200,000 times when it reached to the ground surface where people live. Therefore, the concentrations 800--80,000 ng/$m^3$ of TCDD equivalent in flue gas are considered to be allowable under the ADI 1--100 pg/kg/day (Table 1). The concentration of PCDDs and PCDFs were determined less than 24,000 ng/$m^3$ in Japanese incinerators (4), calculating less than 480 ng/$m^3$ for TCDD equivalent. No data have been reported for PCDDs and PCDFs in drinking water in Japan. Water from the landfill of fly ash from municipal incinerator was determined for PCDDs and PCDFs 15.9 ng/L (5), estimating probably to 0.32 ppt of TCDD equivalent. Drinking water may contain much less than this value. Fish in American and European countries were frequently analyzed for PCDDs and PCDFs and their TCDD equivalents were calculated. However, just a few data have been reported in

Japan (6). The data suggests that TCDD equivalents in Japanese fish are calculated to be 10 ppt at the highest. Japanese may ingest 6 pg/kg/day level of TCDD equivalent with fish in an extreme case. Japanese breast milk (7) was calculated to contain 35 ppt (fat basis) of TCDD equivalent on average. Normal persons in Japan are seemed to consume TCDD equivalent less than 10 pg/kg/day by air, water and fish (Table 1). Some Japanese babies probably ingest more than 100 pg/kg/day level of TCDD equivalent with breast milk during lactation.

Table 1 Calculated concentration of TCDD equivalent in Japanese air, water and food, assuming the ADI values of TCDD contained in the daily intakes

| | | Allowable concentration | | |
|---|---|---|---|---|
| | | ADI value (pg/kg/day) | | |
| | Daily intake | 1 | 10 | 100 |
| Air | 15 $m^3$/day | 4 | 40 | 400 $pg/m^3$ |
| (Flue gas | 15/200,000 | 800 | 8000 | 80000 $ng/m^3$) |
| Water | 1.5 L/day | 0.04 | 0.4 | 4 ppt |
| Fish | 90 g/day | 0.6 | 6 | 60 ppt |
| Breast milk | 150 ml/kg/day | 0.007 | 0.07 | 0.7 ppt |
| (Milk fat | 3.75 g/kg/day | 0.28 | 2.8 | 28 ppt) |

In the underlined ranges, the environmental samples are polluted.

Table 2 Concentrations of PCDDs and PCDFs in various Japanese samples

| | PCDDs | PCDFs | PCBs | TCDD equivalent |
|---|---|---|---|---|
| Air in Kobe | 8.6 $pg/m^3$ | 8.8 $pg/m^3$ | 2.8 $ng/m^3$ | (0.35 $pg/m^3$) |
| | 1.4--37 | 2.2--22 | 0.9--11.7 | |
| Flue gas from | 1510 $ng/m^3$ | 2520 $ng/m^3$ | | (80.6 $ng/m^3$) |
| Municip. Incine. | 133--13600 | 436--10000 | | |
| Water from the landfill | 5.3 ng/L | 10.6 ng/L | | (0.3 ng/L) |
| Blue mussel(Osaka) | 260 ppt | | 76 ppt | (8.3 ppt) |
| Fish (Japan) | 1--26 ppt | 1--71 ppt | | --5 ppt |
| Chicken fat(Fat b) | 33--600 ppt | | | (1--54 ppt) |
| Cattle milk(Fat b) | 17--34 ppt | | | (1--8 ppt) |
| Breast milk(Prim) | 1105 ppt | 167 ppt | | 35 ppt |
| (Fat basis) | 845--1326 | 92--254 | | |
| Breast milk(Multi) | 674 ppt | 91 ppt | | 13 ppt |
| (Fat basis) | 498--894 | 43--156 | | |

Data are cited from Nakano et al.(3), Hiraoka et al.(4,5), Miyata et al. (6), Ogaki et al.(7).
Values in parenthesis are assumption for TCDD equivalent by Y.M.

## Environmental risk evaluation by Yusho poisoning

The ADI values used for assessment of environmental levels of PCDDs and PCDFs were estimated from the toxicity in animals. Human toxicity of PCDDs and PCDFs is important for elucidating the ADI values. Yusho, a mass food poisoning with rice oil containing PCBs, PCDFs, PCDDs and other chlorinated aromatics, occurred in Western Japan in 1968. Intakes of PCBs, PCDFs and clinical symptoms were examined in some group of Yusho patients (8). Table 3 lists the intakes of rice oil and TCDD equivalent calculated from the concentrations of PCDF and PCDD isomers in the rice oil (9). The smallest daily intake of TCDD equivalent, 28 ng/kg/day was obtained from a patient who had consumed 0.031 ml/kg/day of rice oil for 135 days of latent period. Therefore, intake of 100 pg/kg/day, 1/280 of 28 ng/kg/day, for several years would not cause any Yusho like symptoms.

Table 3 Estimated intakes of rice oil and TCDD equivalent in Yusho patients

| | Rice oil | TCDD equivalent |
|---|---|---|
| Average total intake per capita | 688 ml | 0.62 mg |
| Average intake during latent period | 506 ml | 0.46 mg |
| Smallest intake during latent period | 121 ml | 0.11 mg |
| Smallest daily intake during latent period | 0.031 ml/kg/day | 28 ng/kg/day |

TCDD equivalents were calculated by 0.905 ppm in Yusho oil.
Data from Hayabuchi et al.(8).

## Environmental levels of PCBs, PCDDs and PCDFs

Environmental samples are contaminated with not only PCDDs and PCDFs but also PCBs and their PCB levels are usually much higher than those of PCDDs and PCDFs (10). As the toxicities of most PCBs are much weaker than those of PCDDs and PCDFs, toxicological contribution of environmental samples has been considered with only toxic PCDDs and PCDFs. However, coplanar PCBs are more toxic than other PCBs and the toxicity of 3,4,5,3',4'-pentachlorobiphenyl is comparable to those of toxic PCDDs and PCDFs (11,12). Coplanar PCBs are minor components in the PCBs of environmental pollution. However, their concentrations are much higher than those of PCDDs and PCDFs in most of polluted sample in the environment (13). For that example, Table 4 shows the concentrations of toxic PCDDs, PCDFs and PCBs in human adipose tissue (14). The TCDD toxic equivalent factors used for the toxic PCDDs and PCDFs are cited from the international method (15). The relative toxic potencies for coplanar PCBs are obtained from the aromatic hydrocarbon hydroxylase activities relative to that of TCDD (11,12). The concentration of TCDD equivalents were calculated from the concentrations and equivalent factors. Toxic contribution of the PCBs (72.5 %) is higher than those of PCDDs and PCDFs in the adipose tissue of normal persons (Table 4). As the environmental animals have been reported to be contaminated with coplanar PCBs much higher than PCDDs and PCDFs, their toxic threat will be mainly by coplanar PCBs and minor by PCDDs and PCDFs. Coplanar PCBs are significant compounds of toxic importance in the environmental animals.

Table 4 *Concentrations and TCDD equivalents for major components of PCDDs, PCDFs and PCBs in human adipose tissue*

| | Concentration (N=12) (ppt) | Equivalent factor | TCDD equivalent (ppt) |
|---|---|---|---|
| 2,3,7,8-TCDD | 9.6 | 1 | 9.6 |
| 1,2,3,7,8-PCDD | 15.9 | 0.5 | 7.95 |
| 1,2,3,4,7,8-HCDD | 8.1 | 0.1 | 0.81 |
| OCDD | 251 | 0.001 | 0.251 |
| Total PCDDs | 284.6 | | 18.6 (13.8 %) |
| 2,3,7,8-TCDF | 9.4 | 0.1 | 0.94 |
| 2,3,4,7,8-PCDF | 29.1 | 0.5 | 14.55 |
| 1,2,3,4,7,8-HCDF | 14.9 | 0.1 | 1.5 |
| 1,2,3,6,7,8-HCDF | 14.9 | 0.1 | 1.5 |
| Total PCDFs | 68.3 | | 18.5 (13.7 %) |
| 3,4,3',4'-TCB | 348 | 0.0021* | 0.73 |
| 3,4,5,3',4'-PCB | 324 | 0.3* | 97.2 |
| 3,4,5,3',4',5'-HCB | 89.5 | 0.0012* | 0.11 |
| Total PCBs | 761.5 | | 98.04 (72.5 %) |

* Relative potencies are calculated from AHH data of Safe(11,12). Data are from Kannan et al.(14).

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