Item ID Number 02196

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Report/Article Title Risk Assessment, Binghamton State Office Building

Journal/Book Title

Year 1982

Month/Day March 29

Color ☐

Number of Images 11

Descripton Notes

RISK ASSESSMENT

BINGHAMTON STATE OFFICE BUILDING

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March 29, 1982

Two methods are commonly used for establishing standards or guidelines for contaminant levels in food, air or water. One method is to perform an extrapolation to low level exposure using data from a high dose carcinogenic bioassay; this procedure calculates a dose which corresponds to a given lifetime cancer risk. The second is to establish an acceptable daily intake (ADI) usually based on a no observed effect level (NOEL) in an animal study. The only polychlorinated dioxin or furan which has been studied sufficiently to perform a risk assessment is 2,3,7,8-TCDD. This compound has caused cancer in laboratory animals but is not a genotoxin. The scientific community is divided on the proper procedures to use under this circumstance. In the following discussion risk assessments using both carcinogenic extrapolation procedures and a no observed effect level will be used.

Normally the establishment of an ADI from a NOEL is not used for compounds which have been found to be carcinogenic. However, 2,3,7,8-TCDD is not genotoxic and some scientists believe that the establishment of a no observed effect level is justified under these circumstances. For 2,3,7,8-TCDD, a no observed effect level of 0.001 ug/kg-day in rats has been reported in both a three generation reproduction study[1] and a two year oncology study.[2] An uncertainty factor is applied to the no effect level. Since long-term animal studies are available for this compound, an uncertainty factor of 100 is appropriate. The acceptable daily intake for humans would be 1×10^{-5} ug/kg-day.

Cancer risk extrapolations have been used since the early 1960's. Once a dose-response relationship is established, an "acceptable" risk level must be assumed and the corresponding dose calculated. Mantel-Bryan[3] originally defined a virtually safe risk for a lifetime as 1×10^{-8}.

Since then, other regulatory agencies have used a risk of 1×10^{-6} for setting standards or guidelines.[4]

The Carcinogen Assessment Group of the EPA has performed a risk assessment for 2,3,7,8-TCDD using a carcinogenic extrapolation procedure.[5] The 1×10^{-6} risk was found to correspond to a dose level of 2.36×10^{-9} ug/kg-day.

Recently a new method for handling non-genotoxic carcinogens has been suggested. This method uses the dose corresponding to a 1×10^{-2} cancer risk level. This dose is corrected for surface area differences between species. Scientific opinion is divided as to whether or not additional uncertainty factors should be used. In the following risk assessment, the surface area correction and an uncertainty factor of 100 are applied. The dose corresponding to a 1×10^{-2} risk is 0.0026 ug/kg-day. The appropriate daily intake is calculated to be 4.7×10^{-6} ug/kg-day. Since this daily intake is one-half of the ADI calculated from the no-effect level, the guidelines for air samples and wipes using this procedure would be one-half that shown in Tables 1-6 for ADI calculations.

Three different exposure routes are possible for workers in the Binghamton State Office Building: inhalation, ingestion and dermal exposure. The assumption that a worker would be exposed for 30 years, 250 days per year is considered to be the maximum possible exposure. For the inhalation calculations, a respiratory volume of 10 m^3 is assumed for an 8 hour work day. For the ingestion calculations, a worker is assumed to ingest the particulate matter on 1 m^2 of surface area. (This could be possible from food being placed on a work surface or from particulate matter adhering to hands which could subsequently contaminate food and be ingested.) Dermal exposure is considered to be negligible compared to the other two routes of exposure; this decision is based in part on the acute dermal studies conducted by the Toxicology Institute. Inhalation exposure is assumed to account for one-half of the daily exposure and ingestion the other half.

Three different scenarios are used in the calculation of the daily exposure over the 30 year period. Scenario A assumes that the contaminant concentration remains constant during the 30 year period. In Scenario B a first order decomposition curve is calculated, assuming that over 30 years contamination levels drop to one percent of the values when the building is reoccupied. Using this approach, a slightly higher concentration would be acceptable in the building when its reopened. Scenario C also employs a first order decomposition curve, but assumes a half-life of one year for the disappearance of contaminants in the building.

Tables 1-6 contain contaminant concentrations in air or surface wipe samples calculated from the two risk assessment procedures and the three exposure scenarios. Tables 1-3 include the 2,3,7,8-TCDD equivalence factor of 58 which takes into account the toxicity of all the other compounds.[7] Tables 4-6 contain contaminant concentrations based only on the toxicity of 2,3,7,8-TCDD. If the concentration ratios of contaminant compounds remain constant, the decision to reopen the building can be based on the concentration of any one compound. Thus, the guidelines can be expressed in alternate forms; Tables 1 and 4 are in terms of 2,3,7,8-TCDD concentration, Tables 2 and 5 are in terms of PCBS, and Tables 3 and 6 are in terms of 2,3,7,8-TCDF. A sample calculation for an air concentration based on the ADI, Scenario A, the toxicity assumption of 2,3,7,8-TCDD equivalents, and sample analysis for 2,3,7,8-TCDD is provided below.

$$\text{total lifetime exposure} = (0.01\ \text{ng/kg})(70\ \text{kg})(70\ \text{years})(365\ \text{days/year}) = 17885\ \text{ng}$$

$$\text{air concentration} = 17885\ \text{ng} \times \frac{1}{30\ \text{years}} \times \frac{\text{year}}{250\ \text{days}} \times \frac{\text{day}}{10\ \text{m}^3} \times \frac{1}{58\ \text{TCDD equivalents}} \times \frac{1^*}{2} = 0.002\ \text{ng/m}^3$$

*One-half the daily exposure comes from inhalation sources, the other from ingestion.

The available toxicologic data on other compounds beside 2,3,7,8-TCDD are very limited and in most cases none exist. Some reassurance as to the appropriateness of using chronic 2,3,7,8-TCDD data for TCDD equivalents can be obtained by examining the bioassay that was completed for a mixture of 1,2,3,6,7,8- and 1,2,3,7,8,9-hexachlorodibenzo-p-dioxin. Using a multi-hit extrapolation procedure, a value of 7.5×10^{-6} ug/day for humans is found to correspond to a 1×10^{-6} risk level. From this extrapolation procedure, hexachlorodibenzo-p-dioxin mixture is found to be 45 times less potent as a carcinogen than 2,3,7,8-TCDD. For acute data, the hexachloro-p-dioxin compounds are approximately 29 times less potent than the 2,3,7,8-TCDD isomer. These two factors are, probably fortùitously, in good agreement.

Guideline values in Tables 1-6 should be compared with Table 7, a summary of surface and air contamination measurements. Surface wipe values are given before and after cleaning with various solvents. Comparing, for example, the surface wipe guideline in Table 2 derived from the ADI, with the PCB values in Table 7, the guideline falls within the range of surface contamination levels obtained on cleaned desks. Probable detection limits for PCB, TCDD, and TCDF in surface and air samples are given in Table 8.

Other environmental exposures to 2,3,7,8-TCDD are possible. Several samples are calculated so that these values can be compared with the guidelines for air and wipe samples.

Example 1

A person consumes one meal of fish (one-half pound) which is contaminated with 2,3,7,8-TCDD at the Dept. of Health guideline of 10 ppt.

$$(227 \text{ g of fish}) \frac{(0.01 \text{ ng of 2,3,7,8-TCDD})}{\text{g of fish}} = 2.3 \text{ ng of 2,3,7,8-TCDD}$$

Example 2

Recently the Environmental Protection Agency has been evaluating possible 2,3,7,8-TCDD emissions from resource recovery plants. In its recent report[6], EPA stated that there was "no reason for concern" for concentrations of up to 3.8×10^{-5} ng/m^3 of 2,3,7,8-TCDD in the ambient air. If a person inhales 20 m^3 of air per day, then the 2,3,7,8-TCDD intake would be 7.6×10^{-4} ng/day, or 2.8×10^{-1} ng/year or 8.3 ng/30 years.

Example 3

The standard used at Seveso for reoccupancy of buildings was 10 ng/m^2 of 2,3,7,8-TCDD on interior surfaces.

Example 4

The Environmental Protection Agency in its risk assessment document[5] calculated 2,3,7,8-TCDD intake from contaminated beef fat from the use of 2,4,5-T on range land. The report is quoted below.

> "Based on the 4.2 ppt TCDD contamination level in beef fat and a beef consumption of approximately 100 lb/person/year, HED estimates that TCDD dietary intake from beef for the general population is approximately 0.4 pg/day. For the local population consuming only contaminated beef, dietary intake could be as high as 31 pg TCDD/person/day assuming a 5-year treatment cycle.
>
> Likewise, for milk contamination, assumption of 4.2 ppt TCDD in fat of grazing cows would project to as much as 74 pg TCDD/day dietary intake for local populations or for those consuming only contaminated dairy products. Measurements of silvex in milk assumed similar for 2,4,5-T, yield exposure estimates of 7.1 ng/kg/day 2,4,5-T for the local population."

Table 1

Guidelines Calculated Using 2,3,7,8-TCDD Equivalents

	Scenario A	Scenario B	Scenario C
Air - ADI	0.002 ng/m^3	0.010 ng/m^3	0.044 ng/m^3
Air - Cancer Risk	4.8×10^{-7} ng/m^3	2.3×10^{-6} ng/m^3	1.0×10^{-5} ng/m^3
Wipes - ADI	0.020 ng/m^2	0.10 ng/m^2	0.44 ng/m^2
Wipes - Cancer Risk	4.8×10^{-6} ng/m^2	2.3×10^{-5} ng/m^2	1.0×10^{-4} ng/m^2

Table 2

Values in Table 1 Expressed in Terms of PCB Concentration

	Scenario A	Scenario B	Scenario C
Air - ADI	2.1 ng/m^3	11 ng/m^3	47 ng/m^3
Air - Cancer Risk	5.1×10^{-4} ng/m^3	2.4×10^{-3} ng/m^3	1.1×10^{-2} ng/m^3
Wipes - ADI	21 ng/m^2	110 ng/m^2	470 ng/m^2
Wipes - Cancer Risk	5.1×10^{-3} ng/m^2	2.4×10^{-2} ng/m^2	0.11 ng/m^2

Table 3

Values in Table 1 Expressed in Terms of 2,3,7,8-TCDF

	Scenario A	Scenario B	Scenario C
Air - ADI	0.14 ng/m^3	0.7 ng/m^3	3.1 ng/m^3
Air - Cancer Risk	3.4×10^{-5} ng/m^3	1.6×10^{-4} ng/m^3	7×10^{-4} ng/m^3
Wipes - ADI	1.4 ng/m^2	7 ng/m^2	31 ng/m^2
Wipes - Cancer Risk	3.4×10^{-4} ng/m^2	1.6×10^{-3} ng/m^2	7×10^{-3} ng/m^2

Table 7 Binghamton State Office Building Contamination Measurements

Date	Location	Type	Contaminant	Level
Feb. 1981	Throughout building	Air-florisil	PCB (1254)	0.21-8.7 ug/m^3
"	Top of ceiling panel	Dry wipe	PCB	1000-6300 ug/m^2
"	Floors, top of cabinet	"	PCB	140-800 ug/m^2
"	Shelf inside cabinet	"	PCB	480 ug/m^2
"	Doors-vertical surf.	"	PCB	8-64 ug/m^2
"	Floor-cleaned	"	PCB	69 ug/m^2
"	Desks-cleaned	"	PCB	0.4-58 ug/m^2
March 1981	Air particulates	Hi-Vol	TSP	2-3 ug/m^3
"	"	"	PCB	"0"-0.002 ug/m^3
"	Air-vapor	Florisil	PCB	0.45-2.2 ug/m^3
"	Air-particulates	Hi-Vol	2,3,7,8-TCDD	0.92 pg/m^3
"	"	"	Total TCDD	1.4 pg/m^3
"	"	"	2,3,7,8-TCDF	60 pg/m^3
"	"	"	Total TCDF	321 pg/m^3
"	Air-"Volatiles"	Florisil	2,3,7,8-TCDD	3 pg/m^3
"	"	"	Total TCDD	5 pg/m^3
"	"	"	2,3,7,8-TCDF	26 pg/m^3
"	"	"	Total TCDF	292 pg/m^3

Table 8. Lowest Detection Limits (in surface or air samples)

PCB = 3 pg   TCDD, TCDF: 10 pg (possibly 1 pg)

Table 4

Guidelines Based on 2,3,7,8-TCDD Alone

	Scenario A	Scenario B	Scenario C
Air - ADI	0.12 ng/m^3	0.58 ng/m^3	2.6 ng/m^3
Air - Cancer Risk	2.8×10^{-5} ng/m^3	1.3×10^{-4} ng/m^3	5.8×10^{-4} ng/m^3
Wipes - ADI	1.2 ng/m^2	5.8 ng/m^2	26 ng/m^2
Wipes - Cancer Risk	2.8×10^{-4} ng/m^2	0.0013 ng/m^2	0.0058 ng/m^2

Table 5

Values in Table 4 Expressed in Terms of PCB Concentration

	Scenario A	Scenario B	Scenario C
Air - ADI	120 ng/m^3	620 ng/m^3	2700 ng/m^3
Air - Cancer Risk	0.030 ng/m^3	0.14 ng/m^3	0.62 ng/m^3
Wipes - ADI	1200 ng/m^2	6200 ng/m^2	27000 ng/m^2
Wipes - Cancer Risk	0.30 ng/m^2	1.4 ng/m^2	6.2 ng/m^2

Table 6

Values in Table 4 Expressed in Terms of 2,3,7,8-TCDF

	Scenario A	Scenario B	Scenario C
Air - ADI	8.4 ng/m^3	41 ng/m^3	180 ng/m^3
Air - Cancer Risk	0.002 ng/m^3	0.0091 ng/m^3	0.041 ng/m^3
Wipes - ADI	84 ng/m^2	410 ng/m^2	1800 ng/m^2
Wipes - Cancer Risk	0.020 ng/m^2	0.091 ng/m^2	0.41 ng/m^2

Table 7 Binghamton State Office Building Contamination Measurements

Date	Location	Type	Contaminant	Level
Feb. 1981	Throughout building	Air-florisil	PCB (1254)	0.21-8.7 ug/m^3
"	Top of ceiling panel	Dry wipe	PCB	1000-6300 ug/m^2
"	Floors, top of cabinet	"	PCB	140-800 ug/m^2
"	Shelf inside cabinet	"	PCB	480 ug/m^2
"	Doors-vertical surf.	"	PCB	8-64 ug/m^2
"	Floor-cleaned	"	PCB	69 ug/m^2
"	Desks-cleaned	"	PCB	0.4-58 ug/m^2
March 1981	Air particulates	Hi-Vol	TSP	2-3 ug/m^3
"	"	"	PCB	"0"-0.002 ug/m^3
"	Air-vapor	Florisil	PCB	0.45-2.2 ug/m^3
"	Air-particulates	Hi-Vol	2,3,7,8-TCDD	0.92 pg/m^3
"	"	"	Total TCDD	1.4 pg/m^3
"	"	"	2,3,7,8-TCDF	60 pg/m^3
"	"	"	Total TCDF	321 pg/m^3 ←
"	Air-"Volatiles"	Florisil	2,3,7,8-TCDD	3 pg/m^3
"	"	"	Total TCDD	5 pg/m^3
"	"	"	2,3,7,8-TCDF	26 pg/m^3
"	"	"	Total TCDF	292 pg/m^3

0.026 ng

Table 8. Lowest Detection Limits (in surface or air samples)

PCB = 3 pg TCDD, TCDF: 10 pg (possibly 1 pg)

$.002 \frac{ng}{m^3} = 2 \frac{pg}{m^3}$

Table 9

Exposure Calculations Assuming Contamination Decreases Over Time

Scenario B: C_o = initial concentration

$$C(30) = 0.01C_o$$

$$C(30) = C_o e^{-b(30)}$$

$$C_o e^{-30b} = 0.01C_o$$

$$e^{-30b} = 0.01$$

$$b = 0.15$$

This means that after one year $C(1) = C_o e^{-0.15} = 0.86\ C_o$, so that contamination decreases by 14%.

The total exposure over 30 years equals the sum of exposure over time, or the integral

$$\int_0^{30} C(t)dt = \int_0^{30} C_o e^{-0.15t} dt = 6.4\ C_o$$

(units of this expression are years x concentration)

Sample calculation:

$$6.4\ C_o \frac{\text{ng-years}}{m^3} = 17885\ ng * \frac{1}{250\ \text{days}} * \frac{1}{10m^3} * \frac{1}{58} * \frac{1}{2}$$

$$C_o(ng/m^3) = 17885\ ng\ \frac{\text{year}}{250\ \text{days}} * \frac{\text{day}}{10m^3} * \frac{1}{38} * \frac{1}{2} * \frac{1}{6.4\ \text{years}}$$

$$C_o(ng/m^3) = 0.010\ ng/m^3$$

Scenario C:

$$C(1) = 0.5C_o$$

$$e^{-0.69} = 0.5$$

The total exposure over 30 years equals the sum of exposure over time, or the integral

$$\int_0^{30} C(t)dt = \int_0^{30} C_o e^{-0.69t} dt = 1.4C_o$$

Table 10

Calculations for Tables 2, 3, 5 and 6

Tables 2 and 5

$$\frac{2,3,7,8\text{-TCDF}}{2,3,7,8\text{-TCDD}} = \frac{198.5}{2.85} = 70$$

$$\frac{\text{PCB}}{\text{PCDF}} = \frac{1}{0.066}$$

$$\frac{0.002 \text{ ng of } 2,3,7,8\text{-TCDD}}{m^3} \times 70 \times \frac{1}{0.066} = \frac{2.1 \text{ ng of PCB}}{m^3}$$

Tables 3 and 6

$$\frac{2,3,7,8\text{-TCDF}}{2,3,7,8\text{-TCDD}} = 70$$

$$\frac{0.002 \text{ ng of } 2,3,7,8\text{-TCDD}}{m^3} \times 70 = \frac{0.14 \text{ ng of } 2,3,7,8\text{-TCDF}}{m^3}$$

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