

RISK ASSESSMENT

Risk Assessment for PCDD/F Exposure from Soil in the Neighbourhood of Two MSW Incinerators from Catalonia, Spain

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Abstract

The risk for adverse health effects of PCDD/F exposure from soil in the neighbourhood of an old (Montcada) and a modern (Tarragona) municipal solid waste incinerators from Catalonia (Spain) was assessed. The Hawley and the Pohl and associates models of exposure were used to determine annual average doses of PCDD/Fs for adults and young children. For carcinogenic risks, an oral potency scope for TCDD of 1.56×10^5 kg.day/mg was used. The results of the current assessment show that the daily intake of PCDD/Fs from soils in the vicinity of both plants is substantially less than the tolerable daily intake of 10 pg TEq/kg/day.

Introduction

The risk to human health by polluted soils in residential areas depends on the potential extent of exposure to soil and on the toxic properties of the pollutant.¹⁾ Polychlorinated dibenzo-*p*-dioxins (PCDDs) and dibenzofurans (PCDFs) were identified in the fly ash and flue gas of municipal incinerators about 20 years ago.²⁾ At present, municipal solid waste (MSW) incineration is one of the largest known sources of PCDD/Fs.^{3,4)}

The toxic effects of PCDD/Fs, and particularly those of TCDD, have been extensively studied over the last two decades. Although developmental and general system toxicity was initially of concern, a number of subsequent studies showed that TCDD is also carcinogenic in small mammals. Recently, the IARC has classified TCDD as a known human carcinogen.

Human exposure to PCDD/Fs primarily occurs via ingestion, whereas inhalation is a minor pathway. Although skin contact to polluted surfaces may occur, dermal absorption can be neglected.³⁾ It has been reported that daily ingestion of foods can mean up to 98% versus all sources and routes of PCDD/F exposure.⁵⁾ Based on general toxicologic effects (other than cancer) the WHO (1991) established a tolerable daily intake of 10 pg/kg/day for TCDD.⁶⁾ In turn, the oral carcinogenic

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potency slope for TCDD was reported to be 1.56×10^5 kg.day/mg.⁷⁾

Recently, we determined the concentrations of PCDD/Fs in soil samples collected in the vicinity of a modern and an old MSW incinerators from Catalonia (Spain). The purpose of the current study was, in the context of human exposure risk, to assess the potential for adverse health effects resulting from exposure to these soils.

Experimental Methods

The old and modern MSW incinerators began operating in 1975 and 1991, and are placed in Tarragona and Montcada (Catalonia, Spain), respectively. The individual daily intake of PCDD/Fs from soil was calculated according to the Hawley¹⁾ and Pohl et al.⁸⁾ models of exposure to contaminated soils.

Hawley exposure model:

Soil intake: adults (70 kg b.wt.), 66 mg/day; young children (13.2 kg b.wt.), 160 mg/day. Annual average dose of PCDD/Fs for adults = $0.94 \times C_s$ mg/kg/day; annual average dose of PCDD/Fs for young children = $12 \times C_s$ mg/kg/day; C_s : PCDD/F concentration (mg/kg)

Pohl et al. exposure model:

Soil intake: adults (70 kg b.wt.), 100 mg/day; children (10 kg b.wt.), 200 mg/day. Intake of PCDD/F (mg/kg/day) = $C_s \cdot IR \cdot EF \cdot 10^{-6}$ /body weight; C_s : PCDD/F concentration (mg/kg); IR: soil ingestion rate (mg/day); EF: exposure factor (according to the placement of the MSW incinerators, an EF of 9/70 was here assumed considering default values of 9 years for living in residential areas).

PCDD/F concentrations in soil samples collected in the vicinity of both MSW incinerators, as well as in rural soils (background levels) are given in Table 1 .

Table 1. PCDD/F levels (ng TEq/kg, dry matter) in soil samples collected in the vicinity of a modern (Tarragona) and an old (Montcada) MSW incinerator

Samples	Median value	Mean value	Minimum	Maximum
Tarragona	0.80	1.08	0.23	5.80
Montcada	3.52	6.91	0.30	44.26
Rural soils (background)	0.54	0.84	0.08	8.40

Noncarcinogenic risks were estimated comparing the calculated daily intake with the tolerable daily intake for TCDD (10 pg/kg/day).⁶⁾ Carcinogenic risks were calculated by multiplying the calculated daily intake by the cancer potency factor for TCDD: 1.56×10^5 kg.day/mg. The predicted cancer risk is an upper bound

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estimate of the potential risk associated with exposure. In order to avoid that noncarcinogenic and carcinogenic risks were overestimated, a 30% bioavailability of PCDD/Fs from soil was assumed.

Results and Discussion

Table 2 shows the median ingestion doses of PCDD/Fs from soils in the vicinity of a modern and an old MSW incinerators calculated according to the Hawley¹⁾ and the Pohl et al.⁶⁾ models of exposure. The hypothetical intakes corresponding to the maximum values are also given. In all cases, the PCDD/F ingestion was substantially lower than the tolerable daily intake of 10 pg TEq/kg/day.⁶⁾ Even in the very unlikely case of exposure to soils containing the maximum levels of PCDD/Fs in the areas under study, the estimated daily intake of PCDD/Fs for young children from Montcada (0.159 pg TEq/kg/day) would be more than 60-times lower than the tolerable daily intake.

Table 2. Daily intake (ng TEq/kg/day) of PCDD/Fs from soils in the vicinity of a modern (Tarragona) and an old (Montcada) MSW incinerator

	Soils with median levels of PCDD/Fs		Soils with maximum levels of PCDD/Fs	
	Hawley	Pohl et al.	Hawley	Pohl et al.
Tarragona				
Young children	2.88x10 ⁻⁶	2.06x10 ⁻⁶	2.09x10 ⁻⁵	1.49x10 ⁻⁵
Adults	0.23x10 ⁻⁶	0.14x10 ⁻⁶	0.16x10 ⁻⁵	0.10x10 ⁻⁵
Montcada				
Young children	12.7x10 ⁻⁶	9.05x10 ⁻⁶	15.90x10 ⁻⁵	11.37x10 ⁻⁵
Adults	0.99x10 ⁻⁶	0.63x10 ⁻⁶	1.25x10 ⁻⁵	0.79x10 ⁻⁵
Rural soils (background)				
Young children	1.94x10 ⁻⁶	1.39x10 ⁻⁶	3.02x10 ⁻⁵	2.16x10 ⁻⁵
Adults	0.15x10 ⁻⁶	0.10x10 ⁻⁶	0.24x10 ⁻⁵	0.15x10 ⁻⁵

Table 3 summarizes the carcinogenic risks of PCDD/F exposure from soil ingestion according to the daily intake. Only data obtained from the Hawley model of exposure (worst scenario) were used. Risks concerning soils containing both the median and the maximum PCDD/F levels were estimated.

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Table 3. Carcinogenic risks of PCDD/Fs from soils in the vicinity of a modern (Tarragona) and an old (Montcada) MSW incinerator

	Soils with median levels of PCDD/Fs	Soils with maximum levels of PCDD/Fs
Tarragona		
Young children	0.45×10^{-6}	3.26×10^{-6}
Adults	0.04×10^{-6}	0.25×10^{-6}
Montcada		
Young children	1.98×10^{-6}	24.81×10^{-6}
Adults	0.15×10^{-6}	1.95×10^{-6}
Rural soils (background)		
Young children	0.30×10^{-6}	4.71×10^{-6}
Adults	0.02×10^{-6}	0.37×10^{-6}

In this study, actual soil concentrations of PCDD/Fs were used to estimate human health risks. The highest PCDD/F level in soils (44.26 ng TEq/kg) was 1/22 the interim multimedia soil guideline of 1 ppb TEq (1000 ng TEq/kg).⁸⁾ The current PCDD/F intakes from soil would be substantially less than the tolerable daily intake of 10 pg TEq/kg/day for noncarcinogenic effects. With regard to the carcinogenic risks, The US Food and Drug Administration introduced a risk-specific dose of 0.06 pg TEq/kg/day (a 95% upper bound for one in a million risk estimate for cancer).⁸⁾ The oral PCDD/F intakes here observed are all remarkably lower than this limit.

Literature Cited

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