Analyses and Remedial Actions Following an Accidental Fire in a Kindergarten

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1. Introduction

It is well known that almost all thermal processes result in the formation of polychlorinated dibenzo-*p*-dioxins, dibenzofurans, and other by-products [1,2]. Especially high concentrations of PCDD/PCDF on surfaces (up to 10,000 ng TEQ/m^2) have been reported from accidental burnings when PVC, plastics containing flame retardants or PCB, have been involved [3,4]. Lower concentrations (generally <200 ng TEQ/m^2) were found in the soot after "normal" fires in residential homes or offices. Once aware of the potential to generate dioxins and as a consequence that an estimated 500,000 residential fires occur in Germany annually the Federal Health Office (FHO) [5] released general guidelines how to deal with the residues after accidental fires. On May 14, 1990, a fire in a Kindergarten caused by arson destroyed parts of the roof, windows and the furnishings. In this paper we describe the measures taken since first analyses of the residues showed high concentrations of PCDD/PCDF.

2. Experimental

2.1 Description of the Site

The Kindergarten is located in a residential area of a middle-sized community in Germany. The building has one floor and consists of more than a dozen rooms and additional facilities. Several of them were equipped with PVC floors, wooden furnishings, curtains, and an abundance of plastic and wood toys. Rooms 1-5 were most affected by the fire.

2.2 Sampling Phase I

To get an impression of the materials involved in the fire and as a basis for further actions a total of six samples were taken at the following places:

1) Roughcast from the wall of Room 1, 10 cm in depth,
2) Unaffected painted concrete from the wall (Room 1) to determine whether a PCDD/PCDF contamination was present before the fire,
3) Painted concrete from the wall (Room 1) affected by the fire,
4) Soot, fine particulates which has blown through the building,
5) Soil from outside the building in the main wind direction, to determine whether the contamination was extended outside the building.

2.3 Sampling Phase II

After remediation another 14 samples - roughcast, floor coverings, wood of the roof construction (unburnt), wipe samples from the cleaned glazed tiles, indoor air, etc. - were taken and analysed to determine either the final disposal of the refuse or the effectiveness of the cleaning actions. Air sampling was performed by using a standard sampling device with glass-fibre filter and PU-foam, both fortified with an internal standard mixture prior to sampling.

2.4 Analysis

Solid samples were dried for 15 hours at 105°C. The materials were ground, spiked with a $^{13}C_{12}$-labelled standard mixture of PCDD/PCDF (one isomer for each homologue) and extracted with toluene in a soxhlet apparatus for 24 hours. Clean-up was performed by column chromatography on silica-gel and aluminum oxide. The purified extract was concentrated to about 100 µL. Determination of PCDD/PCDF was done either with GC/LRMS (Hewlett Packard 5890 coupled with a HP 5970) or HRGC/HRMS (Varian 3000 coupled with a Finnigan MAT 90), respectively. To determine the recovery rate of 2,3,7,8-Cl_4DD, an additional ^{13}C-labelled Cl_4DD surrogate standard was added prior to injection.

The fortified water sample (1 000 mL) was shaken three times for 5 min with 200 mL of toluene (each) and the combined extracts were dried over sodium sulfate.

3. Results

The analytical results from Sampling Phases I and II are given in Tables 1-2. The dioxin concentration (2.64 ng I-TEQ/kg d.w.) and pattern found in the soil sample close to the Kindergarten showed a "normal" background level, indicating that the fire did not result in outside contamination. Thus, no restriction in the use of the garden and no further actions were necessary [6].

Table 1: Summary of PCDD/PCDF concentrations - Sampling Phase I

No.	Sample	(ng TEQ/kg)	(µg/kg)*
1)	Wall roughcast (unburnt)	0.18	
2)	Painted concrete (unburnt)	1 019.5	
3)	Painted concrete (burnt)	2 082.9	9.601
4)	Soot	45 251	156.228
5)	Soil (outdoor)	2.64	

* 8 Congeners according to Hazardous Substances Act (limit value = 5 µg/kg)

The PCDD/PCDF concentration of 45 251 ng I-TEQ/kg, equivalent to ~15 000 ng I-TEQ/m^2 - were found in the soot. This level was higher than those reported by the Federal Health Office (BGA) from other fires. As can be seen from Table 1 the unaffected painted concrete from the walls had high dioxin concentrations. Therefore, these samples were also analysed for chlorinated phenols and a possible contamination with PCDD/PCDF. Levels of chlorophenols (mono to penta-chlorinated) of the wall roughcast (sample No. 1) were in the lower ppt-range. Higher concentrations of chlorophenols were found in the sample of the painted (unburnt) concrete from the wall (ppb-range) with pentachlorophenol (PCP) as the highest value (827 ppb). The burnt concrete sample (No. 3) gave concentrations in the same range (lower for PCP). Based on raw data the PCDD/PCDF levels in the sample affected by the fire showed twice the contamination as the unaffected sample.

Based on the results of the first sampling campaign which showed that the inside of the walls were not contaminated with dioxins the community decided not to pull down the whole building but to remove all inside coverings and to intensively wash the "new" surfaces. As dioxin contaminations have been detected in various materials from the Kindergarten the way of disposal of the refuse had to be determined by federal authorities. As a consequence all the material removed was pooled into fractions of assumed high or low contamination and analysed to determine the final way of disposal. Furthermore, after removal of the contamination the effectiveness of the remedial action had to be proven analytically. The results of these investigations are given in Table 2.

Table 2: Summary of PCDD/PCDF concentrations, (dry) weight and surface adjusted - Sampling Phase II

Sample	Weight Adjusted	Surface Adjusted
Roughcast, Room 1	6.7 ng TEQ/kg	0.8 ng TEQ/m^2
Roughcast, Room 15	8.9 ng TEQ/kg	2.8 ng TEQ/m^2
Composition floor, Room 1	4.3 ng TEQ/kg	16.1 ng TEQ/m^2
Wipe sample		0.4 ng TEQ/m^2
Wood sample, roof construction (unburnt)	4.6 ng TEQ/kg	
Wood sample, wall + ceiling (burnt)	40.0 ng TEQ/kg	
Mixed sample, carpet, linoleum (burnt)	26.7 ng TEQ/kg	
Rubble, mixed 4 drums for refuse	186.7 ng TEQ/kg	
Floor covering, Room 23	33.6 ng TEQ/kg	7.0 ng TEQ/m^2
Roughcast, Room 23 (unburnt)	0.6 ng TEQ/kg	0.1 ng TEQ/m^2
Fuel for sandblast unit	4.1 ng TEQ/kg	
Water sample, washing	1.0 ng TEQ/kg	
Indoor air		0.068 pg TEQ/m^3
Coverings, wood + ceiling (unburnt)	322.2 ng TEQ/kg	

The cleaning of the Kindergarten was performed by a company with experience in remediation of highly contaminated buildings and with special equipment. Finally, a total of 36 m^3 of burnt wood and rafters, 28 m^3 unburnt wood, floor coverings, wipe tissues, etc. and nine 100 L drums with residues from sandblast were disposed of in a hazar-

dous landfill. No decision on the final disposal of two 1 m^3 containers has been made until now.

4. Discussion

This case study of an accidental fire in a public Kindergarten shows that high concentrations of PCDD/PCDF can be generated in houses which do not seem to exhibit a high potential for dioxin formation (no transformers/capacitors involved). Furthermore, it was shown that the dioxin contamination was associated with the soot particles and was distributed almost throughout the whole building.

According to the Hazardous Substances Act [7] the painted concrete and the soot had to be classified as hazardous waste and need special permission for transportation and disposal.

In connection with the disposal of PCB-containing capacitors the Ministry of the Interior in the State of Hessen released a recommendation that wipe samples (from surfaces) must not exceed 10 ng TEQ/m^2 (especially in homes and offices) [8]. Therefore, the sandblast-cleaned composition floor of Room 1 had to be cleaned once again to a final dioxin level below this limit value. In Germany, the Federal Agencies have not set a limit value [9].

Reconstruction of the Kindergarten started in 1992, the building was reopened in March 1993.

5. References

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