PCDD/PCDF Risk Assessment of a Hazardous Waste Site

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ABSTRACT

From 1973 to 1983 a dioxin potential of about 91 kg TEQ from disposal of 11 tons of residues from herbicide production has been burried the older part of a hazardous waste dump in Northern Germany. A research program revealed that the PCDD/PCDF levels in soils around the landfill were elevated compared to concentrations found in other parts of Germany. A comparison of homologue profile gave strong indications that improper disposal procedures in the 1970s might have resulted in an erosion of dioxin contaminated particles. The results of the investigations showed that no transfer of dioxins from the soil to carrots, potatoes, and sugar beets occurred. Biomonitoring with sugar beet leaves as well as ambient air measurements proved that the present handling and disposal practice does not lead to higher dioxin concentrations in plants or air.

1. INTRODUCTION

The hazardous waste site is located in Northern Germany; its polders (= holes where the wastes are disposed of) are 20-30 m deep. The polders have a multicomponent layer according to legal requirements assuring that no leakage from the waste site would occur. Moreover, below the waste dump there is a 170 m thick geological clay layer which results in a low hydraulic conductivity. From 1973 until 1983 about 11 tons of hazardous wastes - including tetrachlorobenzene and residues from 2,4,5-T-acid production - from a chemical manufacturer have been disposed of in the old part of the landfill. It has been estimated that 9-9.2 kg of 2,3,7,8-Cl_4DD have been landfilled. Alone from the 700 tons of degradation residues from lindane production disposed of the only the PCDD fraction would account for 91 kg TEQ. In 1992, a research project was started to identify the sources of the PCDD/PCDF contamination in the surroundings of the hazardous waste site and to evaluate potential risks for humans and the environment.

2. METHODS

Soil, vegetation, air, water and oily phases from observations wells have been analyzed for PCDD/PCDF. The analyses have been performed by various laboratories in Germany. In addition, the soil samples where PCDD/PCDF are accumulated over years, vegetables, such as carrots, potatoes, sugar beets, and leaves from sugar-beets from the same locations (see Table 2) have been analyzed for PCDD/PCDF. Vegetables can serve as biomonitors to indicate possible transfer from either a) the *soil to the edible* parts of the vegetables or b) from the air to the leaves of sugar beets. Moreover, leaves of plants are capable to monitor the ambient air situation during a vegetation period (Reischl et al. 1989). To prove whether there is an actual release of PCDD/PCDF from the waste site to the atmosphere air samples (gas phase + particle phase) have been analyzed before and behind the landfill (along the main wind direction; three samples each location, 72 hours sampling time).

As the various sources of PCDD/PCDF (industrial, thermal, reservoirs) may generate different profiles of dioxins and furans (Hutzinger and Fiedler 1993) we have used these typical profiles in a mathematical program and calculated ratios between homologues and congeners for different samples to identify potential sources.

3. RESULTS

3.1 Analytical Results

The results of the 19 soil samples and the use of the soils are given in Table 1 and the PCDD/PCDF concentrations of the vegetables in Table 2.

Table 1: PCDD/PCDF Concentrations in Soils

Use of Soil	ng I-TEQ/kg d.m.	Use of Soil	ng I-TEQ/kg d.m.
Arable soil #1	5.00	House garden #9	37.61
Arable soil #2	6.15	House garden #10	13.61
Arable soil #3	5.15	House garden #11	26.2
Arable soil #4	8.4		
Arable soil #5a	9.99	Grassland A	29.5
Arable soil #6	5.02	Grassland B	14.4
Arable soil #7	3.98	Grassland C	24.6
Arable soil #8	41.4	Grassland D	17.5
Arable soil #8/1	17.43		
Arable soil #8/2	5.64	Fallow land E	12.7
Arable soil #8/A	6.16		

Table 2: PCDD/PCDF Concentrations (ng TEQ/kg) in Plants and Vegetables

Sample	Conc.	Basis	Sample	Conc.	Basis
Sugar-beet (Arable soil #3)	0.170	d.m.	Sugar-beet leaf (Arable soil #3)	1.156	d.m.
Sugar-beet (Arable soil #4)	0.073	d.m.	Sugar-beet leaf (Arable soil #4)	0.489	d.m.
Sugar-beet (Arable soil #5a)	0.070	d.m.	Sugar-beet leaf (Arable soil #5a)	0.760	d.m.
Sugar-beet (Arable soil #6a)	0.070	d.m.	Sugar-beet leaf (Arable soil #6a)	1.113	d.m.
Sugar-beet (Arable soil #7)	0.083	d.m.	Sugar-beet leaf (Arable soil #8)	0.461	d.m.
Sugar-beet (Arable soil #8)	0.790	d.m.	Sugar-beet leaf (Arable soil #9*)	0.771	d.m.
Sugar-beet (Arable soil #9*)	0.086	d.m.	Carrot (Garden #9)	0.015	f.w.

* Arable soil, not identical with house garden #9

Carrots and potatoes grown on contaminated soils gave contaminations below or close to the detection limit. The levels in the sugar beets and the sugar-beet leaves were very low, too. No PCDD/PCDF were detected in the wheat samples.

The results of the air measurements are given in Table 3. No difference could be seen between samples taken before and behind the hazardous waste site

(= potential source) at the same time. The PCDD and PCDF profiles were typical for ambient air samples found in remote areas of industrialized countries with increasing concentrations for the dioxins from the tetra to the octachlorinated homologues (Cl_8DD predominant) (HLfU 1991). Within the PCDF the highest levels were found for the lower chlorinated species.

Table 3: PCDD/PCDF in air samples in front (West) and behind (East) of the Landfill. Concentrations in fg I-TEQ/m^3; full detection limit included

Sample	In Front (West) (fg I-TEQ/m^3)	Behind (East) (fg I-TEQ/m^3)
#1	4	5
#2	11	14
#3	5	5

From the wells drilled in the old part of the hazardous waste site leachate water and oily phases were analysed for PCDD/PCDF (Table 4). As expected, the levels in the oil phases were many orders of magnitudes higher than in the water phases.

Table 4: PCDD/PCDF Concentrations in Aqueous and Oily Phases of Oberservation Wells - On-site the Hazardous Landfill

Polder/Matrix	ng TEQ/L or kg	Polder/Matrix	ng TEQ/L or kg
P1/Water phase	0.17	P6/Water phase	0.14
P2/Water phase	0.49	P7/Water phase	4.6
P3/Oil phase	44000	P8/Water phase	4.5
P4/Water phase	0.3	P8/Oil phase	10000
P5/Water phase	1.5	P9/Water phase	0.03

3.2 Source Identification

The statistical evaluation of the dioxin and furan profile of the sugar-beet leaves did not reveal a special dioxin source. The profile was similar to "normal" ambient air background profile and thus, the statistical method confirmed the analytical air measurement that no dioxin contamination results from the present activities on the waste dump. The soil profiles were very similar to each other, independent of the location. No significant correlation was found with soils known to be influenced e.g. by application of compost, sewage sludge, PCB spill, pesticide treatment. However, a relatively high similarity to an area with a known contamination with γ-HCH (lindane) was found (HLfU 1991).

4. DISCUSSION

The mean concentrations found in rural areas of Germany are 3 ng TEQ/kg d.m. for grassland (maximum = 100 ng TEQ/kg d.m.) and 2 ng TEQ/kg d.m. (maximum = 32 ng TEQ/kg d.m.) for arable soil. Levels for house gardens are 2.5-27.3 ng TEQ/kg d.m. Higher levels occur in soils with known sewage sludge application, soils exposed to diffuse inputs with PCDD/PCDF, and in densely populated areas (BLAG 1992). Compared to these values the concentrations detected close to the hazardous waste site were elevated for most of the samples analysed (samples #1, #2, #3, #6, #7, #8/2, #8/A). The concentrations found in carrots and potatoes are within "normal" background concentrations (BLAG 1992). As expected, no transfer of PCDD/PCDF from the soil to the roots (= edible part of the vegetables) was observed. The concentrations found in the sugar beet leaves beets gave typical background levels for rural areas. This finding has been confirmed by the air measurements which gave very low levels, even for remote areas.

The high dioxin level found in a mixed sample on soil #8 (41.4 ng TEQ/kg d.m.) could not be confirmed when in a second sampling campaign two additional samples were taken from the same area (→ samples #8/1, #8/2). From the results obtained on the sampling site #8 it was evident that a more narrow grid of sampling points would not give more information; therefore, no more soil samples were analyzed. Although residues from HCH production have been disposed of in the 1970s improper transport and disposal techniques may have caused erosion of particles resulting in a dioxin contamination around the site. However, a final decision on the origin of the dioxin contamination in soils around the hazardous waste site cannot be made until former land use and input pathways for dioxins such as application of sewage sludge, compost, and pesticides, or erosion (during transport of wastes and disposal into the landfill) and subsequent deposition, etc. are investigated. Moreover, a former brickwork with unknown dioxin emissions was located on the area of the waste site. The usual agricultural practice to burn residues from harvesting - a process that is known to generate PCDD/PCDF - has to be taken into account. All these potential dioxin sources are independent of the landfill for hazardous wastes.

5. REFERENCES

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