Occurrence of PCB's in the vicinity of a transformer house

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Abstract:

The use of PCB's in transformers seems to highly contaminate the immediate environment of the transformer house with PCB's, even with planar PCB 77 and coplanar PCB 126. The toxicological equivalent values are in the same range as dioxin-contaminated sites. The concentrations of the soil samples (B1 = 955 ± 172 μg/kg, B2 = 649 ± 117 μg/kg) exceed the recommended value by the Association of German agricultural experimental and research stations (Verband Deutscher Landwirtschaftlicher Untersuchungs-und Forschungs-anstalten) for private gardens (500 μg/kg).

Thus transformer houses represent a potential danger, particularly within residential areas. According to threshold values from several countries, former transformer houses might be considered as contaminated sites requiring soil remediation.

Introduction:

PCB's are widespread chemicals used by mining industries, metal industries, and electric engineering. Approximately 1.000.000 t of PCB's have been produced worldwide since 1929 [1]. About 60 % of this amount is used in electrical systems e.g. as coolants in transformers [2]. Severe food poisoning occurred in Japan (1968) [3,4] and in Taiwan (1979) [5,6] due to rice cooking in PCB-contaminated bran oil. Ever since, PCB's as persistent chemicals have become another focus of potential environmental hazards because of their detection in the food web. To estimate the environmental hazard potential of PCB filled transformers, samples were taken inside and outside a former transformer house in the Hessian Odenwald, Germany. Only undisturbed soils have been sampled. To assess their toxicological relevance, PCB 77 and PCB 126 concentrations (according to Ballschmiter) were converted into their toxicological equivalent values (TEQ).

Experimental

<u>Sampling</u>

The building was in operation for about 40 years. In this study, the cooling cycle was filled with several hundred liters. Until closure in the early eighties, leakage and refill processes released large amounts of PCB's into the environment. To record the spreading of PCB's and to estimate their capacity of soil infiltration, additional soil samples were taken at different depths and distances from the building (fig. 1).

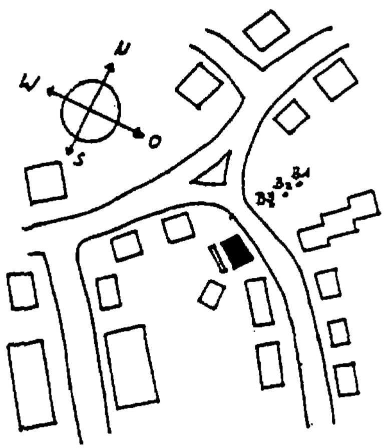

Figure 1: Location of the transformer house and the soil sampling points (scale: 0,5 cm ≙ 10 m)

Figure 2 shows the 13 sampling locations. To estimate the PCB distribution within the house, wall plaster samples from all three floors were examined.

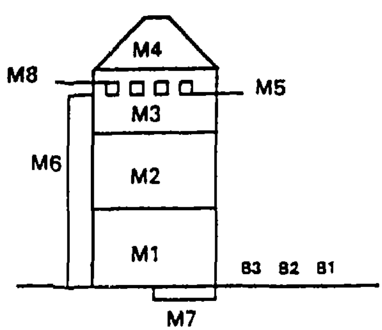

Figure 2: Transformer house and sampling points
M4 = dust sample, attic
M5 = dust sample window sill, third floor
M6 = wall plaster (w.p.) sample, staircase
M7 = w.p.s., manhole groundfloor
M8 = sample, scraped from glass bricks
B1 = soil sample in 20 m distance
B2 = soil sample in 15 m distance
B3 = soil sample in 12 m distance
B3a ≙ 0-2 cm soil depth
B3b = 2-5 cm soil depth
B3c = 5-10 cm soil depth

Analysis and evaluation

The PCB's were determined by gas chromatography (Tab. 1). The samples were processed in accordance with the German Sewage Sludge Standards (Klärschlammverordnung) [7]. The PCB concentrations were determined as the sum total of the six Ballschmiter PCB's (# 28,52,101,138,156,180). External standards were used for the calibration and quantification of the data. All given values are averages from single values (n = 3).

Table 1: GC/ECD-parameter: Carlo Erba, HRGC 5300

Carrier gas	Hydrogen	2,3 ml/min		
Injector	SSL-Injector	2 µl	manuel	
Retention gap	5 m	0,32 mm ID	Phenyl-Sil desactivated	
column	a) CP-Sil 8cb	50 m	0,25 mm ID	0,25 µm df
	b) DB 17	30 m	0,25 mm ID	0,25 µm df
Detector	ECD	Ni-63	300 °C	
Make up gas	Argon/Methan (95/5)	40 ml/min		

Results and discussion

The results show a serious PCB contamination for most of the samples (Tab. 2). The PCB load on the second floor is about three times higher than on the third floor, on the ground floor it is twice as much as on the second floor. The distribution within the building can be explained by the high density of the PCB's. The sample taken from the glass bricks (insect transported fine dust) has the highest PCB concentration (8 mg/kg), which equals those found in highly contaminated river sediments [8].

Table 2: PCB values of the samples [µg/kg]

	M1	M2	M3	M4	M5	M6
PCB ges.	2278±370	1087±160	318±51	53±9	474±85	771±139
PCB 77	502±100	355±64	123±22	-	-	-
PCB 126	93±14	49±6	14±2	-	-	-
PCB 169	< 0,1	< 0,1	< 0,1	-	-	-

	M7	M8	B 1	B 2	B3a	B3b	B3c
PCB ges.	436±79	8352±1503	955±172	649±117	148±27	220±40	65±12

The highly toxic planar PCB 77 and coplanar PCB 126 could be detected in three samples. Their TEQ-values (up to 9,2 TEQ/kg) are in the range of cable refining plants [9].

Table 3: TEQ-values for PCB 77 and PCB 126, according to Safe [10] [TEQ/kg]

	M 1	M 2	M 3
TEQ 77	5,02	3,55	1,23
TEQ 126	9,3	4,9	1,4

With prevailing westerly winds, the outside distribution of the contaminants in eastward direction is explainable. The main quantity of PCB's accumulates in a depth of two to five cm and decreases with increasing depth. Along a straight line drawn from the contamination source to the sampling points the PCB concentration does not decrease steadily .

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