Distribution of Chlorinated Aromatics in Leaves, Needles and two Soils from the Fichtelgebirge (NE-Bavaria), FRG

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Introduction

Atmospheric organic pollutants may reach soils via direct deposition but also adsorbed on fallen plant leaves. The intensive accumulation of lipophilic compounds on plant surfaces led us to expect that leaf fall is an important vector for soil contamination of lipophilic compounds, and that substance behavior in the soil depends on the decomposition of leaves. Since a large portion of organochlorine compounds is adsorbed on the cuticular plant surface, the soil lipids and alkyl-C-components may be useful correlation parameters for contaminant levels.

Two podsolic soils in beech and spruce stands (described in Zech et al. 1986) and the corresponding fresh leaves and needles were examined for their content of chloroorganics.

Experimental

PCDD/PCDF: The soil samples were dried (12h, 75°C) and soxhlet-extracted with toluene for 48h. Fresh leaf-samples were extracted with dichloromethane in an ultrasonic bath (3 times, 10 min each).

Other organochlorines: Undried soil samples were extracted with a hexane/acetone-mixture (1:1) in an ultrasonic bath followed by intensive shaking. The extraction procedure was repeated once. Leaf-samples were macerated and extracted ultrasonically three times with hexane. Clean-up and details of the GC/MS-analysis are described elsewhere (Reischl et al. 1987, Reischl et al. 1989). All compounds were quanitfied using isotope dilution.

The determination of C_{org}, pH, lipids and alkyl-C was done according to Hempfling et al. 1987. The dry weights of the plants and soil were determined by drying at 105°C for 14h. The needles were two and three years old in the case of the PCDD/F-analysis and four years old for the other organochlorines. Beech leaves were about four months old.

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Results and Discussion

Table 1 C org(%), bulk density,b.d. (g/cm^3), lipids (mg/g org. substance), alkyl-C (% of C org), of the two different soils under Picea abies and Fagus sylvatica. Data from Zech et al. 1986.

	C org %	b.d. g/cm^3	lipids mg/g o.s.	alkyl-C % C org
Spruce stand				
L	50.4	0.03	34.3	22
Of	50.2	0.08	15.3	24
Oh	47.8	0.09	15.7	29
Aeh	5.58	0.73	8.1	36
Ae	0.62	1.2	7.8	35
Bhs	1.35	1.06	11.1	33
Beech stand				
L	50.2	0.01	24.4	20
Of	41.0	0.09	7.8	25
Oh	42.0	0.15	8.1	34
Aeh	14.4	0.73	6.6	42
Bhs	2.1	1.12	6.2	41

Table 2 Distribution of some organochlorines in the soil profiles, spruce needles and beach leaves. units: ng/g d.w.

Cl5B: pentachlorobenzene; HCB: hexachlorobenzene

αHCH: alpha-hexachlorocyclohexane; γHCH-gamma-hexachlorocyclohexane

DTB: para-Dimethoxytetrachlorobenzene

PCBs(according to Ballschmiter): PCB52, PCB101, PCB153;

DDE: p,p'-DDE; DDT: p,p'-DDT

	Cl5B	HCB	αHCH	γHCH	DTB	PCB52	PCB101	PCB153	DDE	DDT
Spruce Stand										
Spruce-Needles	0.7	1.3	4.7	9.5	8	0.4	0.6	3.4	2.6	4.7
Soil										
L	0.6	6.5	25.5	54	548	0.9	3.4	11.7	6.4	16
Of	2.7	11.6	33	51	30	1.4	11.4	55	31.5	143
Oh	1.5	6.9	3.6	8.5	12.9	0.5	4.7	21.4	12.7	52
Aeh	-	-	-	-	0.2	-	-	-	-	0.1
Beech Stand										
Beach-Leaves	0.1	0.8	2.7	7.1	1.7	0.4	0.8	3.3	1.9	2.4
Soil										
L	0.9	2.3	6.5	21.4	10.1	0.7	2.5	10.1	5.9	11
Of	0.8	2.9	6.0	23.2	24	0.7	7.1	32.6	13.6	33
Oh	0.7	1.8	1.2	3.1	6.7	0.4	3.3	18.0	22.5	46
Aeh	-	-	-	-	2.9	-	-	0.2	0.32	0.3
Bhs	-	-	-	-	1.1	-	-	-	-	0.2

PCB and other Organochlorines

Concentrations on a dry weight basis increased for most compounds from needles/leaves to the L-horizon and the Of, and decreased for the Oh. Concentrations in leaves/needles and the corresponding L-horizons were within the same range. One exception was p-DTB for spruce, where the concentrations increase by two orders of magnitude. p-dimethoxytetrachlorobenzene is probably a metabolite of pentachlorophenol and quite persistent under environmental conditions (Schramm et al. 1989). However, we have no explanation for the high level in the L-horizon.

The increase of concentrations on a dry weight basis from leaves to the L-horizon might be due to the decrease of slightly degradable leaf-contents such as carbohydrates (Dickinson, Pugh 1974), which in addition are not expected to be significant storage pools for lipophilic pollutants.

The alkyl-portion of organic carbon increases with soil depth. Alkyl-C-components are mainly attributed to cutin-structures (Kögel, 1987) and are relatively resistent to degradation. Since the plant cuticle strongly accumulates lipophilic compounds, one would expect that alkyl-C and lipid in soil also accumulate these compounds. As plant leaves do not appear to reach a steady state with ambient air concentrations during their life time (Gaggi, Bacci 1985) it may be that the rising concentrations from the leaves to the L-horizon are partially due to direct atmospheric deposition driven by this continuing non-equilibrium state.

Although the Aeh-horizons show relatively high Corg values, most compounds determined are below the detection limit. However, this might be due to reduced extraction efficiency with age.

PCDD/F

Although beech leaves had, compared to spruce needles, a reduced exposure time, they showed far higher dry weight concentrations of PCDD and PCDF. This is most likely attributible to the higher surface to dry weight ratios of beech leaves.

An enrichment of the higher chlorinated furan-congeners is observed moving from the leaves/needles to the corresponding Oh. This is not true for the dioxins, which show stable ratios except for a shift in the TCDDs. Therefore the furan-shift cannot be attributed to volatilization.

The concentration levels related to dry weight are extremely high when compared to soils with no distinct organic layer, esp. soils in agricultural use. However, it should be mentioned that these organic layers possess a rather low bulk density (Table 1). The measurements presented here clearly show that soils with a well defined organic layer and no intensive agricultural use may serve as important sinks for PCDD/F unless no degradation of soil organic matter occurs.

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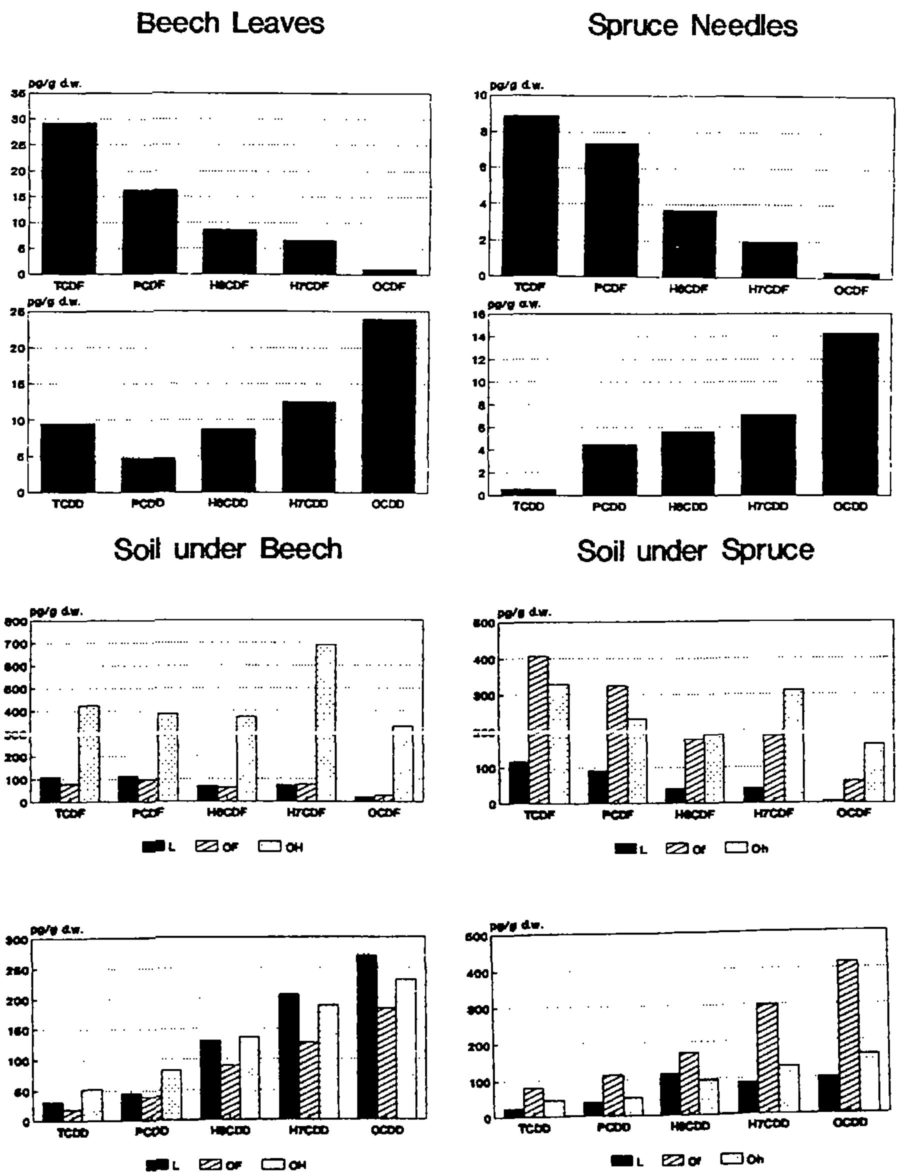

Figure 1-8 Distribution of PCDD/F in the organic layer of the two soil profiles, spruce needles and beach leaves. Concentrations in pg/g d.w.