Coplanar Polychlorinated Biphenyls in Soils: Contents and Patterns

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Introduction

It has been frequently suggested to include coplanar PCBs when assessing environmental contaminations by PCDD/PCDF. Since only few data exist on their environmental occurrence the State authorities of Hamburg conducted an investigation on levels of PCB 77, PCB 126, and PCB 169 in soils in comparison to PCDD/PCDF and other representative PCBs (PCB 28, PCB 52, PCB 101, PCB 138, PCB 153, PCB 180). Furthermore materials considered potential sources of soil contaminations where analyzed. Coplanar PCB-TEQ were evaluated according to WHO/ICPS [1]. The investigation was intended to determine the present situation of contamination by coplanar PCBs. Correlations to other organic pollutants like PCDD/PCDF and non coplanar PCB should be established.

Materials and methods

28 top soil samples were taken within the State territory of Hamburg, mostly from 0 - 10 cm depth and three from the litter horizon of a forest. The sites were chosen to include different soil uses (lawns in residential areas, gardening colonies, public greens) and different expositions to possible sources (car traffic, industrial areas). Two of the samples were from sites where dredging materials from the River Elbe and Hamburg Harbour had been deposited. Moreover three compost samples (mature garden compost) and one sample of each of three waste materials (waste oil, soot of fire in a computer centre, shredder material from cable burner) were examined. Non coplanar PCBs were only determined in 18 of the soil samples.

All PCBs and PCDD/PCDF were analyzed after clean up on silica gel and activated carbon columns by high resolution gas chromatography-high resolution mass spectrometry and quantified by isotope dilution method with internal C-13 standards. The method is described in [2].

Results

A comprehensive overview of the results for coplanar PCBs is given in tab. 1 where soils others than the ones listed later on are combined to represent not specifically influenced "urban soils".

Contents of the sum of coplanar PCBs in the topsoils ranged from 0,3 to 6,3 ng/kg I-TEQ. 75% of all soil samples investigated were below 4,5 ng/kg I-TEQ.

PCDD/PCDF values in the soils varied from 2 to 2205 ng/kg I-TEQ, 75 % were below 14 ng/kg I-TEQ. These results correspond with former measurements [2]. Non coplanar PCB ranged from 4 to 292 µg/kg d.m., 75% were below 33 µg/kg d.m..

Tab. 1: Average contents of coplanar PCBs in investigated samples (ng/kg d. m.)

Samples	n	PCB 77	PCB 126	PCB 169	Sum copl.PCB	I-TEQ sum cPCB
"urban soils"	18	34,2	15,3	3,4	52,6	1,6
Soils industrial areas and dredging materials	7	153,2	77,1	51,1	267,7	8,1
Forest litter horizons	3	317	131	21	470	13
Composts	3	150,3	33,7	5,5	189,5	3,5
Waste oil	1	585000	109000	313	694313	10962
Cable shredder waste	1	24610	3000	390	28000	306
Soot	1	3800	n.d.	n.d.	3800	10

The contribution of the TEQ of the coplanar PCBs to the total TEQ, i. e. PCDD/PCDF TEQ included, in the background samples ranged from 10 % to 32 %, in the more contaminated soils from industrial areas and dredging material soils it was only 1 % to 3 %.
The samples of mature garden and graveyard composts had similar coplanar PCB contents as background topsoil samples (1,8 und 5,5 ng/kg I-TEQ). PCDD/F contents in composts also were in the same range as in the topsoils (4,4 und 11,1 ng/kg I-TEQ).

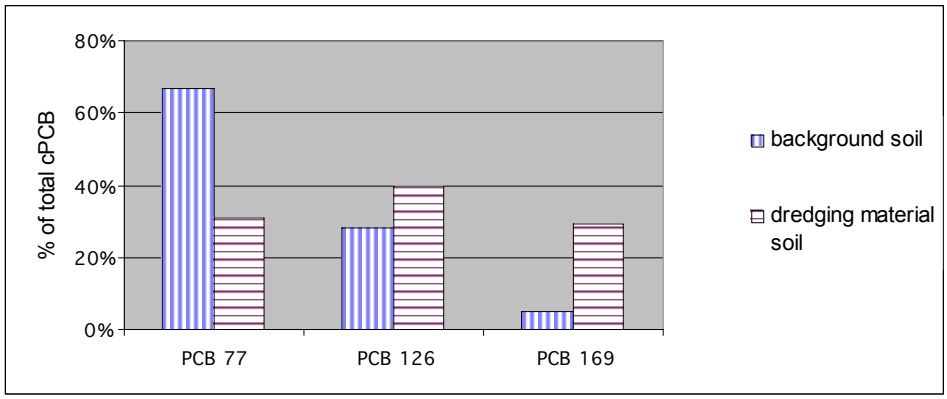
Contents of waste materials are shown in tab. 2.

Tab. 2: Contents of coplanar PCBs, non coplanar PCBs, and PCDF/PCDD in wastes

Sample	Sum coplanar PCB (ng/kg TEQ)	Sum non coplanar PCB (µg/kg)	Sum PCDD (ng/kg TEQ)	Sum PCDF (ng/kg TEQ)	total TEQ (ng/kg TEQ)	TEQ cPCB/ totalTEQ
Waste oil	10962	98900	76	571	11599	94,5
Cable shredder	306	101750	57	1667	2040	0,2
Soot	10	100	307	1994	2311	0,4

Discussion and conclusion
Comparison of the coplanar PCB and PCDD/F patterns of the samples showed different congener patterns. Samples influenced by dredging material from the River Elbe and Hamburg Harbour deviated from all other samples. Fig. 1 shows the different coplanar PCB patterns of a background sample and of a dredging material sample.
Commercial PCB mixtures display a pattern with an even much more marked decrease from PCB 77 to PCB 169 than in the background soil. Considering the physicochemical properties (volatility, solubility) and possible degradation it can be assumed that higher chlorinated congeners will be relatively enriched in environmental samples. Thus it may be assumed that investigated background samples are mainly influenced by commercial PCB mixtures. However,

Fig. 1: Distribution of coplanar PCBs in a background soil sample and a soil sample from dredging material



similar patterns are generated in incineration processes (soot in tab. 1) so these may be an additional source. This is in accord with other investigations [3]. In the dredging material a dioxin pattern attributed to metallurgical processes is found [4] so there might be a specific cPCB pattern for these, too, but no source samples of such processes were investigated.

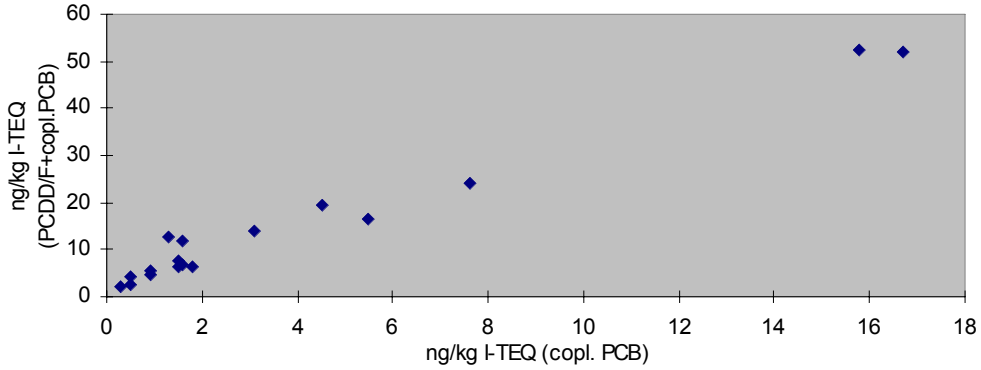
For background soil samples a significant relation between organic carbon content (measured as ignition loss) and coplanar PCB concentration is found (n = 25, r = 0,937). The samples influenced by dredging material deviate from this as also described for PCDD/PCDF in [2].

For background samples the correlation between coplanar PCB-TEQ and total TEQ (included PCDD/PCDF-TEQ) points to a homogeneous source of contamination (s. fig. 2; n = 17, r = 0,988) as well as the examination of congener patterns (see above). This coincides with investigations of other matrices [5].

Results of a possible hazard assessment for all samples in this investigation would not have been different if the coplanar PCBs were included because the contribution of the coplanar PCB TEQ

- in the background samples is up to one third but not leading to relevant levels,
- in the more contaminated soils is almost neglegible, and
- in the the highly contaminated waste oil it is not relevant with respect to assessment because legal PCB levels are exceeded.

Fig. 2: Correlation of coplanar TEQ with total TEQ, that is coplanar PCB and PCDD/PCDF



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