

Polychlorinated Dibenzo-p-dioxins (PCDD) and Dibenzofurans (PCDF) Compared to other Organohalogen Pollutants in Biological Samples from Swedish Ecosystems

Lillemor Asplund, Bo Jansson, Cynthia de Wit
Special Analytical Laboratory
Swedish Environmental Protection Agency, S-171 85, Solna, Sweden.

Sture Bergek, Maria Hjelt, Christoffer Rappe
Institute of Environmental Chemistry
University of Umeå, S-901 87 Umeå, Sweden.

Tjelvar Odsjö, Mats Olsson
Swedish Museum of Natural History
Box 50007, S-104 05 Stockholm, Sweden.

Abstract

Biological samples from Swedish ecosystems have been analyzed for a number of organohalogen pollutants including PCDD and PCDF. The planar compounds (PCDD/F, pPCB and PCN) do not biomagnify in seal in the same way as the major, less planar, PCB components. Levels of the planar compounds in seal samples from Spitzbergen and the Baltic are nearly the same which is not the case for the major PCB congeners. The enzyme induction potencies of the individual compounds indicate that 3,3',4,4',5-PeCB is the most dangerous pollutant of the studied substances. Among the PCDD/F, 2,3,4,7,8-PeCDF is responsible for about 50% of the NTEQ value.

Introduction

Polychlorinated dibenzo-p-dioxins (PCDD), polychlorinated dibenzofurans (PCDF), planar (non-ortho) polychlorinated biphenyls (pPCB) and polychlorinated naphthalenes (PCN), are planar or almost planar molecules. These compounds have high toxicities^{1,2} and are biologically active as measured by enzyme induction tests^{3,4}.

A method for multiresidue analysis of a number of chlorinated and brominated organic compounds in biological samples has recently been described⁵ and this method has been applied to some representative samples from Swedish ecosystems.

In that study, the following groups of substances were analyzed in each sample: polychlorinated paraffins (CP), aldrin and dieldrin, hexachlorocyclohexanes (HCH), chlordanes, polychlorinated camphenes (PCC), DDTs, polychlorinated biphenyls (PCB), polybrominated biphenyls (PBB), polybrominated diphenyl ethers (PBDE), hexachlorobenzene (HCB), pPCB and PCN.

Materials and methods

The samples consisted of representative homogenates covering various ecosystems (Table 1). From the terrestrial environment reindeer (*Rangifer tarandus*) was analyzed.

Two fish species were selected from the freshwater environment: whitefish (*Coregonus lavaretus*) from a lake in the northern part of Sweden with no local industry and arctic char (*Salmo salvelinus*) from a southern Swedish lake with local industrial activities. As a fish predator from the freshwater community osprey (*Pandion haliaetus*) was selected.

From the marine environment herring (*Clupea harengus*) was chosen to represent three different brackish and marine areas. Seals were selected as fish consumers in the marine environment. Grey seal (*Halichoerus grypus*) from the Baltic and ringed seal (*Pusa hispida*) from Spitzbergen were analyzed. It is known that the levels of organochlorine compounds in seals increase with age in males but not in females, and thus only females are represented in these samples.

Table 1. Description of the investigated samples.

Species	n	Sex	Age	Org	Sampling place and year
Reindeer	31	m,f		s	Northern Sweden, 1986
Whitefish	35	m,f		m	Northern Sweden, 1986
Arctic Char	15	m,f		m	Southern Sweden, 1987
Herring	25	m,f	2-7	m	Bothnian Sea, 1987
Herring	15	m,f	2-7	m	Baltic Sea, 1987
Herring	25	m,f	2-7	m	Skagerrak, 1987
Ringed Seal	7	f	7-32	b	Spitzbergen, 1981
Grey Seal	7	f	7-30	b	Baltic Sea, 1979-85
Osprey	35	m,f		m	Sweden, 1980-86

n = number of specimens in the homogenate; m = male; f = female; s = suet; m = muscle; b = blubber; age is given in years.

The analytical method used for PCDD/F analysis in this investigation has been described earlier^{7*}.

Results and discussion

Results of the PCDD/F analyses are presented in Table 2. Levels of some PCB and PCN congeners previously reported⁸ are included for comparison. As a representative for a highly bioaccumulating and biomagnifying non-planar PCB congener 2,2',4,4',5,5'-hexachlorobiphenyl (IUPAC 153) is also presented.

Toxic equivalents are also given in Table 2 and for PCDD/F these are calculated according to the Nordic model¹. Factors based on enzyme induction activities are used for pPCB⁹ (0.001 for IUPAC 77, 0.15 for IUPAC 126 and 0.006 for IUPAC169, respectively).

Table 2.

Levels of some organochlorine compounds in biological samples (pg/g lipid weight). SNV ID nr is the Swedish Environmental Protection Agency sample identification number in the dioxin database. NTEQ is TCDD equivalents calculated according to the Nordic model. < = not detected at this level. Total pPCB = sum of IUPAC 77, 126, 169. The labelling of PCN is according to their degree of chlorination (TeCN-HeCN) and elution order (a,b,c etc) on a 5% phenyl methyl silicone GC column. Total PCN = sum of the detected compounds (TeCN - HxCN). (na) for IUPAC 77 in the osprey sample is due to interferences. PCDD/F levels in the whitefish samples are close to the detection limits.

	Reindeer	Wb fish	Ar char	Bo herr	Ba herr	Sk herr	Ru seal	Gr seal	Osprey
Lipid (%)	41	0.5	4.7	4.7	3.0	3.4	95	71	2.8
SNV ID #	0026001	0005004	0005001	0001015	0001017	0001016	0020019	0020020	0042001
2,3,7,8-TeCDD	0.68	<12	43	45	71	8	4.0	6.2	180
1,2,3,7,8-PeCDD	2.1	<15	53	38	50	11	6.7	6.6	310
1,2,3,4,7,8-HxCDD	<0.68	<38	<1.5	<3.4	<5.0	<5.0	<0.44	<0.55	<5.7
1,2,3,6,7,8-HxCDD	1.8	<25	17	28	29	<3.8	4.6	50	190
1,2,3,7,8,9-HxCDD	<0.53	<35	<1.3	3.2	<4.7	<4.7	<0.39	<0.48	13
2,3,7,8-HpCDD	<0.68	<21	<1.7	<1.9	<3.3	<3.2	<0.26	<0.32	<6.1
OCDD	3.4	<19	3.8	<1.7	5.7	5.6	2.9	5.9	24
2,3,7,8-TeCDF	2.7	79	170	98	97	53	8.4	10	125
1,2,3,7,8-PeCDF	0.94	17	45	30	63	35	1.5	2.1	24
2,3,4,7,8-PeCDF	5.6	17	150	210	370	59	4.3	11	540
1,2,3,4,7,8,9-HxCDF	3.6	<17	10	9.2	21	14	0.31	4.4	40
1,2,3,6,7,8-HxCDF	2.0	<12	8.5	8.5	24	18	0.26	5.6	40
1,2,3,7,8,9-HxCDF	<0.48	<13	<1.1	<1.5	<2.0	<2.1	<0.17	<0.21	<3.9
2,3,4,6,7,8-HxCDF	<0.46	<9.6	11	7.5	19	<1.5	<0.13	3.1	20
1,2,3,4,6,7,8-HpCDF	<0.46	<13	<1.1	<1.1	<2.0	<1.8	<0.15	1.4	<4.3
1,2,3,4,7,8,9-HpCDF	<0.72	<17	<1.7	<1.7	2.7	<2.7	<0.21	<0.27	<6.4
OCDF	<0.72	<19	<1.9	<1.7	<2.7	<2.4	<0.23	<0.34	<7.5
Total 2,3,7,8-PCDD	8.0	0.0	120	110	110	25	18	69	720
Total 2,3,7,8-PCDF	15	110	390	360	590	180	15	38	790
Total 2,3,7,8-PCDD/F	23	110	510	470	700	210	33	110	1500
NTEQ	5.6	17	170	190	250	50	11	22	640
IUPAC 153	17000	200000	1200000	380000	550000	150000	500000	92000000	36000000
IUPAC 77	140	2500	18000	11000	24000	7500	3400	1300	na
IUPAC 126	240	480	6900	1400	2700	860	630	3000	46000
IUPAC 169	44	270	1200	380	710	200	29	1800	5500
Total pPCB	420	3300	26000	13000	27000	8500	4100	6100	52000
"TEQ(pPCB)"	36	74	1100	220	430	140	100	450	6900
TeCN(a)	nd	150	1100	920	2000	1000	16	14	10000
Total TeCN	19	440	1400	1400	2500	1600	14	16	13000
PeCN(a)	14	340	3700	2300	4300	2100	22	53	16000
Total PeCN	39	340	4400	2600	5300	3100	22	100	19000
HxCN(a)	940	1500	27000	10000	22000	9300	nd	710	15000
Total HxCN	940	1800	35000	13000	27000	15000	nd	770	18000
Total PCN	1000	2600	41000	17000	34800	20000	38	890	50000

In the herring samples from different places the concentration of 2,3,7,8-TeCDD seems to increase from the Swedish west coast to the Bothnian Sea, a trend which is not seen for the other PCDD/F congeners. Geographical comparison of the seal samples shows surprisingly low differences for both PCDD/F and pPCB, as has been reported before¹⁰. Differences between pristine and industrialized areas are seen in the NTEQ and "TEQ(pPCB)" for the white fish and arctic char, respectively.

In all the samples the main contribution (about 50%) to the NTEQ value comes from 2,3,4,7,8-PeCDF while in most cases the contribution from 2,3,7,8-TeCDD is smaller than 10%.

Grey seals in the Baltic mainly feed on herring and for total PCB (here represented by IUPAC 153) a biomagnification of about 170 times can be seen while most of the PCDD/F congeners analyzed are present in the herring samples at a higher level than in the seals. There is also a trend that this difference is more pronounced for the more toxic isomers, which results in a ten times higher value for NTEQ in the herring than in the seal. For the pPCB a reduction can be observed in the food chain herring - seal, a trend which is still more pronounced for PCN.

Using the above mentioned toxic equivalent factors for the pPCB congeners gives "TEQ" values much higher than the NTEQ results for the PCDD/F group for most of the samples. Again the herring samples differ from the others as these have more or less the same "TEQ" values for the two groups of substances.

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