Concentrations of PCDDs, PCDFs and coplanar PCBs in Fish from Subarctic Lakes in Finland

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1. Introduction

Arctic Monitoring and Assessment Program[1)] (AMAP) is one part of the Arctic Environmental Protection Strategy which is signed by all eight Arctic countries. The monitoring program will harmonize and expand existing international environment monitoring networks and activities (atmospheric, marine, terrestrial, freshwater and human health) to arctic areas. The priority pollutants are persistent organic compounds, heavy metals, and radionuclides. There are currently insufficient data on sources, sinks and pathways and spatial and temporal trends of the contaminants in the arctic. The freshwater contaminant program of AMAP in Finland[1)] is initially focused on lake sediments and fish. This paper present the levels of polychlorinated dibenzo-p-dioxin and dibenzofuran (PCDD/F) and coplanar polychlorinated biphenyl (PCB) of three subarctic headwater lakes in Lapland, the Northern part of Finland.

2. Materials and Methods

Three subarctic lakes were selected for PCDD/F and PCB sediment analysis. Lake Pahtajärvi (68°10' N 24°00' E) is in Pallas-Ounas National Park, a fjell area in Northwestern Lapland. Lake "222" (69°27'N 29°10' E) is in Northeastern Lapland near Norwegian and Russian borders, ca. 40 km west from the Nickel smelter area. These lakes are small headwater lakes situated near the tree line and are surrounded by rocky terrain with thin soil layers. Lake Nitsijärvi (69°11'N 28°06' E) is relatively large lake (41 km^2) draining to the Lake Inari, the biggest lake of the region. Lake Nitsijärvi has some value for fisheries and there are few permanent housings in the watershed.

Determination of PCDD/Fs and PCBs

Fish samples were catched during winters 1993 and 1994 and freeze-dried before analysis. About 10 g of freeze dried fish sample was soxhlet extracted for 24 h with toluene. Fat content was weighted and the raw

extract was purified over a silica gel column, fractionated using activated carbon column containing Celite, and further cleaned with an activated alumina column. The analyses were performed with a fused silica capillary column (DB-DIOXIN) and a VG 70 SE mass spectrometry (resolution 10,000). The separated PCB fraction was further purified with another activated carbon column (without Celite) and planar PCBs were also analyzed with a high resolution mass spectrometry equipped with the fused silica capillary column. Nine ^{13}C-labelled PCB congeners (100 pg/sample of coplanar PCBs and 900 pg/sample the others, Cambridge Isotope Laboratories) were used as internal PCB-standards as well as a total of 16 ^{13}C-PCDD/Fs congeners (100 pg/ sample, Cambridge Isotope Laboratories), added to the samples before silica gel column extraction. To test the recoveries, ^{13}C-1,2,3,4-TCDD and ^{13}C-1,2,3,7,8,9-HxCDD or IUPAC 159 were added to the final concentrate before GC-MS analyses.

Table 1.
Average concentrations of PCDDs, PCDFs, and planar PCBs as pg/g w.w. of arctic char muscles from three subarctic lakes in Finland.

congener	Lake Pahtajärvi (N=10)	Lake 222 (N=12)	Lake Nitsijärvi (N=6)
2,3,7,8-TCDF	0.058 ± 0.057	0.069 ± 0.44	0.292 ± 0.110
2,3,7,8-PcCDF	0.008 ± 0.012	0.070 ± 0.032	0.082 ± 0.026
1,2,3,6,7,8-HxCDD	0.036 ± 0.083	0.010 ± 0.018	0.102 ± 0.218
1,2,3,4,6,7,8-HpCDD	0.260 ± 0.78	0.056 ± 0.078	0.135 ± 0.303
OCDD	0.36 ± 0.58	0.091 ± 0.095	0.303 ± 0.370
sum of PCDD/Fs	2.91 ± 7.31	0.370 ± 0.270	1.18 ± 1.16
I-TEQ	**0.057 ± 0.115**	**0.056 ± 0.034**	**0.101 ± 0.051**
IUPAC 77	1.83 ± 0.78	1.26 ± 0.69	3.21 ± 0.94
IUPAC 126	0.39 ± 0.19	1.18 ± 0.73	1.78 ± 0.56
IUPAC 169	0.10 ± 0.16	0.59 ± 0.40	0.77 ± 0.40
TEQ of planar PCBs	**0.0492**	**0.130**	**0.202**
sum of TEQs	**0.106**	**0.186**	**0.303**

* toxic equivalency factors of 0.005, 0.1, and 0.01 for IUPAC 77,126, and 169, respectively

3. Results and Discussion

The PCDD/F and coplanar PCB results of cartic char muscle samples are shown in Table 1. The PCDD/F levels were extremelly low, on average 0.056 and 0.057pg I-TEQ/g w.w. in the Lakes Pahtajärvi and Lake 222, respectively, and on average 0.101 pg I-TEQ/g w.w. in Lake Nitsijärvi. The highest concentration of the sum of PCDD/Fs in Lake Pahtajärvi and Lake 222 in the dated sediment cores was in our earlier studies

55 pg/g d.w. (0.84 pg I-TEQ/g d.w.) and 143 pg/g (1.19 pg I-TEQ/g d.w., respectively, e.g. very low[2]. The level of PCDD/Fs in Lake Nitsijärvi sediments has not been analyzed. The dominant congeners in fish muscle samples were octachlorodibenzo-p-dioxins (OCDD), 1,2,3,4,6,7,8-heptachlorodibenzo-p-dioxin and -furan, 1,2,3,6,7,8-hexachlorodibenzo-p-furan and 1,2,3,4,7,8-hexachlorofuran. The pattern of PCDD/Fs in different fish samples from different lakes were highly similar. Coplanar PCB concentrations were on a same level as PCDD/Fs, IUPAC 77 had the highest concentration and IUPAC 169 the lowest concentrations. If calculated as TEQs, the level of coplanar PCBs was almost identical with the level of PCDD/Fs (Table 1). The only trout samples were catched from Lake 222, and the level of PCDD/Fs and coplanar PCBs were similar with arctic char muscle samples (Table 2).

Table 2.
Average concentrations of PCDDs, PCDFs, and planar PCBs as pg/g w.w. of burbot liver or trout muscle samples in three subarctic lakes in Finland.

congener	Lake Pahtajärvi (4 burbot liver samples)	Lake 222 (4 trout muscle samples)	Lake Nitsijärvi (5 burbot liver samples)
2,3,7,8-TCDF	3.85 ± 2.46	0.078 ± 0.026	13.1 ± 3.13
2,3,7,8-PeCDF	0.40 ± 0.26	0.040 ± 0.008	1.48 ± 0.23
1,2,3,6,7,8-HxCDD	0.15 ± 0.11	0.011 ± 0.020	0.52 ± 0.39
1,2,3,4,6,7,8-HpCDD	<0.01	0.030 ± 0.052	0.27 ± 0.42
OCDD	<0.01	0.135 ± 0.235	0.87 ± 0.57
sum of PCDD/Fs	12.1 ± 7.91	1.36 ± 2.10	19.5 ± 3.41
I-TEQ	**0.70 ± 0.43**	**0.080 ± 0.075**	**2.76 ± 0.53**
IUPAC 77	40.0 ± 23.7	0.937 ± 0.726	60.0 ± 9.15
IUPAC 126	41.2 ± 27.2	0.594 ± 0.36	53.1 ± 17.1
IUPAC 169	32.7 ± 7.07	0.277 ± 0.16	25.2 ± 9.20
TEQ of planar PCBs*	**4.65**	**0.0668**	**5.86**
sum of TEQs	**5.35**	**0.147**	**8.62**

* toxic equivalency factors of 0.005, 0.1, and 0.01 for IUPAC 77,126, and 169, respectively

The PCDD/F and coplanar PCB levels of burbot liver samples are shown in Table 2. The PCDD/F concentrations were about 10-times higher in burbot liver samples comparing to arctic char muscle samples. Burbot liver samples from Lake Pahtajärvi were less contaminated than those from Lake Nitsijärvi, the trend which was also found with arctic char muscle samples. The profile of PCDD/Fs was quite different in muscle and liver samples: the dominant congeners in liver samples were 2,3,7,8-tetrachlorodibenzofurans, 2,3,4,7,8- and pentachlorodibenzofuran, three hexachlorofurans and 1,2,3,6,7,8-hexachlorodibenzo-p-dioxin. 2,3,7,8-tetrachlorodibenzo-p-dioxin was found to be present in burbot liver samples from Lake Nitsijärvi, in all four

samples about 0.5 pg/g w.w, but in the other samples the level was usually much lower if present. The coplanar PCB concentrations in burbot liver samples were 20–100 times higher than the concentrations in arctic char muscles. On average, concentrations of IUPAC 77 and 126 were almost the same and IUPAC 169 concentration was 20–50% lower.

4. Conclusion

In conclusion, the arctic fish samples contained very low levels of PCDDs, PCDFs and coplanar PCBs. The level was about one tenth of the level analyzed from other part in Finland[3] and about two magnitudes lower than the concentrations in Baltic Sea or in the Gulf of Finland[3].

5. Acknowledgement

The authors thank Mr M. Salminen, Lapland Regional Environment Centre, for helping in the sampling, P. Reinikainen and Mr. T. Korhonen, Mrs. T. Rissanen, and Ms K. Mehtonen, National Public Health Institute, for valuable technical assistance.

6. References

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