THE LEVEL OF PCB'S IN AQUATIC BIOTA IN FINLAND

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1. Introduction

Water and Environment Administration (presently Finnish Environment Agency, FEA) has been monitoring organic pollutants in inland and coastal waters since the end of 1970s[1]. PCB's, DDT's and heavy metals have been analysed from fish species Northern pike (*Esox lucius*, L.), roach (*Rutilus rutilus*, L.) and vendace (*Coregonus albula*, L.) in inland waters and in the coastal areas from Northern pike, cod (*Gadus morhua*, L.) and Baltic herring (*Clupea harengus*, L.). Trough the 1980's the coastal monitoring has included Baltic mussel (*Macoma baltica*) and an isopod crustacean (*Mysis relicta*).

At the end of 1980s the monitoring of inland and coastal waters was reorganized and new persistent chlorinated organic compounds were included (chlorinated phenols, anisols, veratroles, HCB, lindane and PCDD/DF's).

One of the primary objectives of the Arctic Monitoring and Assessment Program (AMAP) is to document levels and trends of pollutants in different compartments of the environment. The freshwater contaminant program of AMAP in Finland is initially focused on lake sediments and fish.

This paper presents concentrations of PCBs in Arctic char (*Salvelinus alpinus*, L.) of two small subarctic lakes in Lapland, the northern part of Finland in comparison to the PCB level history in pike of representative lakes and coastal areas and also to the levels of PCBs in selected indicator species in whole Finland in the past decade.

2. Materials and Methods

Description of the study areas

The monitoring lakes represent typical Finnish lakes in chain-type watercourses and coastal stations are situated from Gulf of Finland to the end of Gulf of Bothnia. Principally, about 20 inland and 10 coastal monitoring sites have been the same since 1971. Only in 1978 the monitoring was more extensive including about 100 sites. Most of them are still receiving some pollution from pulp and paper mills and other industry as well as from agricultural and urban areas. The monitoring stations are still not located in the close vicinity of any point sources.

Two small subarctic headwater lakes were selected for AMAP fish studies. Lake Pahtajärvi (5 hectares, location 68°10'N 24°00'E) is situated in a fjell area in northwestern

Lapland and Lake 222 (24 hectares, 69°27'N 29°10'E) in northeastern Lapland. Both lakes are situated near the northern coniferous border and are surrounded by rocky terrain with thin soil layers.

Determination of PCBs

Muscle tissues were prepared and freeze-dried. Then the samples are extracted in a Soxhlet apparatus for 24 h with toluene. The concentrated extract is purified over a silica gel column with a minor modification without using basic silica gel. The sample is then fractionated using an activated carbon column (Carbopack C, 60/80 mesh) containing Celite (Merck 2693) to separate PCDD/Fs from PCBs and further cleaned with an activated alumina column (Merck 1097, standardized, activity level II-III).

If also coplanar PCBs are analysed, they are separated from the main PCB fraction after the gas chromatographic mass spectrometric (GC-MS) analysis with an activated carbon column without Celite (Carbopack C, 60/80 mesh). The analyses of PCBs are performed with a high resolution mass spectrometry equipped with a fused silica capillary column (DB-DIOXIN). The quantitation is performed by selective ion recording using a VG 70 SE mass spectrometry (resolution 10,000). A total of 38 ^{13}C-labelled PCB congeners (100 pg/sample of co-planar PCBs and 900 pg/sample the others, Cambridge Isotope Laboratories) are used as internal standards, added to the samples before silica gel column.

3. Results and Discussion

The PCB concentrations have been decreasing in pike muscle in Finnish waters since 1970's (Table 1). These values are based on about 30 locations and about 300-400 pikes per year. These values are average numbers from each year and should not be directly compared as trend values between years. The results from the year 1994 are only from some areas and the total mean values are presently only approximations.

The intercalibration of analytical methods are taken into account between years. Year 1971 and 1978 the analytical method has based on packed colums and Aroclor 50 and 60. The analyses from year 1980 are done with glass capillary colums and the separate conceners (28, 31, 52, 101, 118, 153, 138, 180) are calculated together after recommendations of the ICES (International Council for the Exploration of the Seas) and HELCOM.

Table 1. Concentration level of PCBs in the pike muscle (μg/g l.w.) in inland and coastal areas of Finland.

Area	1971	1978	1989	1992	1994
lakes (>10 km^2)	> 7	2	0.5	1.2	1.7
coastal waters	10	6	2.2	1.7	2.1

The mean concentrations of PCBs in selected indicator specimens in whole Finland are shown in table 2.

Table 2. *Average concentrations of PCBs in selected indicator specimens in whole* Finland in the 1980's.

Specimen	PCB's		time
white tailed eagle *[2]	200 µg/g	lf	
ringed seal **[3,4]	100–150 µg/g	lf	(70s–80s)
	40–70 µg/g	lf	(80s–90s)
grey seal *[3,4]	*100 µg/g*	*lf*	*(70s–80s)*
	30 µg/g	lf	(80s–90s)
salmon ***[5]	3.5–5 µg/g	lf	
–spawning	4–9 µg/g	lf	
pike ***[1]	6–10 µg/g	lf	(70s–80s)
	1–3 µg/g	lf	(80s–90s)
Baltic herring ***[1]	2–10 µg/g	lf	(70s–80s)
	1 µg/g	lf	(80s–90s)
Macoma balthica *[1]	*0.5 µg/g*	*lf*	
Anodonta piscinalis **[1]	0.4 µg/g	lf	
freshwater ***[1]	<0.1–1 ng/l		
human serum ***[6]	2.5–3.5 µg/l		

***=large data, **=some data, *=small data;
lf=lipid fraction
70s–80s= at the end of 1970s and in the beginning of the 1980s
[1]Korhonen et.al. 1995
[2]Paasivirta et.al. 1992
[3]Helle et.al. 1991
[4]Perttilä et.al. 1986
[5]Vuorinen et.al. 1993
6Luotamo et.al. 1991

The biomagnification factors are approximately as follows:

water/fish	10^6–10^7
water/human serum	10^3–10^4
Baltic herring/Salmon	4
Baltic herring/Seals	40
Baltic herring/Eagle	200
salmon/Eagle	40

The concentrations of PCBs in Arctic char lipid fraction are about 10 times smaller than the PCB concentrations in pike, Baltic herring or salmon (tables 1–3). The AMAP congener sum includes only two congeners more (105 and 156) than HELCOM–congener sum and is only about 10 percent higher than HELCOM–congener sum in these char data. When the congener sum is calculated on a wet weigth basis, the PCB level in char compared to that of herring and salmon differs more, because these fishes consist more lipid than pike (5 and 0.5, respectively).

The PCB's in Arctic char muscle in some arctic lakes in Canada range from 7 ng/g wet wt (Buchanan Lake) to about 23 ng/g w.w. (Sanikiluaq Lake) and even up to 70 ng/g w.w. (Amituk Lake)[7]. The PCB sum (sum of 89 congeners) in Canadian lakes (excluding

Amituk L.) are 3–12 times higher than in Finnish lakes (sum of 38 congeners) measured on a wet weight basis. However, the level is almost the same, 100–600 ng/g when comparing results on a lipid weight basis (4–7 percent lipid in Canadian chars).

Arctic char from Lake 222 are catched during open water time in September 1993, whereas those from Lake Pahtajärvi are from ice cover time in November 1993. The differences in catching time, fish size and perhaps diet are probable reasons for the differences in the lipid content.

Table 3. PCB concentrations in Arctic char muscle in two subarctic lakes, Pahtajärvi and Lake 222 in Finland year 1993. "amap" congeners: 28, 52, 101, 118, 105, 153, 138, 156 and 180. "All38" congeners: 18, 28, 33, 77, 80, 51, 52, 49, 47, 74, 66, 60, 81, 126, 101, 99, 110, 123, 118, 114, 122, 105, 169, 153, 141, 138, 159, 167, 128, 156, 157, 180, 170, 187, 183, 189, 194 and 206.

	sex	weigth	%lipid	lipid ng/g amap	lipid ng/g all38	wet wt. ng/g amap	wet wt. ng/g all38
Lake Pahtajärvi							
Arctic char 1	F	425	1.17	79	130	0.93	1.51
Arctic char 2	F	432	1.33	70	115	0.93	1.53
Arctic char 3	F	401	1.50	95	158	1.43	2.37
Arctic char 4	F	445	1.17	64	106	0.75	1.25
female mean	F	426	1.29	77	127	1.01	1.67
Arctic char 5	M	465	1.54	59	99	0.90	1.52
Arctic char 6	M	432	1.17	93	153	1.08	1.79
Arctic char 7	M	486	1.87	62	100	1.16	1.87
male mean	M	461	1.52	71	117	1.05	1.73
Lake 222							
Arctic char 1	F	216	0.42	385	591	1.62	2.50
Arctic char 2	F	60	0.43	419	643	1.80	2.76
female mean	F	138	0.43	402	617	1.71	2.63
Arctic char 3	M	156	0.42	319	498	1.33	2.08
Arctic char 4	M	296	0.37	317	486	1.18	1.81
male mean	M	226	0.40	318	492	1.26	1.95

4. References

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