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Organochlorines in salmon (*Salmo salar* L.) from the Teno river

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Atlantic salmon (*Salmo salar* L.) from the Teno River were sampled during July and August of 1990. Altogether 15 female salmon were sampled. Their mean weight was 5.6 kg (range 1.7 - 10.6 kg) and mean length 83.7 cm (range 58 - 106 cm). Epaxial muscle samples (30 - 50 g) were taken from under the dorsal fin excluding the red muscle tissue. Organochlorine concentrations, including polychlorinated dibenzo-p-dioxins (PCDDs) and dibenzofurans (PCDFs) at the detection level of 3 - 10 pg g^{-1} (depending on the isomer), were analysed as was depicted earlier for the Baltic salmon (Koistinen et al. 1989, Tarhanen et al. 1989, Koistinen 1990). For the calculations of the Baltic/Arctic compounds' concentration ratios (B/A), the results based on fat weight were used, and results for the Baltic salmon were based on samples taken the same year (Vuorinen et al. unpubl. data) as those from the Teno River.

On the basis of fresh weight, the concentrations of organochlorines in the Teno River salmon were very low (Table 1). The mean (± SE) sum concentration of DDT and its metabolites was 17 ± 2 µg kg^{-1} and the mean PCB concentration was 35 ± 4 µg kg^{-1}. The sum DDT concentration was about 1/7th of that in the Baltic salmon and the PCB concentration about 1/5th. The concentrations of -HCH, lindane and chlordanes were also lower in Teno salmon than in Baltic salmon. The concentrations of all these toxicants were only a fraction of what is allowed for human consumption (Table 1). The (preliminary) toxaphene concentration of Teno salmon muscle was much lower than in the liver of marine cod (*Gadus morhua*) from the Canadian east coast (Musial & Uthe 1983), but was at about the same level as that in cod muscle from the central eastern Canadian Arctic (Muir et al. 1988) and in burbot (*Lota lota*) liver from remote Canadian lakes and rivers (Muir et al. 1990). The concentrations of HCB, DDT, chlordanes and PCB in salmon muscle from the Teno River were at the same level as those in burbot liver (Muir et al. 1990). The B/A ratios are now smaller than those measured earlier (Vuorinen et al. in print), but this is due, at least in part, to a very high fat content in Baltic salmon samples in 1990.

Of the congeners of PCDDs and PCDFs, three were detected: 1,2,3,4,6,7,8-HpCDD and 1,2,3,4,7,8-HxCDF, each in one salmon, and 2,3,7,8-TCDF was detected in 10 salmon with a mean concentration of 2 ng kg^{-1} (range 0 - 5 ng kg^{-1}) on the basis of fresh weight. This concentration is 7 - 20 times lower than the concentrations in lake trout (*Salvelinus namaycush*) and walleye (*Stizostedion vitreum vitreum*) from the Great Lakes (De Vault et al. 1989).

The concentrations of HCB, oxy-chlordane, DDE, PCB and toxaphene on the fat weight basis had a significant, positive correlation with the size of a salmon (Table 2).

Table 1. The concentrations of organochlorine compounds (mean ± SE, µg kg^{-1} fresh weight) in the muscle of the Teno River salmon. The range, number of samples, allowable limit values of some compounds for human consumption and the Baltic to Teno salmon organochlorine concentration ratios (B/A) are also given.

Compound	Mean ± SE	Range	N	Limit value	B/A
Fat,%	5.0 ± 0.6	2.1 - 9.6	15		
HCB	3.0 ± 0.3	1.0 - 6.0	15	200	2.0
-HCH	0.4 ± 0.1	0.2 - 0.8	15	-[a,b]	1.4
LINDANE	0.2 ± 0.0	0.1 - 0.4	15	100[a]	1.3
CHLORDANES	10.2 ± 1.2	4.1 - 17.4	15	100	1.4
DDE	7.5 ± 0.9	4.0 - 18.0	15	-	7.7
DDD	4.9 ± 0.8	0.6 - 10.0	15	-	8.4
DDT	4.5 ± 0.7	0.6 - 10.0	15	-	4.9
DDT	17.0 ± 2.2	4.1 - 35.0	15	500	7.2
PCB	35 ± 4	10 - 66	15	2 000	4.9
TOXAPHENE	43 ± 7	5 - 98	15	-	-

[a] limit value 100 µg kg^{-1} is the sum of concentrations of -HCH, ß-HCH and lindane

[b] - means that limit value is not determined

Table 2. The significant Pearson correlations between the organochlorine compounds (on the fat weight basis) from the muscle and the weight and length of the Teno River salmon. Sample size was 15. * = P < 0.05 and ** = P < 0.01.

Compound	Weight	Length
HCB	0.636*	0.724**
OXY-CHLORDANE	0.496	0.540*
DDE	0.443	0.545*
PCB	0.534*	0.630*
TOXAPHENE	0.709**	0.695**

Key words: salmon, Teno River, Arctic, organochlorines, PCDD/PCDF

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POLYCHLORINATED DIBENZO-P-DIOXINS, DIBENZOFURANS AND BIPHENYLS IN SALMON (*SALMO SALAR* L.) FROM THE SOUTHERN BALTIC SEA AND THE ARCTIC TENOJOKI RIVER

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Polychlorinated hydrocarbons are ubiquitous pollutants in wildlife. Through long-range transport they have spread to areas where they have not been used or where there are no local waste sources. Preliminary concentrations of polychlorinated dibenzo-*p*-dioxins (PCDDs) and dibenzofurans (PCDFs) as toxic equivalents in salmon from the arctic Tenojoki River have previously been reported (Vuorinen *et al.* 1992) as well as concentrations of chlorinated hydrocarbons, including polychlorinated biphenyls (PCBs), and polychlorinated diphenylethers (Vuorinen *et al.* 1992, 1995).

In this report concentrations of PCDDs/PCDFs and PCBs in muscle of salmon from the arctic Tenojoki River are compared to those in Baltic salmon.

Materials and methods

Baltic salmon (*Salmo salar* L.) from the main basin of the Baltic Sea were sampled in June 1994 and ascending salmon from the arctic Tenojoki River in August. The weights and lengths of fish are given in Table 1. For organochlorine analysis, a piece of epaxial muscle (60 - 100 g) was sealed in a polyethylene bag and frozen at -20 °C until analysed.

Table 1. The weight, length, muscle fat (mean ± SE) and number of sampled salmon. The letter "a" as a superscript to SE indicates a significant difference ($p < 0.05$) between the means.

	Weight, kg	Length, cm	Muscle fat, %	N
Baltic Sea	5.8 ± 0.2	80 ± 1	10.9 ± 2.4	7
Tenojoki River	11.1 ± 1.0[a]	104 ± 4[a]	~~2.4 ± 1.4~~ 4.6 ± 0.5	5

Vartiainen, Terttu & Komulainen, Hannu (Eds.). 7th Nordic Symposium on Organic Pollutants. Kuopio University Publications C. Natural and Environmental Sciences 68. 1997.

Determination of PCDD/Fs and PCBs was performed as described earlier (Vartiainen *et al.* 1995). Briefly, the analysis was run as follows. About 10 g of freeze dried fish sample was soxhlet extracted for 24 h with toluene. The fat content was weighed 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 13C-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 13C-PCDD/Fs congeners (100 pg/ sample, Cambridge Isotope Laboratories), added to the samples before silica gel column extraction. To test the recoveries, 13C-1,2,3,4-TCDD and 13C-1,2,3,7,8,9-HxCDD or IUPAC 159 were added to the final concentrate before GC-MS analyses.

Toxic equivalent concentrations (TEQs) were calculated with the Nordic toxic equivalent factors. Because the Tenojoki River salmon were bigger than salmon from the Baltic Sea (Table 1), differences in concentrations were tested by analysis of covariance with the weight of fish as a covariate. All statistical calculations were made with the Statistical Analysis System (1988).

Results and discussion

Concentrations of most of the 36 detected PCB congeners were lower in muscle of salmon from the arctic Tenojoki River than in Baltic salmon muscle. The six most notable PCB congeners were #153, #118, #101, #138, #110 and #99 in Baltic salmon and #118, #153, #101, #138, #110 and #52 in the arctic salmon, respectively. The total PCB concentration, 37 $\mu g\ kg^{-1}$ (in fresh weight), in the Tenojoki river salmon was quite close to that reported earlier (Vuorinen *et al.* 1992). In the Baltic salmon the total PCB concentration was 200 $\mu g\ kg^{-1}$ (in fresh weight). On the lipid basis there was not a great difference in the total PCB concentration between the arctic and Baltic salmon; the concentrations were 893 and 1482 $\mu g\ kg^{-1}$, respectively.

On the fresh weight basis, concentrations of PCDD/DFs and sums of non-ortho-, mono-ortho- and di-ortho-PCBs were significantly ($p < 0.05$) lower in the Tenojoki River salmon muscle than in Baltic salmon, but on the lipid basis there were no significant difference in PCDD/DFs between salmon from the two areas (Table 2). TEQs of these parameters on the fresh weight basis were also significantly lower in the Tenojoki River salmon muscle than in Baltis salmon, but in lipid weight only TEQs of non-ortho-PCBs and the total TEQ were significantly lower in the arctic salmon than in the Baltic ones (Table 3).

To summarize concentrations of PCDD/DFs and PCBs were clearly lower in the arctic Tenojoki River salmon muscle than in the Baltic salmon, as was previously reported of other chlorinated compounds (Vuorinen *et al.* 1992, 1995). According to the Nordic recommendations of TEQs (total weekly intake of 35 pg per kg of body weight) a person weighing 70 kg could consume 840 g of arctic salmon in a week, but only 120 g of Baltic salmon, when the TEQs were calculated with the PCDD/DFs and the toxic PCBs included.

Table 3. Concentrations of PCDD/DFs and non-ortho-, mono-ortho- and di-ortho-PCBs in muscle of the arctic Tenojoki River salmon and Baltic salmon on the fresh weight basis (fw) and in lipid (lw). For other explanations see text of Table 1.

	Baltic		Arctic	
	ng g^{-1} (fw)	ng g^{-1} (lw)	ng g^{-1} (fw)	ng g^{-1} (lw)
PCDD/DFs	18.3 ± 4.2	138.0 ± 31.6	2.46 ± 0.48[a]	57.8 ± 8.1
Non-ortho-PCBs	0.48 ± 0.13	2.5 ± 0.2	0.05 ± 0.01[a]	1.1 ± 0.1[b]
Mono-ortho-PCBs	39.4±4.4	291.3±14.5	8.9±1.6[a]	210.2±23.8[a]
Di-ortho-PCBs	74.2±8.8	547.2±26.9	10.1±0.9[a]	242.8±13.2[a]

Table 4. Toxic equivalent concentrations (TEQs) in muscle of the arctic Tenojoki River salmon and Baltic salmon on the fresh weight basis (fw) and in lipid (lw). For other explanations see text of Table 1.

	Baltic		Arctic	
	TEQs pg g^{-1} (fw)	pg g^{-1} (lw)	TEQs pg g^{-1} (fw)	pg g^{-1} (lw)
PCDD/DFs	4.81 ± 0.8	35.9 ± 5.2	0.35 ± 0.10[a]	8.0 ± 1.5[b]
Non-ortho-PCBs	13.1 ± 1.8	86.7 ± 7.5	2.1 ± 0.4[a]	49.3 ± 9.2[b]
Mono-ortho-PCBs	2.8 ± 0.3	20.8 ± 1.2	0.4 ± 0.1[a]	9.8 ± 1.2[b]
Di-ortho-PCBs	0.1 ± 0.0	0.8 ± 0.0	0.02 ± 0.00[a]	0.4 ± 0.1[b]
Total	20.8 ± 2.3	144.1 ± 12.4	2.9 ± 0.5[a]	67.4 ± 8.6[b]

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