PCDD/F, PCB, PBDE and PCN in six fish species from the Finnish Baltic Sea coastal and inland waters

Pekka Vuorinen[1], Hannu Kiviranta[2], Pirjo Isosaari[3], Raimo Parmanne[1], Jaana Koistinen[4], Anja Hallikainen[5], Terttu Vartiainen[2]

[1]Fiinish Game and Fisheries Research Institute
[2]National Public Health Institute, Department of Environmental Health
[3]VTT Building and Transport
[4]Natioanal Public Health Institute, Department of Environmental Health
[5]National Food Agency

Introduction

In July 2002 the decision of the European Commission set a new maximum allowable concentration in fish edible part to 4 pg WHO-TEQ g^{-1} (fresh weight) for human consumption. Finland and Sweden got an exemption order until the end of 2006 for commercial exploitation of Baltic fish within their own markets, because quite high concentrations of polychlorinated dibenzo-p-dioxins (PCDDs) and dibenzofurans (PCDFs) have been measured in Baltic fish species.[1,2] On the other hand, hardly any data exists of the concentrations of organohalogen compounds in fish caught from the Finnish inland waters. In order to be able to estimate the dioxin intake of Finnish people from fish, new and extensive data were needed. Thus a large project was performed during 2002–2003 to study PCDD/F and PCB, and also PBDE and PCN concentrations in fish. Fish samples were collected from professional fishermen and fish were caught from three most important Baltic Sea and inland fishing areas.

The aim of the present paper was to investigate organohalogen concentrations and relationships in six fish species that live in the coastal waters of the Baltic Sea and in inland waters. Such knowledge is important for setting regulations for fisheries, advising consumers and finding means to further reduce emissions of these toxicants, the concentrations of which have earlier been demonstrated to increase according to age of Baltic herring (*Clupeaharengus*).[3,4]

Materials and Methods

The sampled fish species were perch (*Percafluviatilis*), pike (*Esoxlucius*), pikeperch (*Stizostedionlucioperca*), bream (*Abramisbrama*), vendace (*Coregonusalbula*) and whitefish (*Coregonuslavaretus*) (Table 1 and 2). These species live in both freshwater lakes and in the low-salinity coastal waters of the Baltic Sea. After capturing fish were frozen and transported to the laboratory, where they were kept frozen (-20 ºC) until analyzed. Homogenates were prepared comprising either the whole, cleaned fish (heads and guts were removed, vendace) or a slice of 50-150 g that was dissected from just behind the dorsal fin. The pools of ten vendace or slices of three other species were thoroughly homogenised, freeze-dried and extracted with toluene in a Soxhlet apparatus. Determination of concentrations of PCDD and PCDF was performed as described earlier.[1] Toxic equivalent concentrations (WHO-TEQ, pg g^{-1} in fresh weight) were calculated according to Van den Berg et al.[5]

Table 1. The mean (± SE) length, weight, age and concentrations of organohalogen compounds as well as dioxin and PCB WHO-TEQs in predatory fish from the Finnish inland and Baltic Sea coastal waters. Number of samples in italics.

Inland Waters	Perch	Pike	Pikeperch
	6	*6*	*6*
Length, mm	203 ± 18	571 ± 52	427 ± 25
Age, years	6.3 ± 0.9	7.3 ± 0.9	5.9 ± 0.7
Fat, %	1.1 ± 0.1	0.4 ± 0.1	1.6 ± 0.4
SPBDE ng g^{-1}	0.47 ± 0.18	1.01 ± 0.40	1.06 ± 0.25

SPCN, pg g^{-1}	6.3 ± 1.3	6.5 ± 2.0	5.4 ± 1.1
$WHO_{PCDD/F}$-TEQ, pg g^{-1}	0.25 ± 0.06	0.43 ± 0.24	0.43 ± 0.11
WHO_{PCB}-TEQ, pg g^{-1}	0.49 ± 0.13	0.56 ± 0.27	0.69 ± 0.17
Baltic Sea			
	11	*6*	*4*
Length, mm	262 ± 7	661 ± 30	429 ± 22
Age, years	7.1 ± 0.6	6.0 ± 0.9	5.9 ± 0.5
Fat, %	2.1 ± 0.3	0.5 ± 0.1	1.3 ± 0.2
SPBDE ng g^{-1}	1.00 ± 0.21	0.65 ± 0.14	0.56 ± 0.05
SPCN, pg g^{-1}	39.2 ± 7.6	16.5 ± 2.6	28.2 ± 5.4
$WHO_{PCDD/F}$-TEQ, pg g^{-1}	2.29 ± 0.45	0.90 ± 0.16	1.30 ± 0.33
WHO_{PCB}-TEQ, pg g^{-1}	2.35 ± 0.42	1.05 ± 0.18	1.48 ± 0.25

Table 2. The mean (± SE) length, weight, age and concentrations of organohalogen compounds as well as dioxin and PCB WHO-TEQs in bottom (bream) and plankton (vendace and whitefish) feeding fish from the Finnish inland and Baltic Sea coastal waters. Number of samples in italics.

Inland Waters			
	Bream	Vendace	Whitefish
	6	*9*	*6*
Length, mm	444 ± 18	166 ± 10	271 ± 16
Age, years	12.1 ± 1.8	1.9 ± 0.4	4.3 ± 0.6
Fat, %	6.1 ± 0.9	2.6 ± 0.4	2.1 ± 0.5
SPBDE ng g^{-1}	1.20 ± 0.39	1.09 ± 0.27	0.85 ± 0.33
SPCN, pg g^{-1}	41.3 ± 8.3	22.3 ± 4.2	16.3 ± 6.3
$WHO_{PCDD/F}$-TEQ, pg g^{-1}	2.00 ± 0.66	0.90 ± 0.22	0.83 ± 0.38
WHO_{PCB}-TEQ, pg g^{-1}	1.26 ± 0.35	0.88 ± 0.16	0.96 ± 0.30
Baltic Sea			
	3	*3*	*4*
Length, mm	445 ± 42	171 ± 9	331 ± 44
Age, years	16.6 ± 2.3	1.9 ± 0.4	5.3 ± 0.5
Fat, %	3.4 ± 1.4	5.1 ± 0.4	3.1 ± 0.5
SPBDE ng g^{-1}	3.32 ± 0.67	1.01 ± 0.18	1.16 ± 0.51
SPCN, pg g^{-1}	72.7 ± 48.1	10.7 ± 3.2	70.0 ± 26.8
$WHO_{PCDD/F}$-TEQ, pg g^{-1}	2.01 ± 0.64	0.60 ± 0.13	3.33 ± 1.39
WHO_{PCB}-TEQ, pg g^{-1}	5.64 ± 1.44	0.45 ± 0.10	2.25 ± 0.55

Results and Discussion

On average the concentrations of PCDD/F and PCB in the six fish species were higher in the coastal waters of the Baltic Sea than in inland waters (Fig.1). This was also seen in the toxic equivalent values (Table 1 and 2). However, in vendace the PCDD/F and PCB, and consequently, the TEQs were even higher in fish from the inland waters. The reason for this is not yet elucidated as the sampled fish were approximately of similar size and age. On the other hand, the concentrations of PCDD/F and PCB in the six fish species increased according to age (Fig. 1) as has earlier been observed in the Baltic herring.[3,4]

In the concentrations of PBDE in fish there were no clear differences between the Baltic Sea and inland waters or between the predatory and other fish species. However, the PCN concentrations were mostly much higher in fish from the Baltic Sea than from the inland waters (Table 1 and 2).

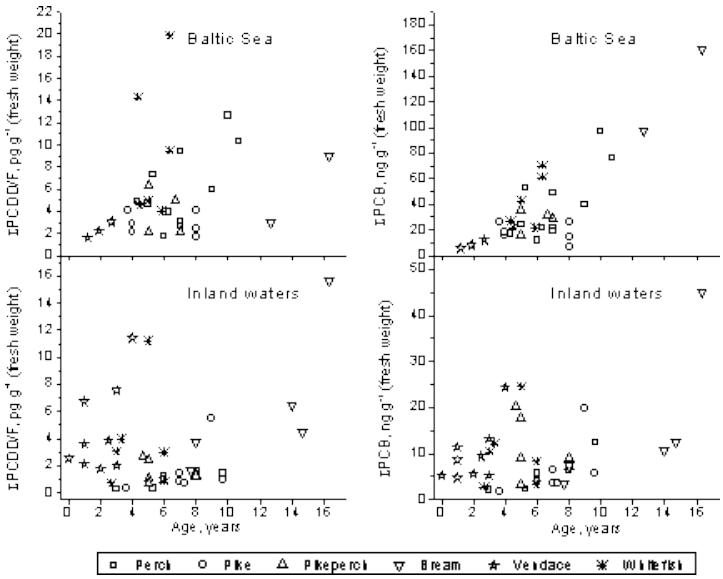

Fig. 1. The concentration of PCDD/F (left panel) and PCB (right panel) according to age in six species of fish from the Finnish Baltic Sea coastal and inland waters.

The concentrations of PCDD/F and PCB in the six fish species demonstrated good correlations whether the fish were caught from the Baltic Sea or the inland waters, except for whitefish from the Baltic Sea (Fig. 2). The $WHO_{PCDD/F}$-TEQs were lower than the WHO_{PCB}-TEQs in predatory fish (perch, pike and pikeperch) from the inland waters but approximately at a similar level in the Baltic Sea (Table 1). In vendace and whitefish both TEQ concentrations were about at a similar level in both environmental surroundings, but in bream the WHO_{PCB}-TEQ level was over two times higher than the $WHO_{PCDD/F}$-TEQ concentration in the Baltic Sea compared to the fish from the inland waters. Apparently this was due to younger age of bream from the latter environment. In fatty fish species from the Baltic Sea the dioxin-like PCBs have been reported to contribute more to the total dioxin equivalents than dioxins.[6]

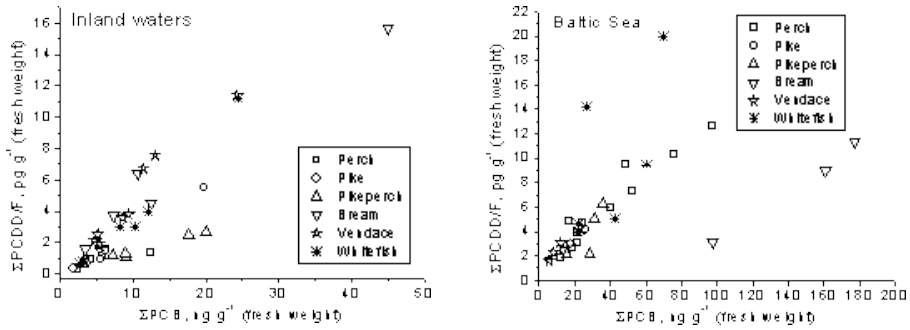

Fig. 2. The relationship between PCDD/F and PCB concentrations in six fish species from the Finnish Baltic Sea coastal and inland waters.

In all, the concentrations of the measured organohalogens were relatively low in the studied six fish species, and the $WHO_{PCDD/F}$-TEQ concentrations were clearly below the maximum allowable concentration set by EU.

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