Development of Otter-based Quality Objectives for PCBs (DOQOP). Studies on Biomagnification of PCBs in the Limfjord Area (Denmark).

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Introduction

Populations of the otter (Lutra lutra) have suffered from serious declines during the past decades in many parts of Western Europe. In some areas the species has become virtually extinct. Apart from habitat destruction, isolation, drowning in fykes and traffic accidents, morbidity and reproductive failure due to exposure to PCBs and other contaminants usually are considered as important causal factors [1) 2)], although mechanisms and relative importance of contaminant effects have not yet been elucidated [3)]. In the Netherlands the total number of otters decreased from several hundreds during the 1950s to less than 20 during the first half of the 1980s [4)]. The last regular traces (footpints, spraints) were spotted in 1988 in wetland habitats in the Northern part of the Netherlands with low contaminant burdens [3)]. The Dutch government adopted in 1989 a policy plan [4)] for the return of the otter, which included, amongst others,

restoration of habitats and ecological corridors, hydrological isolation, sediment remediation, the design of breeding programmes and feasibility studies on potential repopulation projects in low-contaminated areas. Especially for such reintroduction programmes a further confirmation of the role of contaminants in the etiology of decline of the otter and the development of quality objectives is of great importance. During 1993 the joint project 'Development of Otter-based Quality Objectives (DOQOP)' was started in order to provide a further scientific basis for the development of quality objectives for PCBs in otterhabitats. In the contribution of Van der Weiden et al. [5] scope, objectives and preliminary results of the overall DOQOP-project are presented. In the first phase of the project, review and modelling studies were executed, which included critical evaluations of literature data from fieldstudies on otters [3] and experimental toxicity studies with mink [6], a mustelid species closely related to the otter. During the second phase of the project, a fieldsurvey in the Limfjord area and monitoring studies with captive and feral otters from various European countries were executed, aiming at: the validation of models for trophic transfer of sediment-bound PCBs in otterhabitats, the elucidation of potential dose-effect relationships of toxic PCBs and physiological effect paramaters, and the development of non-destructive techniques for the assessment of exposure and effects in feral otters. The results of the studies on the latter two subjects are presented by Murk et al. [7] and Leonards et al. [8].

Methods

The Limfjord area in the Northern part of the Danish mainland (Jutland) has a well performing otterpopulation living in freshwater, brackish and marine habitats. The area was selected because of the resemblance to Dutch wetland habitats considered for future reintroduction experiments.
Liver samples were taken from otter-carcasses (road victims, drowning, natural deaths) collected in the period 1985-1993. The otters originated from five different habitats within the Limfjord area, which were sampled for sediments and prey-fish in the summer of 1995. The selection of fish species and age classes was based on available data from regional otter-diet studies. Sediments and biological samples were analysed for 19 PCB congeners with GC-ECD and GC-ITD described by Leonards *et al.* [8,9]. Non-ortho substituted CBs included (IUPAC numbers): 77, 126 and 169; mono-ortho substituted CBs: 28, 60, 74, 105, 114, 118, 123, 156, 157, 167 and 189; di-ortho substituted CBs included: 52, 101, 138, 153 and 180. Results will be expressed on the basis of the summation of 7 indicator congeners (28, 52, 101, 118, 138, 153 and 180) commonly used for environmental monitoring studies, or on the basis of the sum of 2,3,7,8-tetrachlorodibenzo-*p*-dioxin toxic equivalents for PCBs (Σ TEQ) according to Ahlborg *et al.* [10].
Fish-sediment bioaccumulation factors (BAF) were normalized for lipid weight and organic carbon content. Diet-specific otter-fish biomagniciation factors (BMF; lipid wt.) were calculated according to Leonards et al. [6,11]. In this procedure a correction is made for the relative contribution of each fish species to the otter diet.

Results and discussion

PCB concentrations of sediments, fish species and otters, calculated fish-sediment BAFs and otter-fish BMFs are indicated for the different habitats in the Limfjord area in Table 1. A marked increase of PCB concentrations was observed with successive trophic levels in all habitats in the Limfjord area, as is clearly demonstrated in Fig.1.

Table 1. Concentrations of PCBs (Σ 7 PCBs mg/kg lipid wt.) in otters, fish and sediments (composite samples) in different habitats in the Limfjord area (Denmark) in relation to calculated fish-sediment bioaccumulation factors (BAF; lipid/org-C normalized) and diet-specific otter-fish biomagnification factors (BMF; lipd wt.).

habitat:		Oveso freshwater	Indfjorden brackish	Virksund brackish	Boddum marine	Flynderso freshwater
PCB-concentrations						
Otter (n=4)	mean	9.3	4.7	5.3	10.1	12.2
	range	0.8 - 12	5 - 15	4 - 31	2 - 8	2 - 21
Eel		0.20	0.05	0.13	0.10	0.25
Roach		1.64	0.42	0.57		
Percidae		0.45	0.93	0.27		0.30
Flounder				0.09	0.19	
Viviparous blenny				0.11	0.16	
Bream						0.08
Stickleback				0.20		
Sediment		0.023	0.038	0.038	0.079	0.019
Fish-sediment BAF						
Σ 7 PCB		8 - 67	1-25	3-15	1-2	13 - 30
Σ TEQ		6 - 56	3-20	5-16	0.1-1	2 - 4
Otter-fish diet-specific BMF [a]						
Σ 7 PCB		5	19	48	28	28
Σ TEQ		13	- [b]	206	60	133

[a] explained in text

[b] non- and mono-ortho PCBs not analysed at this location

Sediment concentrations varied within 1 order of magnitude, with the lowest concentrations in the freshwater environments (Oveso, Flynderso), intermediate values in the brackish habitats (Indfjorden, Virksund) and the highest levels in the marine habitat (Boddum). Fish-sediment BAFs on Σ 7 PCB basis tended to be higher in freshwater locations (8-67) compared to the marine and brackish locations (1-25). Diet-specific otter-fish BMFs ranged from 5 to 48 on Σ7 PCB basis. Expressed on Σ TEQ basis much higer BMF values were found (13 - 206). This increase of biomagnification of toxic PCBs compared to other PCBs is mainly due to the high BMF values of congener 126, which contributes for more than 60% to Σ TEQ. Similar observations are known from other studies [11] for habitats in the Netherlands. It is interesting to note that the most marked concentration of toxic PCBs seems to occur at the higher trophic levels. Fish-sediment BAFs expressed on Σ TEQ basis are similar or less than BAF-values expressed as Σ 7 PCB basis.

Preliminary analysis of PCB patterns (Principal Component Analysis) revealed relatively high concentrations of low-chlorinated PCBs in sediments and increasing dominance of higher chlorinated PCBs at the with increasing trophic position. This is in line with findings on biotransformation of specific congeners in otters [8].

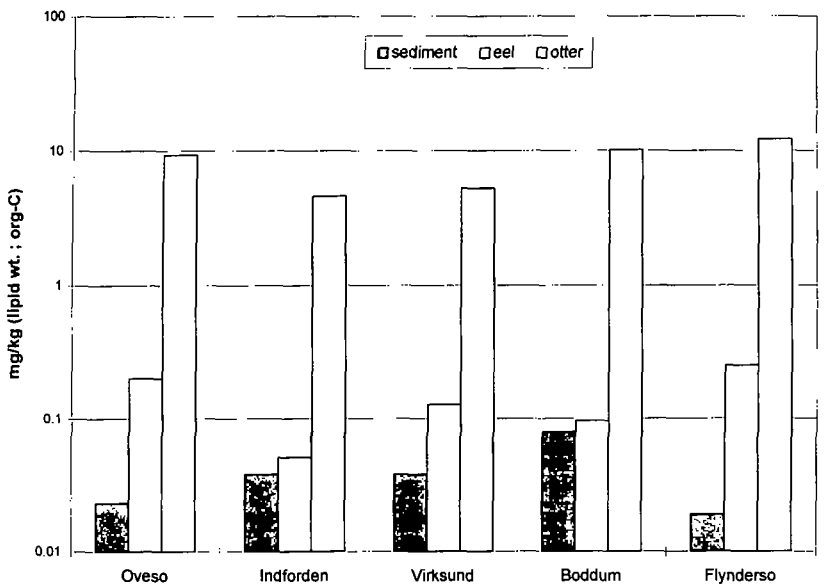

Figure 1. Ambient levels of PCBs (Σ 7 PCBs mg/kg) in sediments (org-C based), eel and otters (lipid based) from the Limfjord area.

PCB concentrations in sediments and organisms in wetland habitats in the Northern part of the Netherlands [3) 11)], some of which are selected for potential reintroduction experiments, are comparable to the levels encountered in the present study. Although the results of the study in the Limfjord area with its thriving otterpopulations seem to give hope to proposed reintroduction experiments in low-contaminated habitats in the Netherlands, it should be noted that much higher contamination levels (up to 1-2 orders of magnitude) still persist in many water systems in the Netherlands influenced by the Rivers Rhine and Meuse.

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References

[1] Mason C.F. (1989): Water pollution and otter distribution: a review. Lutra 32, 97-131.

[2] Olsson M. and F. Sandegren (1983): Is PCB partly responsible for the decline of the otter in Europe? Proc. 3th International Ottersymposium, Strasbourg, November 24-27, 1983. Published in: Reuther, C and R. Rochert (eds.): Proc. V Int. Otter Colloquium. Habitat 6, Hankensbuttel, 191 pp 223-227.

[3] Smit M.D., P.E.G. Leonards, B. van Hattum and A.W.J.J. de Jongh. 1995. PCBs in European otter (Lutra lutra) populations. Report no. R-94/7. Institute for Environmental Studies, Free University / Dutch Otterstation Foundation., Amsterdam.

[4] Ministerie Landbouw en Visserij (1989). De otter in perspectief: een perspectief voor de otter. Herstelplan leefgebieden otter. Directie Natuur, Milieu en Faunabeheer. Den Haag. (In Dutch)

[5] Van der Weiden M.E.J., A.J. Hendriks, M. Klein, P.E.G. Leonards, M. Smit, T. Crommentuijn, R. Luttik and B. Van Hattum (1996). Development of otter-based quality objectives for PCBs: overview of the project in view of the environmental policy aims. Proceedings Dioxin '96, Amsterdam

[6] Leonards P.E.G., T.H. de Vries, W. Minnaard, S. Stuijfzand, P. de Voogt, W.P. Cofino, N.M. van Straalen and B. van Hattum (1995). Assessment of experimental data on PCB-induced reproduction inhibition in mink, based on an isomer- and congener-specific approach using 2,3,7,8-tetrachlorodibenzo-p-dioxin toxic equivalency. Environ. Toxicol. Chem. 14, 639-652.

[7] Murk A.J, P.E.G. Leonards, R. Luit, B. van Hattum, and M. Smit (1996): Monitoring exposure and effects of polychlorinated aromatic hydrocarbons (PHAHs) in European otters (Lutra lutra). Proceedings Dioxin '96, Amsterdam.

[8] Leonards P., B. Van Hattum, W. Cofino, M. Elmeros, M. Smit and A.B. Madsen (1996).Toxic PCBs in European otter populations in relatin to biological factors. Proceedings Dioxin '96, Amsterdam.

[9] Leonards P.E.G. B. van Hattum, W.P. Cofino and U. Th. Brinkman. 1994. Occurrence of non-ortho, mono-ortho and di-ortho-substituted PCB congeners in different organs and tissues of polectas (Mustela putorius L.) from the Netherlands. Environ. Toxicol. Chem. 13, 129-142.

[10] Ahlborg U.G. Becking, G.C. Birnbaum, L.S. Brouwer, A. Derks, H.J.G.M. Feeley, M. Golor, G. Hanberg, A., Larsen, J.C. Liem, A.K.D. Safe, S.H. Schlatter, C. Waern, F. Younes, M. Yrjanheikki, E. 1994. Toxic Equivalency Factors for Dioxin-Like PCBs - Report on a WHO-ECEH and IPCS Consultation, December 1993. Chemosphere. 28:1049-1067.

[11] Leonards P.E.G., Y. Zierikzee, U.A.Th. Brinkman, W.P. Cofino, N.M. van Straalen, B. van Hattum (submitted). Exposure of otters (Lutra lutra) to planar PCBs accumulated in an aquatic food web. Submitted to Environ. Toxicol. Chem.