DIOXIN LEVELS IN EUROPEAN EELS, A BELGIAN STUDY

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Introduction

Dioxins are persistent environmental contaminants, which influence the health and reproductive success of many freshwater species, including eel. Dioxins, dibenzofurans (PCDD/Fs) and dioxin like polychlorinated biphenyls (DL-PCBs) have a comparable chemical structure and have similar toxicological characteristics. Research indicated that the peak of the environmental levels of dioxin like PCBs and the decline of eel coincide worldwide. This suggests that, in addition to other threats, these contaminants contributed significantly to the current collapse in eel populations[1]. Due to their high toxicity dioxins are also considered hazardous chemicals for human health. Therefore, harmonised EU maximum levels in foodstuffs have been established (4 pg TEQ (toxicity equivalents) g^{-1} fresh weight for the sum of dioxins (WHO-PCDD/F TEQ) and 12 pg TEQ g^{-1} fresh weight for the total-TEQ - i.e. the sum of dioxins and dioxin-like PCBs (PCDD/Fs-DL-PCBs) - in muscle meat of eel and products thereof)[2].

In order to gain insight in the current status of dioxin pollution in Flanders (northern region of Belgium), a baseline study was conducted in (yellow) eels from several locations. Results give an indication of the current dioxin concentrations in Belgian wild eels and hence, in the aquatic environment, relation to the international food safety standards and the health of the Belgian eel population.

Materials and Methods

Between 2000 and 2007, yellow eel (*Anguilla anguilla*) were caught at 38 locations spread over Flanders (Figure 1). Sampling sites included canals, polder water courses, rivers, and closed water bodies. The sites selected for this baseline study included a known range of levels of PCB pollution in eel. On each locality 4-10 yellow eel were captured and placed in cooling units for live transport to the laboratory. Eel were of variable length (range 33.9 – 64.1 cm) and weight range (59.7 – 566.4 g). At the lab, fish were measured, weighed and samples of muscle tissue (10 g wet weight each) were removed, labelled and stored at -20°C. From each sampling location, tissues from 10 individual eel were pooled prior to homogenisation and analysis (5.0 g).

Table 1 gives an overview of eel characteristics measured and the dioxin concentrations (ΣPCDD/F), the sum of dioxin-like PCB concentrations (ΣDL-PCB), and the total-TEQ concentrations (ΣPCDD/F+DL-PCB) for each site. The results are expressed as pg WHO TEQ contaminant g^{-1} product fresh weight (instead of fat weight) to be able to estimate health risks from human consumption.

Sample preparation, separation, and measurement were performed on the CART laboratory of the University of Liège with strict QA/QC criteria under BELAC accreditation.

Results and Discussion

The European maximum limit for the sum of dioxins and dioxin-like PCBs (WHO-PCDD/F-DL-PCB TEQ) in muscle meat of eel and products thereof is expressed in toxicity equivalents. It is set on 12 pg TEQ g^{-1} fresh weight. In this study the levels of this sum varied between 1.14 and 141.86 pg TEQ g^{-1}. In 42% of the sampling sites the limit is exceeded.

Palstra et al.[1] reported disrupting effects in the embryonic development of eels, occurring at levels below 4 pg TEQ kg^{-1} gonad. From this, we may deduce that in most Flemish eel (66% > 4 pg) reproduction is impaired due to the presence of dioxins and dioxin-like PCBs.

The contribution of the DL-PCBs to the total sum (PCDD/F-DL-PCB) is significant and consistent, regardless of the sampling site. In the Congovaart, the contribution of DL-PCB to the total TEQ is as high as 97% while the lowest contribution is found in the Handzamevaart with 72.5%.

DL-PCB congener 126 is the most prominent DL-PCB (Figure 2). The contribution of PCB 126 to total DL-PCBs is on average 52% (range 27-98%). A correlation analysis of the congener PCB 126 with the sum DL-PCB reveals a strong correlation (Spearman, r= 0.97, p= 0).

ΣDL-PCBs show an increasing trend from west to east Flanders with remarkably high concentrations at the Congovaart (138,53 pg WHO TEQ g^{-1} fresh weight) en the Canal Bocholt-Herentals (81,48 pg WHO TEQ g^{-1} fresh weight). The ΣPCDD/Fs did not show such a trend. The Handzamevaart stands out with a striking concentration of 9,79 pg WHO TEQ g^{-1} fresh weight (mean concentration of ΣPCDD/Fs is 1,16 pg WHO TEQ g^{-1} fresh weight). The broad range in ΣDL-PCBs and ΣPCDD/Fs concentrations monitored in the current study is likely due to the large variety in sampling locations, from highly industrialized areas to small rural creeks. The Congovaart and the Canal Bocholt-Herentals are well-known for their high PCB load and they belong to the most PCB polluted waters in Belgium. They run through an important industrial area including energy production and power transformation industries, which are possible historical sources of PCB contamination. The Handzamevaart on the other hand is situated in an agrarian area, known for its strong pesticide pollution. The high levels of ΣPCDD/Fs are surprising and a possible source is unclear.

The highest human exposure risk is through the consumption of fish, containing more contaminants than most other food products[3]. Hence fish consumption can lead to an increase in (human) body burden. Health effects are expected through the long-term exposure of the most sensitive part of the population, i.e. recreational fishermen consuming self caught eel from contaminated locations. So, the Total Daily Intake standard (4 pg WHO TEQ per kg body weight per day[4] aims at lowering the intake of dioxins and related compounds in order to prevent tissue levels from reaching critical concentrations[5]. Thus, in such cases, an advice to limit consumption of fish from such areas may be the most appropriate risk management option to decrease the intake of dioxins and related compounds.

Dioxin concentrations in eel vary considerably between sampling sites, indicating that they are good indicators of local pollution levels. Levels found in these eels are believed to be representative for all eels in the catchments in which they were collected[6]. The majority of Flemish eels from this study had levels considered to be detrimental for their reproduction. Field levels of dioxin and DL-PCBs are therefore suggested as a further contributing causal factor in the decline of the European eel. Half of the sampling sites show especially DL-PCB levels exceeding the European consumption level (with a factor 3 on average). Human consumption of eels, especially in these highly contaminated sites, seems unjustified.

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Table 1: Overview of the pool samples from this study. Following characteristics are given: site code and water body where the eel were caught. Mean length (cm), mean weight (g) and the muscle lipid content of the pool sample (%). For each sample the dioxin concentrations (ΣPCDD/Fs.), the sum of dioxin-like PCB concentration (ΣDL-PCB;), and the total-TEQ concentration (ΣPCDD/F and DL-PCB) are given, expressed as pg WHO TEQ g^{-1} fresh weight

Site code	*Water body*	*Sampling year*	*Mean length*	*Mean weight*	*Fat percentage of pool sample*	*ΣDL-PCBs*	*ΣPCDD/Fs*	*ΣPCDD/Fs and DL-PCB*
AB	Abeek	2004	42,10	116,53	4,41	4,80	0,21	5,02
AK2	Albertkanaal	2000	45,24	157,76	12,73	32,43	2,80	35,22
BBV	Blankenbergse Vaart	2003	37,19	99,77	9,2	0,96	0,18	1,14
BGG	Oude Leie Bourgoyen	2000	39,04	95,95	14,29	12,11	0,96	13,07
BK1	Boudewijnkanaal	2006	64,05	566,40	7,76	5,19	0,34	5,53
COM	Congovaart	2001	43,21	162,28	10,64	138,53	3,33	141,86
DAV2	Damse vaart	2006	39,93	109,01	17,57	14,06	1,61	15,67
DE1	Dender	2006	53,49	253,54	4,8	3,41	0,37	3,78
DE3B	Dender	2006	49,59	202,82	3,6	6,34	0,36	6,70
DE4A	Dender	2002	42,09	141,31	10,63	15,01	0,88	15,89
DEM2	Demer	2003	50,57	307,97	4,79	2,41	0,27	2,68
DGH	Gavers	2000	60,50	388,26	16,35	16,96	1,95	18,91
DIJ7	Dijle	2006	52,13	296,57	27,4	6,96	0,54	7,50
DO1	Dommel	2006	43,08	154,21	7,1	2,98	0,29	3,27
GN1	Grote Nete	2000	39,41	101,16	13,36	3,82	0,58	4,40
HV2	Handzamevaart	2002	33,88	59,65	0,74	25,86	9,79	35,66
IB1	Itterbeek	2005	38,29	109,28	5,49	1,39	0,33	1,72
IK1B	Ieperkanaal	2002	37,42	93,71	10,58	3,29	0,24	3,52
KB2	Canal of Beverlo	2005	41,16	110,11	3,58	2,04	0,30	2,35
KB6	Canal of Beverlo	2005	49,94	244,25	7,87	14,67	1,64	16,31
KBH1B	Canal Bocholt-Herentals	2002	41,30	115,06	10,19	81,48	2,82	84,30
KBH5	Canal Bocholt-Herentals	2002	40,39	110,54	3,12	10,92	0,56	11,48
KDS6	Canal of Dessel naar Schoten	2003	40,42	126,04	2,3	8,86	0,57	9,43
KDS7	Canal of Dessel naar Schoten	2003	48,06	181,87	10,6	36,34	1,67	38,01
KGO2	Canal Ghent-Oostende	2004	40,63	125,95	6,89	11,35	0,82	12,18
KN2C	Kleine Neet	2003	40,40	110,05	11,71	4,49	0,48	4,97
KND1	Canal from Nieuwpoort to Duinkerke	2005	39,37	133,00	11,58	2,94	0,17	3,10
KNN	Kreek van Nieuwendamme	2002	35,30	77,82	9,96	1,61	0,26	1,87
KZ	klein Zuunbekken	2002	39,56	106,96	15,01	23,39	1,63	25,02
LE1	Leie	2001	56,47	466,10	3,16	9,35	0,60	9,95
LEO2	Leopoldkanaal	2003	36,33	77,97	7,9	1,78	0,32	2,10
MA3E	Grensmaas	2002	44,57	159,40	6,46	14,27	0,60	14,87
ODU	Oude Durme	2002	38,58	99,64	8,93	3,98	0,62	4,60
OMS	Oude Maas	2002	40,86	109,53	1,73	30,73	3,33	34,06
RM	Rotselaar meer	2007	37,86	94,93	3,68	1,86	0,16	2,02
WBV6	Willebroekse vaart	2002	39,70	103,05	10,1	24,03	0,69	24,72
WBV8	Willebroekse vaart	2002	36,29	84,84	12,3	25,29	1,06	26,35
YZ2	Yser	2000	43,24	201,68	15,62	9,20	0,85	10,05

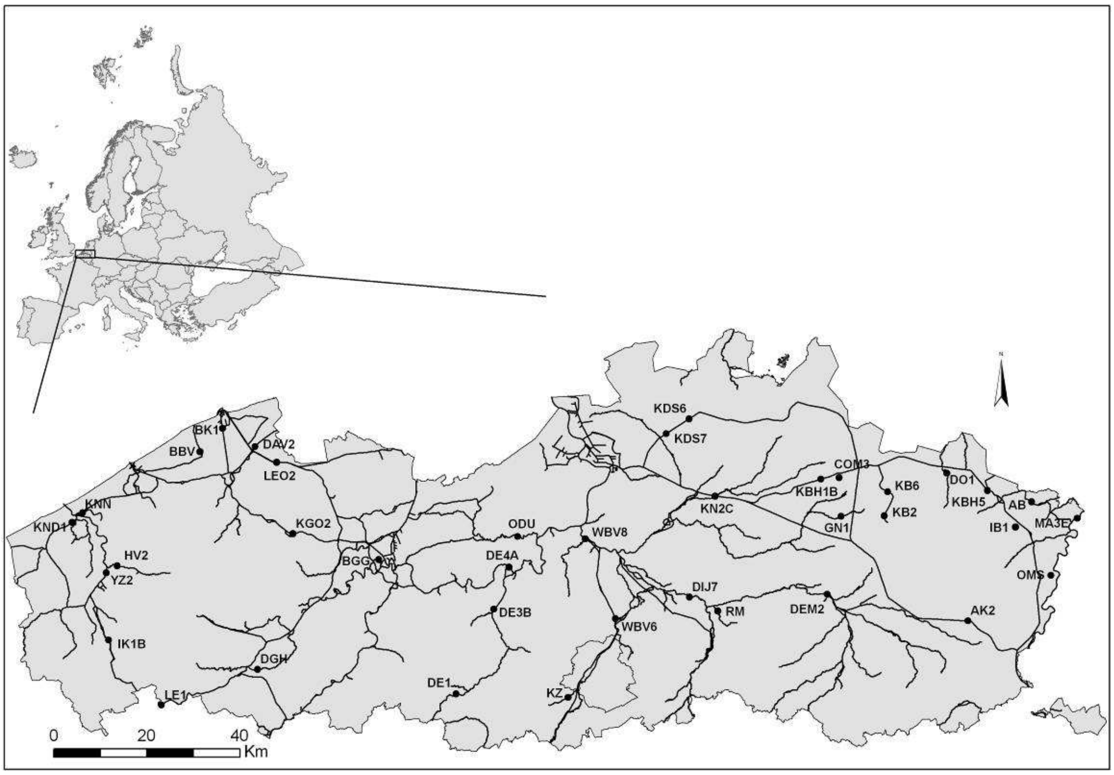

Figure 1: Geographic position of Flanders in Europe and location of the sampling points of eel. For site abbreviations see Table 1

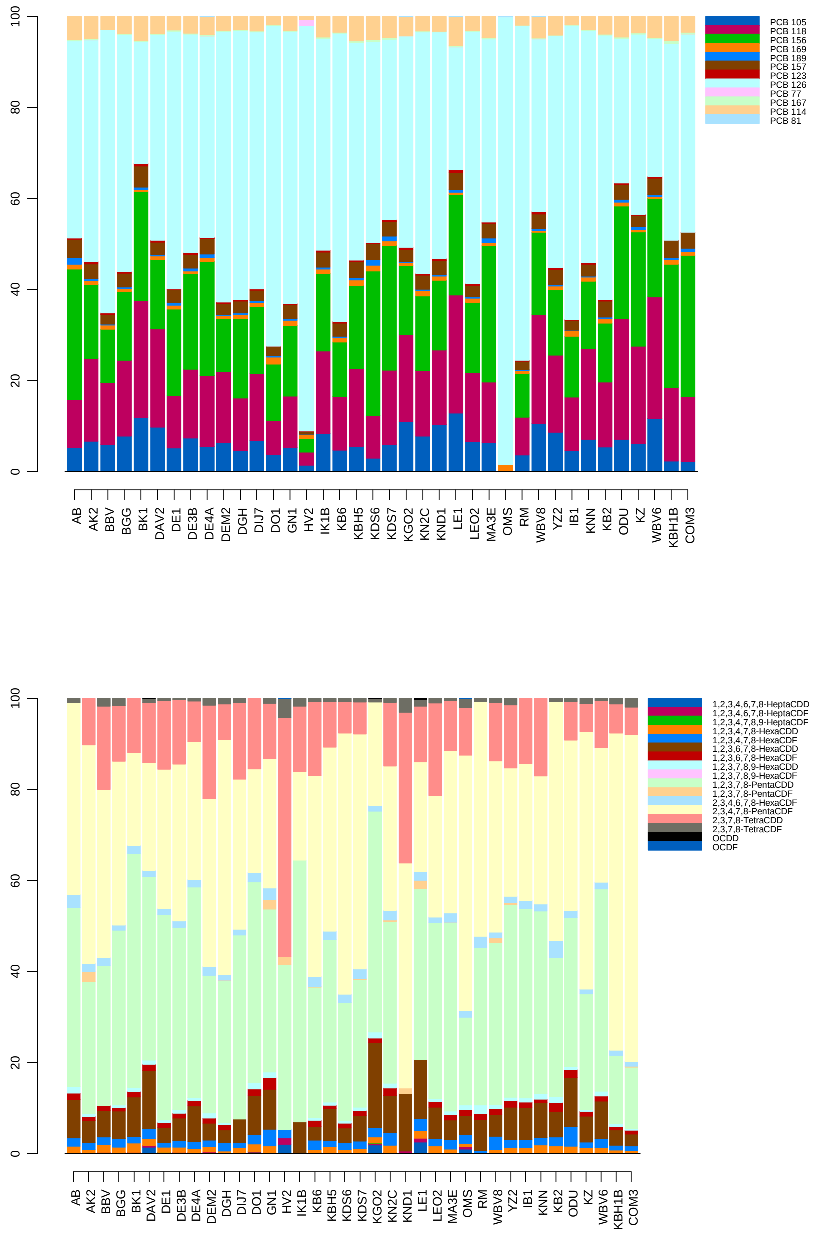

Figure 2: Distributions of the DL-PCB (above) and PCDD/F (under) congeners in the eel muscle (pooled samples) in Flanders. For site abbreviations see Table 1