A Comparison of Polychlorinated Dibenzodioxins and Dibenzofurans Concentration Patterns in Outdoor Air and Human Blood

R. Dolgner, U. Ranft, J. Abel, C. Vogel
Medizinisches Institut für Umwelthygiene an der Heinrich-Heine-Universität Düsseldorf, Auf'm Hennekamp 50, D-40225 Düsseldorf

Purpose of the study:
The main intake path of polychlorinated dibenzodioxins and dibenzofurans (PCDF/PCDD) is the nutrition[1)]. But there is still some concern that larger outdoor air concentration may contribute for PCDF/PCDD levels in humans. Therefore, in 1992 a study has been conducted with support of the ministry of environment in North Rhine-Westfalia to investigate the correlation of PCDF/PCDD blood fat concentration levels in humans living in differently exposed areas to the corresponding PCDF/PCDD outdoor air concentration levels.

Methods:
Two investigation areas were selected: part of the city of Duisburg with the typical air pollution of a highly industrialized region and the rural town Simmerath (100 km SW of Duisburg). Annual mean concentration levels of PCDF/PCDD in fine dust and gas phase were available from a measuring program of the ministry of environment in 1989 at four location in the Duisburg area and at one in Simmerath. A group of 61 women (30 in Duisburg and 31 in Simmerath) aged between 25 and 35 years (mean: 31.1 ys., std: 2.2 ys.) were randomly selected. Inclusion criteria were German nationality, at least eight years of residence in the investigation area, and during this time no employment. Blood samples were taken within one week for all participants under carefully controlled conditions. The blood sampling set was provided by the chemical laboratory responsible for the chemical analysis. A self-administered questionnaire was used to establish eating and smoking habits, housing conditions and exposure to motor vehicle exhaust. Information about the nursing habit were also collected. The analysis of the blood samples for 17 PCDF/PCDD congeners using GC/MS was performed by a chemical laboratory (Gesellschaft für Arbeitsplatz- und Umweltanalytik, Münster-Roxel, Germany) according to international quality standards. Linear regression analysis was used to test main effects for each congener separately. Group differences were tested by the t-test. The k-means case clustering algorithm has been applied to detect patterns of the concentration of the 17 PCDF/PCDD congeners in human blood fat.

Results:
The outdoor air concentration levels of the 17 PCDF/PCDD congeners are approximately one order of magnitude higher in the urban air of Duisburg than in the rural air of Simmerath (table 1). However, the statistical analysis did not reveal clear and significant differences of PCDF/PCDD blood fat concentrations between samples from the urban and rural areas, respectively (Figure 1). A confounder analysis considering age, smoking habit, nutrition, indoor air quality, traffic exposure, and nursing habit showed the significant decreasing influence of tobacco consumption and the significant increasing effect of age on the blood fat concentrations. Effects of nursing (decreasing) and kale consumption (increasing) could be observed, but were not significant. Corrections for these confounders in the regression analysis did not alter the finding that there are no differences between the two investigation areas. In table 1 the results of the blood fat analysis are displayed for the whole collective.

Table 1: Concentrations of polychlorinated dibenzodioxins and dibenzofurans in human blood fat and outdoor air. Blood samples were taken from 61 women at ages between 25 and 35 years living in urban as well as rural regions.

Congener	blood fat [ng/kg] n = 61 geo. mean	min	max	urban air [fg/m³] n = 4 geo. mean	min	max	rural air [fg/m³] n = 1
2,3,7,8 - TetraCDF	1.81	0.5	4.1	188	130	200	17
1,2,3,7,8 - PentaCDF	0.64	0.3	1.4	279	210	300	17
2,3,4,7,8 - PentaCDF	17.39	7.1	40.0	238	190	250	17
1,2,3,4,7,8 - HexaCDF	7.35	3.5	14.4	221	170	230	16
1,2,3,6,7,8 - HexaCDF	7.78	3.6	15.2	191	150	200	14
2,3,4,6,7,8 - HexaCDF	2.33	0.8	5.8	180	140	180	16
1,2,3,7,8,9 - HexaCDF	0.20	0.1	0.8	30	20	30	4
1,2,3,4,6,7,8 - HeptaCDF	12.10	4.1	86.1	682	490	730	66
1,2,3,4,7,8,9 - HeptaCDF	0.46	0.2	1.6	50	40	50	5
OctaCDF	4.12	1.4	11.1	737	590	800	58
2,3,7,8 - TetraCDD	3.02	1.0	5.8	10	10	10	1
1,2,3,7,8 - PentaCDD	7.81	2.1	16.5	67	50	70	5
1,2,3,4,7,8 - HexaCDD	6.28	1.7	15.6	50	50	50	6
1,2,3,6,7,8 - HexaCDD	28.38	5.9	72.9	107	90	110	11
1,2,3,7,8,9 - HexaCDD	7.06	3.0	19.3	103	90	110	12
1,2,3,4,6,7,8 - HeptaCDD	54.92	18.2	177.4	983	95	1060	142
OctaCDD	569.29	254.0	1709.1	2259	2130	2560	622

A cluster analysis concerning the congener patterns in the blood fat could clearly partition the 61 cases into two disjunctive groups of almost equal size. In figure 1 one cluster consisting of 34 members is marked by shading. The two clusters could essentially be explained by differences of the total level of the internal PCDF/PCDD exposure. The arithmetic mean of the toxic equivalents in the one cluster amounts to 17.5 ng/kg with a standard deviation of 4.3 ng/kg whereas the other cluster (shaded stars in figure 1) exhibits an arithmetic mean of 29.9 ng/kg TEQ with a standard deviation of 6.0 ng/kg. The two clusters did not show significant differences with respect to the two investigation areas and the other considered influencing factors. If the concentration of the congener OctaCDD was used as the individual reference concentration in blood as well as air samples, the individual relative congener spectra revealed clearly that PCDF/PCDD outdoor air concentrations and human blood fat concentrations are uncorrelated. Within each of the two compartments blood and outdoor air, respectively, the congener spectra of the samples are almost identical, whereas the pattern of congeners in blood fat does not reflect the respective pattern in the air (figure 2).

Conclusions:
This study show that the various outdoor air concentration levels of PCDF/PCDD as observed in rural and urban regions of Germany have no measurable influence on the PCDF/PCDD concentrations in the blood fat of women. The data confirm the well known relationship between internal PCDF/PCDD levels and age[2)] and nutrition[3)]. Smoking and nursing[4)] seems to lower the PCDF/PCDD level in human blood fat. Occupational exposure to PCDF/PCDD was excluded by the study design. A grouping by unsupervised clustering of the multidimensional (17 congeners) PCDD/PCDF concentrations pattern in the blood fat of the 61 samples produced two clearly separable groups. A good distinguishing feature of the two groups is the toxic equivalent, but no explanations could be found in the available information about exposures. Despite large differences in concentration levels, remarkably stable, but quite different patterns of relative congener concentrations were found for each compartment, outdoor air and blood fat, respectively. A comparison using data reported[5)] show the close resemblance of the blood fat congener pattern with the respective pattern in European dairy products (figure 2). The later resemblance lead to the conclusion that similar mechanisms are responsible for PCDD/PCDF enrichment in the fatty tissue of man and cow, respectively.

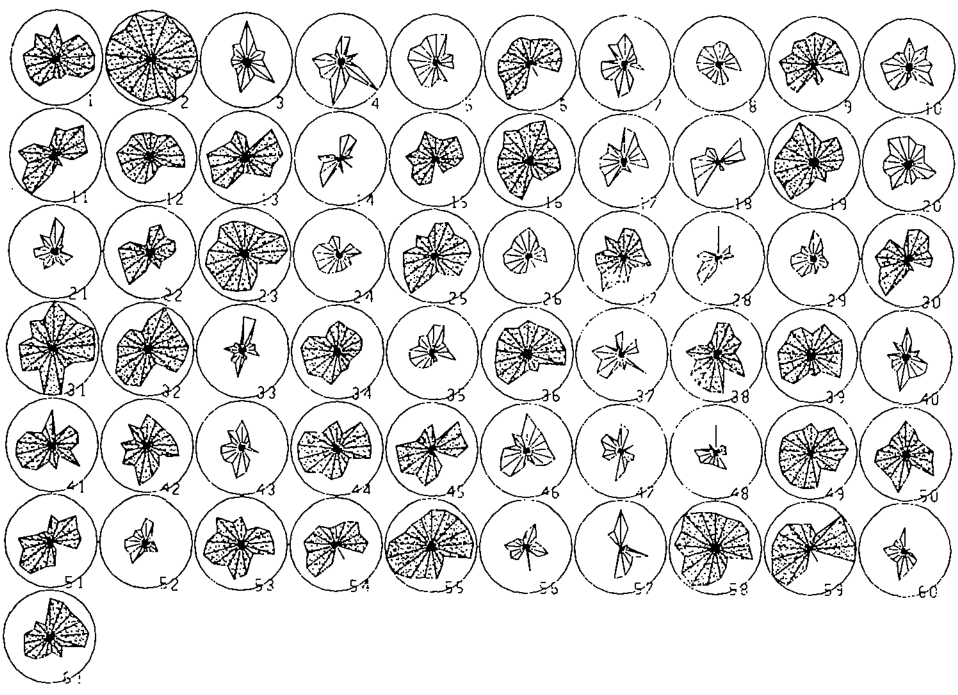

Figure 1: Star diagrams of PCDF/PCDD blood fat concentrations [ng/kg] of 61 human blood samples in logarithmic scale. The congeners are ordered clockwise with respect to the sequence in table 1 starting at noon. Samples are from women living in an urban region (number 1 to 30) and in a rural region (number 31 to 61), respectively. The shading of the stars refers to the clustering result (see text).

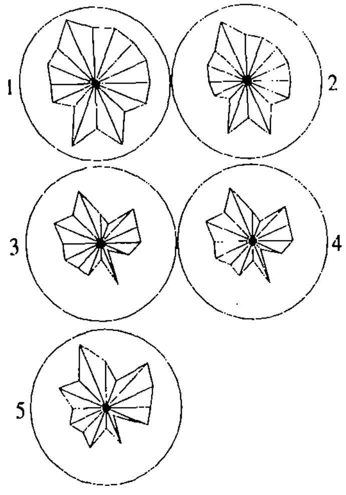

Figure 2: Star diagrams of relative PCDF/PCDD congener concentrations in outdoor air, human blood fat and dairy products with the OctaCDD concentration as individual reference in logarithmic scale. The congeners are ordered clockwise with respect to the sequence in table 1 starting at noon.
Star 1: urban outdoor air
Star 2: rural outdoor air
Star 3: blood fat samples of an urban region
Star 4: blood fat samples of a rural region
Star 5: European dairy products[5)]
Scale of the stars 1 to 4: 10^{-4} - 10^{0}
Scale of the star 5: $10^{-2.5}$ - $10^{-0.5}$

References:

1. Beck, H.; Dross, A.; Mathar, W. (1994) PCDD and PCDF exposure and levels in humans in Germany. Environmental Health Perspectives 102 (Suppl. 1), 173-185
2. Schrey, P.; Wittsiepe, J.; Ewers, U.; Exner, M.; Selenka, F. (1992) Age-related increase of PCDD/F-levels in human blood - a study with 95 unexposed persons from Germany. Organohalogen Compounds 9, 261-267
3. Fürst, P.; Fürst, C.; Groebel, W. (1990) Levels of PCDDs and PCDFs in food-stuffs from the Federal Republic of Germany. Chemosphere 20, 787-792
4. Fürst, P.; Fürst, C.; Wilmers, K. (1994) Human milk as bioindicator for body burden of PCDDs, PCDFs, organochlorine pesticides, and PCBs. Environmental Health Perspectives 102 (suppl. 1), 187-193
5. U.S. Environmental Protection Agency (1994) Estimating Exposure to Dioxin-Like Compounds, Vol. II: Properties, Sources, Occurrence and Background Exposures. Washington, D.C.