Correlation of concentrations of PCDDs, PCDFs and non-ortho coplanar PCBs in human samples

Takahiko Matsueda*, Takao Iida*, Hironori Hirakawa* and Junya Nagayama**

*Fukuoka Institute of Health and Environmental Sciences, 39 Mukaizano Dazaifu Fukuoka, 818-0135, Japan
**Laboratory of Environmental Health Sciences, School of Health Sciences, Kyusyu University, Fukuoka 812-8582, Japan

Introduction

Polychlorinated dibenzo-*p*-dioxins (PCDDs), polychlorinated dibenzofurans (PCDFs) and non-ortho coplanar polychlorinated biphenyls (Co-PCBs) accumulate in the human body due to their highly lipophilic properties. These chemicals have been determined in almost every human sample measured in many countries. In spite of the huge amount of data gathered about the detection of these chemicals, information concerning correlation among them hardly exists. It is known that the data of regression analysis can provide us with useful information, e.g., the differentiation of contamination sources in the human body. However, studies concerning the correlation between the concentrations of various congeners and/or toxic equivalency quantities (TEQ) detected in human samples have not been reported. We have been measuring the concentrations of PCDDs, PCDFs and Co-PCBs in several human tissue samples, including breast milk, blood, adipose tissue, and skin lipids. Some of our data have previously been reported at the Dioxin symposium in Kyoto (1994) [1], Edmonton (1995) [2-4], and Amsterdam (1996) [5], respectively. Recently, we have finished the analysis of total of 125 milk, 94 blood, 38 adipose tissue and 44 skin lipids samples. In this study, we performed regression analysis of the respective data set to evaluate the relationships between concentrations of TEQ and congeners detected in various human samples. We suggest that this kind of analysis will provide very important information about the conventional screening methods for human contamination by dioxins and related compounds as well.

Materials and Methods

The human samples analyzed in this study are summarized in Table 1. Breast milk, blood, adipose tissue and skin lipids samples were collected from volunteers living in Fukuoka, Japan. We analyzed the samples for the presence of PCDDs, PCDFs and Co-PCBs. TEQs for PCDDs and PCDFs were calculated using 2,3,7,8-TCDD toxic equivalency factors (I-TEFs) and those of the Co-PCBs were calculated using the data reported by WHO (1993)[6].

Results and Discussion

Table 2 summarizes the analysis results of the levels of PCDDs, PCDFs and Co-PCBs found in the 125 milk, 94 blood, 38 adipose tissue and 44 skin lipids samples that were obtained from Fukuoka, Japan. Among the congeners detected, OCDD indicated the highest level in all human samples ranging from 129 pg/g fat (blood) to 2070 pg/g fat (skin lipids). In PCDF congeners, 2,3,4,7,8-PeCDF occurred in the highest level in milk, blood and adipose tissue; however, 1,2,3,4, 6,7,8-HpCDF was the most dominant congener in skin lipids. In Co-PCBs, 3,4,5,3',4'-HxCB occurred in the highest concentration in milk, blood and adipose tissue except for skin lipids. The congener profiles were similar in breast milk and blood samples, and in adipose tissue and skin

lipids.

Table 1 List of human samples

	Sex	N	Range of age	Mean age	Sampling period
Breast milk	FM	125	21-40	28	05/1994-10/1996
Blood	M	31	20-73	43	07/1990-07/1996
	FM	63	18-81	26	07/1990-07/1996
Adipose tissue	M	17	19-81	55	07/1990-07/1995
	FM	21	20-82	57	07/1990-07/1995
Skin lipids	FM	14	35-61	45	09/1994-11/1996
	M	30	20-73	45	09/1994-11/1996

N:Number of samples

The mean TEQ concentrations of breast milk, blood, adipose tissue and skin lipids were 25.0, 27.7, 56.1 and 31.0 pg/g fat weight, respectively. Adipose tissue showed the highest level of toxicity among these samples. This may be due to much higher mean age in the adipose tissue donors than those in other sample ones, because it has been demonstrated clearly that residual concentrations of these persistent chemicals increased with donors age[1]. The TEQ levels are comparable to those considered background levels reported from industrialized countries.

Table 2 Mean Concentration of PCDDs, PCDFs and Co-PCBs in human samples (pg/g fat)

Congener	Breast milk	Blood	Adipose tissue	Skin lipids
2,3,7,8-TCDD	1.8	2.0	3.0	1.4
1,2,3,7,8-PeCDD	6.9	7.6	12.2	5.0
1,2,3,4,7,8-HxCDD	2.1	2.6	4.5	1.9
1,2,3,6,7,8-HxCDD	25.4	29.7	60.9	14.3
1,2,3,7,8,9-HxCDD	6.9	5.5	8.8	3.0
1,2,3,4,6,7,8-HpCDD	16.4	32.9	103	105
OCDD	129	485	1067	2070
2,3,7,8-TCDF	1.2	0.7	3.1	3.8
1,2,3,7,8-PeCDF	0.9	0.9	0.4	5.2
2,3,4,7,8-PeCDF	11.1	12.6	23.9	10.1
1,2,3,4,7,8-HxCDF	4.6	7.0	7.7	4.6
1,2,3,6,7,8-HxCDF	3.6	7.7	7.2	3.8
1,2,3,7,8,9-HxCDF	0.8	2.8	NA	4.1
2,3,4,6,7,8-HxCDF	4.5	2.8	NA	7.2
1,2,3,4,6,7,8-HpCDF	3.4	8.1	3.8	20.7
1,2,3,4,7,8,9-HpCDF	NA	0.0	2.2	0.0
OCDF	2.7	2.6	1.4	NA
3,3',4,4'-TeCB	20.3	18.3	21.3	346.6
3,3',4,4',5-PeCB	85.2	83.8	256.4	135.5
3,3',4,4',5,5'-HxCB	39.9	43.2	111.4	34.5
PCDD-TEQ	8.9	10.4	17.7	8.9
PCDF-TEQ	7.1	8.5	13.8	7.9
Co-PCB-TEQ	8.9	8.8	26.8	14.1
TEQ	25.0	27.7	56.1	31.0

NA:not available

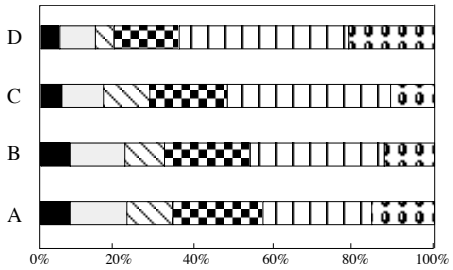

Fig. 1 Relative contribution of specific congeners to the total TEQ in various human samples

A:Breast milk C:Adipose tissue
B:Blood D:Skin lipids
■:2,3,7,8-TCDD □:1,2,3,7,8-PeCDD
▨:1,2,3,6,7,8-HxCDD ▪:2,3,4,7,8-PeCDF
□:3.3',4,4',5-PeCB ▩:Others

Table 3 Correlation between the concentrations of some isomers and I-TEQ in human samples

Breast milk(n=125)	2,3,7,8-TCDD	1,2,3,7,8-PeCDD	1,2,3,6,7,8-HxCDD	2,3,4,7,8-PeCDF	3,3',4,4',5-PeCB
2,3,7,8-TCDD	1				
1,2,3,7,8-PeCDD	0.4062	1			
1,2,3,6,7,8-HxCDD	0.3334	0.6394	1		
2,3,4,7,8-PeCDF	0.4443	0.5513	0.5268	1	
3,3',4,4',5-PeCB	0.4068	0.6470	0.3830	0.5559	1
TEQ	0.5633	0.8040	0.6725	0.8193	0.8689
Blood(n=94)					
2,3,7,8-TCDD	1				
1,2,3,7,8-PeCDD	0.5079	1			
1,2,3,6,7,8-HxCDD	0.4112	0.5341	1		
2,3,4,7,8-PeCDF	0.6067	0.8396	0.5061	1	
3,3',4,4',5-PeCB	0.4235	0.6610	0.2224		1
TEQ	0.6192	0.8684	0.5184	0.9154	0.8951
Adipose Tissue(n=38)					
2,3,7,8-TCDD	1				
1,2,3,7,8-PeCDD	0.3761	1			
1,2,3,6,7,8-HxCDD	0.4594	0.5034	1		
2,3,4,7,8-PeCDF	0.6392	0.4702	0.5038	1	
3,3',4,4',5-PeCB	0.4649	0.1698*	0.2713**	0.3361	1
TEQ	0.6640	0.4910	0.5676	0.7393	0.8893
Skin lipids(n=44)					
2,3,7,8-TCDD	1				
1,2,3,7,8-PeCDD	0.0439*	1			
1,2,3,6,7,8-HxCDD	0.6151	0.3746	1		
2,3,4,7,8-PeCDF	0.3828	0.4479	0.4970	1	
3,3',4,4',5-PeCB	0.6232	0.0998*	0.4844	0.5547	1
TEQ	0.5624	0.3195	0.7221	0.7264	0.8080

*:Not Correlated **:p<0.05 Others:p<0.005

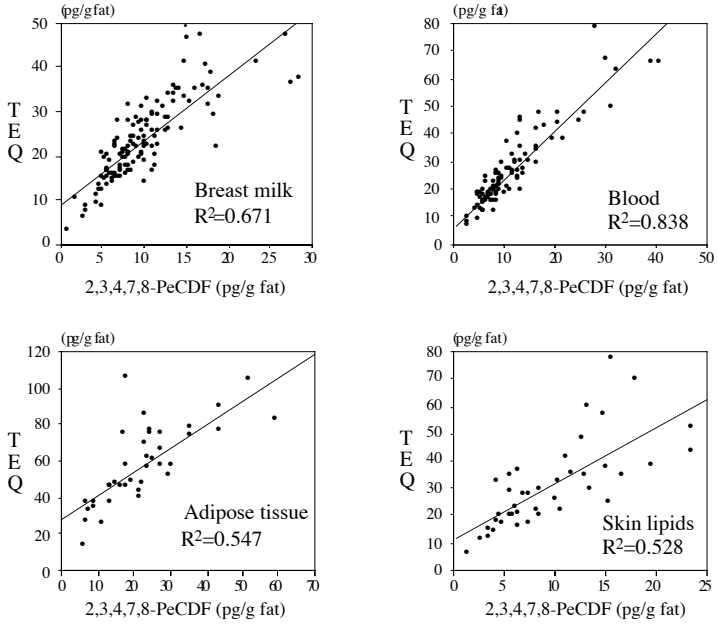

Fig.2 Relationship between TEQ and 2,3,4,7,8-PeCDF concentration

The contributions of selected congeners to total TEQ are shown in Fig.1. The respective percent contributions were as follows: 2,3,7,8-TCDD; 4.7-7.6%, 2,3,7,8-PeCDD; 9.1-14.2%, 1,2,3,6,7,8-HxCDD; 4.8-11.9.2%, 2,3,4,7,8-PeCDF; 16.7-22.7% and 3,4,5,3',4'-HxCB;27.8-43.1%. Among these five congeners, the greatest contribution was seen in 3,3',4,4',5-PeCB, the most toxic congener of the Co-PCBs, for all samples. Of PCDDs and PCDFs, 2,3,4,7,8-PeCDF showed the highest contribution. These 5 isomers occupied nearly 80 % of the total TEQ for each sample.

We applied regression analysis using Pearson's correlation coefficient to determine whether a linear relationship existed between each concentration of all congeners and total TEQ in breast milk, blood, adipose tissue and skin lipids. The results are summarized in Table 3. The concentrations of 2,3,7,8-TCDD, 1,2,3,7,8-PeCDD, 1,2,3,6,7,8-HxCDD, 2,3,4,7,8-PeCDF and 3,4,5,3',4'-HxCB, which contribute mainly to the total TEQ, are significantly positively correlated to each other in all samples, and we also found a significant correlation with the total TEQ. Other minor congeners were also to have a positive correlation to each other and with the TEQ. The empirical relation of TEQ concentration and the congeners were described by a regression model: TEQ = $b + a$ CONGENER was fitted with constant b and slope a for each congener. The constant b for 2,3,4,7,8-PeCDF in milk, blood, adipose tissue and skin lipids was 8.1, 6.1, 27.4 and 10.3, respectively, and value of slope a was 1.49, 1.73, 1.29 and 2.05, respectively .The regression curve of TEQ and 2,3,4,7,8-PeCDF in four different samples are shown in Fig. 2.

Conclusions

The sum of the five congeners (2,3,7,8-TCDD, 1,2,3,7,8-PeCDD, 1,2,3,6,7,8-HxCDD, 2,3,4,7,8-PeCDF and 3,4,5,3',4'-HxCB) contributed around 80 % of the total TEQ in the four different human tissue samples examined. Significant correlations were observed among the congeners and/or TEQ in human samples. This suggested that the TEQ levels could be predicted by measuring only some congeners such as 2,3,4,7,8-PeCDF or 3,4,5,3',4'-HxCB. This concept would allow us to use a simple screening method for human contamination of dioxin-like compounds.

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