5. Evaluation of Exposure to Dioxins

(1) Estimation of Exposure to Individuals

The results for estimated amounts of exposure through the air, exposure through the soil, and exposure through food based on the PCDD+PCDF+Co-PCB concentrations in each medium of exposure are shown below. Attachment 1 describes the method of estimation.

(a) Estimated Exposure through the Air

The estimated exposure through the air was based on the PCDD+PCDF+Co-PCB concentration in air at the survey site closest to the survey subjects' residence and the PCDD+PCDF+Co-PCB concentration in indoor air in the survey subject's residence, using a body weight of 50 kg and a daily respiration volume of 15 m^3. The time spent indoors and outdoors were estimated according to three types of assumptions. Under Case 1, the length of time spent indoors and outdoors was established for each survey subject using the self-administered questionnaire on everyday activity. Under Case 2, the length of time spent indoors was assumed to be 20 hours and the length of time spent outdoors was assumed to be 4 hours uniformly for all survey subjects. Under Case 3, all survey subjects were uniformly assumed to spend 24 hours outdoors. The estimated exposures through the air are shown in Table 5-1 (Case 1), Table 5-2 (Case 2), and Table 5-3 (Case 3).

Table 5-1. Concerning Estimated Exposure through the Air (Case 1)

(Unit: pg-TEQ/kg/day)

	Osaka Prefecture Nose Town Regions		Saitama Prefecture Regions			Hiroshima Prefecture Fuchu City Regions	
	A region (n=22)	B region (n=15)	A1 region (n=14)	A2 region (n=22)	B egion (n=13)	A region (n=16)	B region (n=19)
PCDD+PCDF							
Mean	0.030	0.17	0.060	0.054	0.12	0.020	0.0083
Standard deviation	0.011	0.40	0.045	0.020	0.017	0.011	0.0025
Median	0.035	0.017	0.037	0.056	0.11	0.024	0.0069
Range	0.011 – 0.053	0.0068 – 1.2	0.025 – 0.15	0.025 – 0.090	0.089 – 0.14	0.0060 – 0.032	0.0063 – 0.012
Co-PCB							
Mean	0.0023	0.00037	0.0015	0.0014	0.0021	0.0015	0.00040
Standard deviation	0.0012	0.00022	0.0014	0.00069	0.00049	0.00053	0.00024
Median	0.0027	0.00025	0.00071	0.0014	0.0020	0.0016	0.00030
Range	0.00039 – 0.0044	0.00020 – 1.2	0.00028 – 0.0042	0.00029 – 0.0023	0.0013 – 0.0028	0.00063 – 0.0020	0.00023 – 0.0010
PCDD+PCDF +Co-PCB							
Mean	0.032	0.17	0.062	0.055	0.12	0.022	0.0088
Standard deviation	0.012	0.40	0.047	0.021	0.018	0.012	0.0025
Median	0.037	0.018	0.037	0.056	0.12	0.026	0.0078
Range	0.012 – 0.058	0.0072 – 1.2	0.026 – 0.16	0.026 – 0.093	0.092 – 0.15	0.0069 – 0.035	0.0066 – 0.013

Table 5-2. Estimated Exposure through the Air (Case 2)

(Unit: pg-TEQ/kg/day)

	Osaka Prefecture Nose Town Regions		Saitama Prefecture Regions			Hiroshima Prefecture Fuchu City Regions	
	A region (n=22)	B region (n=15)	A1 region (n=14)	A2 region (n=22)	B region (n=13)	A region (n=16)	B region (n=19)
PCDD+PCDF							
Mean	0.030	0.16	0.067	0.057	0.13	0.020	0.084
Standard deviation	0.011	0.38	0.056	0.019	0.019	0.011	0.0025
Median	0.036	0.017	0.042	0.062	0.12	0.024	0.0072
Range	0.012 – 0.053	0.0085 – 1.1	0.029 – 0.19	0.028 – 0.088	0.10 – 0.15	0.0060 – 0.032	0.0064 – 0.012
Co-PCB							
Mean	0.0022	0.00036	0.0019	0.0015	0.0024	0.0014	0.00041
Standard deviation	0.0012	0.00021	0.0019	0.00070	0.00045	0.00052	0.00024
Median	0.0029	0.00024	0.00088	0.0015	0.0023	0.0015	0.00030
Range	0.00043 – 0.0044	0.00021 – 0.00071	0.00042 – 0.0058	0.00051 – 0.0023	0.0019 – 0.0030	0.00063 – 0.0020	0.00030 – 0.0010
PCDD+PCDF +Co-PCB							
Mean	0.032	0.16	0.069	0.058	0.13	0.022	0.0088
Standard deviation	0.013	0.38	0.057	0.020	0.016	0.012	0.0023
Median	0.038	0.018	0.042	0.062	0.12	0.026	0.0079
Range	0.013 – 0.058	0.0088 – 1.1	0.030 – 0.19	0.029 – 0.092	0.11 – 0.15	0.0069 – 0.035	0.0068 – 0.012

Table 5-3. Estimated Exposure through the Air (Case 3)

(Unit: pg-TEQ/kg/day)

	Osaka Prefecture Nose Town Regions		Saitama Prefecture Regions			Hiroshima Prefecture Fuchu City Regions	
	A region (n=22)	B region (n=15)	A1 region (n=14)	A2 region (n=22)	B region (n=13)	A region (n=16)	B region (n=19)
PCDD+PCDF							
Mean	0.018	0.017	0.11	0.085	0.22	0.025	0.0071
Standard deviation	0.0018	0.0042	0.11	0.017	0.010	0.014	0.00065
Median	0.018	0.019	0.069	0.087	0.22	0.026	0.0069
Range	0.016 – 0.022	0.0096 – 0.021	0.039 – 0.36	0.063 – 0.11	0.20 – 0.23	0.0060 – 0.048	0.0060 – 0.0084
Co-PCB							
Mean	0.00050	0.00031	0.0042	0.0032	0.0058	0.0012	0.00067
Standard deviation	0.00019	0.00017	0.0046	0.0017	0.00043	0.00072	0.00011
Median	0.00063	0.00022	0.0020	0.0029	0.0060	0.0016	0.00063
Range	0.00018 – 0.00063	0.00018 – 0.00063	0.0013 – 0.014	0.00075 – 0.0060	0.0051 – 0.0063	0.00021 – 0.0019	0.00063 – 0.00099
PCDD+PCDF +Co-PCB							
Mean	0.019	0.017	0.11	0.087	0.22	0.026	0.0079
Standard deviation	0.0020	0.0042	0.11	0.017	0.0095	0.015	0.00063
Median	0.019	0.020	0.72	0.093	0.22	0.028	0.0078
Range	0.016 – 0.023	0.0099 – 0.022	0.039 – 0.36	0.066 – 0.11	0.21 – 0.24	0.0069 – 0.051	0.0069 – 0.0093

(b) Estimated Exposure through the Soil

The estimated exposure through the soil was obtained using the concentration of dioxins in soil at the survey location closest to the residence of each survey subject, and a body weight of 50 kg. The daily intake of soil was assumed to be 100 mg in Case 1 and 50 mg in Case 2. The estimated exposure through soil is shown in Table 5-4 (Case 1) and Table 5-5 (Case 2).

Table 5-4. Estimated Exposure through the Soil (Case 1)

(Unit: pg-TEQ/kg/day)

–	Osaka Prefecture Nose Town Regions		Saitama Prefecture Regions			Hiroshima Prefecture Fuchu City Regions	
	A region (n=22)	B region (n=15)	A1 region (n=14)	A2 region (n=22)	B region (n=13)	A region (n=16)	B region (n=19)
PCDD+PCDF							
Mean	0.015	0.036	0.075	0.068	0.018	0.0046	0.00018
Standard deviation	0.018	0.075	0.061	0.065	0.017	0.0049	0.000047
Median	0.014	0.0032	0.060	0.046	0.014	0.0041	0.00020
Range	0.00070 – 0.088	0.00096 – 0.22	0.010 – 0.16	0.022 – 0.26	0.0018 – 0.046	0.00028 – 0.016	0.00013 – 0.00026
Co-PCB							
Mean	0.0011	0.00090	0.0062	0.0080	0.00089	0.00029	0.000011
Standard deviation	0.0017	0.0013	0.0060	0.0042	0.00018	0.00034	0.000020
Median	0.00042	0.00046	0.0046	0.0077	0.00096	0.00022	0.0000066
Range	0.0000004 – 0.0082	0.000011– 0.0040	0.0000022– 0.019	0.0024 – 0.014	0.00062 – 0.0011	0.0000058 – 0.0010	0.0000014– 0.000066
PCDD+PCDF +Co-PCB							
Mean	0.016	0.037	0.081	0.075	0.018	0.0049	0.00019
Standard deviation	0.019	0.075	0.066	0.064	0.017	0.0052	0.000060
Median	0.015	0.0036	0.065	0.056	0.015	0.0043	0.00020
Range	0.00070 – 0.096	0.00096 – 0.22	0.011 – 0.18	0.024 – 0.26	0.0028 – 0.046	0.00028 – 0.017	0.00013 – 0.00032

Table 5-5. Concerning Estimated Exposure through the Soil (Case 2)

(Unit: pg-TEQ/kg/day)

	Osaka Prefecture Nose Town Regions		Saitama Prefecture Regions			Hiroshima Prefecture Fuchu City Regions	
	A region (n=22)	B region (n=15)	A1 region (n=14)	A2 region (n=22)	B region (n=13)	A region (n=16)	B region (n=19)
PCDD+PCDF							
Mean	0.0076	0.018	0.037	0.034	0.0088	0.0023	0.000091
Standard deviation	0.0088	0.038	0.030	0.033	0.0087	0.0025	0.000024
Median	0.0069	0.0016	0.030	0.023	0.0069	0.0021	0.000099
Range	0.00035 – 0.044	0.00048 – 0.11	0.0051 – 0.079	0.011 – 0.13	0.00090 – 0.023	0.00014 – 0.0087	0.000064 – 0.00013
Co-PCB							
Mean	0.00053	0.00045	0.0031	0.0040	0.00045	0.00015	0.0000053
Standard deviation	0.00087	0.00066	0.0031	0.0021	0.000098	0.00018	0.0000099
Median	0.00021	0.00023	0.0023	0.0040	0.00048	0.00011	0.0000033
Range	0.00000020 –0.0041	0.0000055 –0.0020	0.0000011 –0.0097	0.0012 – 0.0068	0.00031 – 0.00057	0.0000029 –0.00052	0.00000070 –0.000033
PCDD+PCDF +Co-PCB							
Mean	0.0080	0.018	0.040	0.037	0.0091	0.0025	0.000094
Standard deviation	0.0095	0.038	0.032	0.032	0.0085	0.0027	0.000030
Median	0.0075	0.0018	0.033	0.028	0.0074	0.0022	0.00010
Range	0.00035 – 0.048	0.00048 – 0.11	0.0055 – 0.088	0.012 – 0.13	0.0014 – 0.023	0.00014 – 0.0087	0.000065 – 0.00016

(c) Estimated Exposure through Food
See Table 4-3.

(d) Estimated Total Exposure
The total exposure to PCDD+PCDF+Co-PCB was estimated using case 1 for the estimated exposures through air and soil under the estimated exposures by the routes shown in sections (a) through (c) above. The results are shown in Table 5-6.

Table 5-6. Concerning Estimated Total Exposure

(Unit: pg-TEQ/kg/day)

	Osaka Prefecture Nose Town Regions		Saitama Prefecture Regions			Hiroshima Prefecture Fuchu City Regions	
	A region (n=22)	B region (n=15)	A1 region (n=14)	A2 region (n=21)	B region (n=13)	A region (n=16)	B region (n=19)
PCDD+PCDF							
Mean	0.75	1.1	0.87	0.92	0.78	0.58	0.61
Standard deviation	0.39	0.78	0.42	0.41	0.29	0.37	0.31
Median	0.62	0.86	0.80	0.90	0.68	0.51	0.57
Range	0.22–1.7	0.53–3.6	0.49–2.1	0.29–1.8	0.38–1.5	0.15–1.5	0.15–1.3
Co-PCB							
Mean	1.1	0.99	0.87	0.91	0.62	0.67	1.1
Standard deviation	0.95	0.53	0.53	0.47	0.30	0.41	0.60
Median	0.87	0.96	0.75	0.96	0.62	0.56	1.1
Range	0.23–4.6	0.46–2.6	0.31–2.2	0.26–2.2	0.21–1.0	0.15–1.6	0.21–2.3
PCDD+PCDF +Co-PCB							
Mean	1.8	2.1	1.7	1.8	1.4	1.2	1.7
Standard deviation	1.3	1.0	0.81	0.83	0.56	0.77	0.80
Median	1.6	1.8	1.6	1.7	1.2	1.1	1.8
Range	0.45–6.2	1.0–4.7	0.84–3.2	0.60–3.8	0.70–2.4	0.32–3.2	0.35–3.3

Analysis and Evaluation

Comparison of Regions with Respect to Estimated Total Exposure to Dioxins

As shown in Table 5-6, the estimated total exposure to PCDD+PCDF+Co-PCB can be described as follows:

- In the Nose Town area of Osaka Prefecture, both mean values and median values were lower in A region than in B region.
- In the Saitama Prefecture areas, both mean values and median values were lower in B regions than in A1 regions and A2 regions, and A1 regions and A2 regions showed generally similar values.
- In the Fuchu City area of Hiroshima Prefecture, both the mean and median values shown were lower in B region than in A region.
- In all three areas, however, no distinct difference was observed between regions.

Figures 5-1 through 5-3 show histograms of individual exposure to dioxins.

Comparison by Routes of Exposure

In all districts alike, food was the route accounting for approximately 90% or more of exposure to PCDD+PCDF and to Co-PCB during the survey period. The percentage of exposure through the air and the soil was small.

As shown in Tables 5-7 through 5-9, however, there was a considerable range in the percentage of exposure accounted for by each route.

Figure 5-4 shows the estimated total exposure and the respective percentages by route of exposure.

Table 5-7. Percentage of Exposure by Route (PCDD+PCDF)

	Mean	Range
Estimated exposure through air	7.72%	0.48 – 73.80%
Estimated exposure through soil	3.69%	0.013 – 24.13%
Estimated exposure through food	88.60%	24.03 – 99.48%

Table 5-8. Percentage of Exposure by Route（Co-PCB）

	Mean	Range
Estimated exposure through air	0.24%	0.020 – 1.30%
Estimated exposure through soil	0.39%	0.000020 – 5.15%
Estimated exposure through food	99.40%	94.53 – 99.98%

Table 5-9. Percentage of Exposure by Route（PCDD+PCDF+Co-PCB）

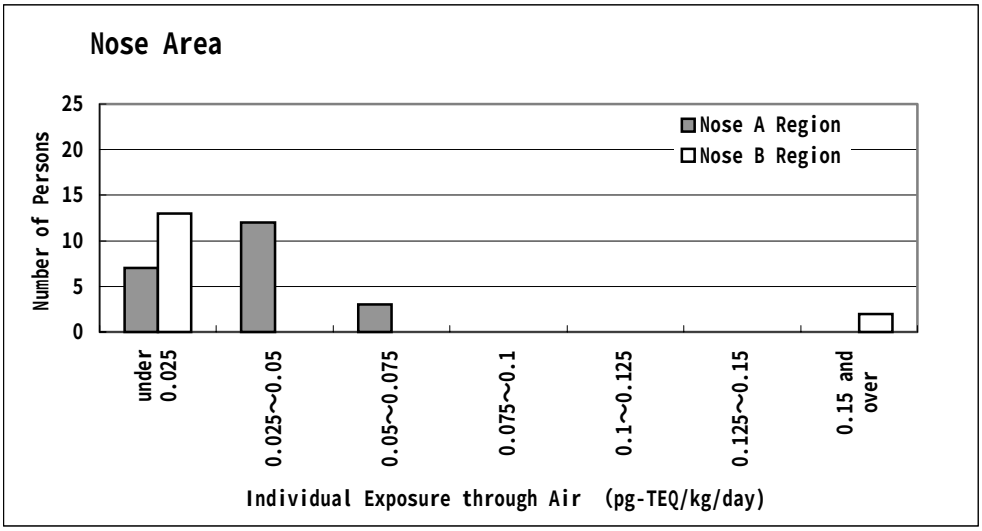
	Mean	Range
Estimated exposure through air	4.24%	0.38 – 56.36%
Estimated exposure through soil	2.03%	0.0049 – 16.49%
Estimated exposure through food	93.73%	41.89 – 99.61%

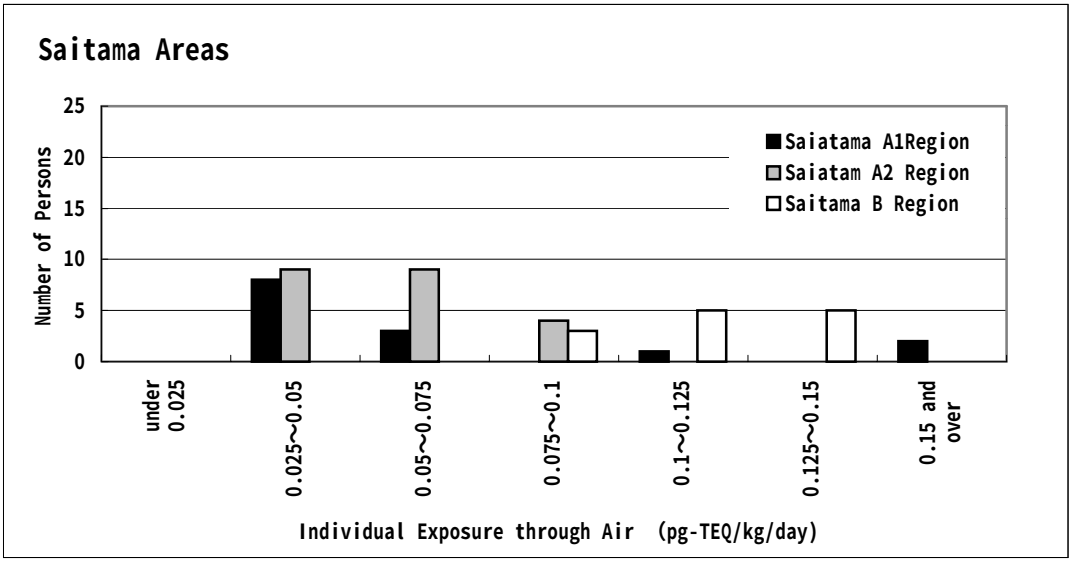
Comparison to the Tolerable Daily Intake (TDI) of 4 pg-TEQ/kg/day

In all regions, mean values and median values for total exposure to PCDD+PCDF+Co-PCB were 4 pg-TEQ/kg/day or less. Among the total of 120 estimates of total exposure to PCDD+PCDF+Co-PCB during the survey period, in two cases the estimated total exposure exceeded 4 pg-TEQ/kg/day.

However, the TDI is an indicator calculated from the effects on the health when that level of intake continues throughout a lifetime. The estimated total exposures to PCDD+PCDF+Co-PCB for this survey, however, are inferred from cross-sectional study during the period of the survey. Consequently, the exposures estimated here do not represent long-term exposures for the survey subjects, which means that these two cannot subject to simple comparison.

In fiscal 1998, the food survey was conducted once for three days (a total of three times), while in fiscal 1999, the food survey was conducted three times for three days each (a total of nine days). This is thought to have resulted in smoothing of the measurements of the amount of dioxin ingested from the food is, and similar tendencies were observed with respect to total exposure levels.





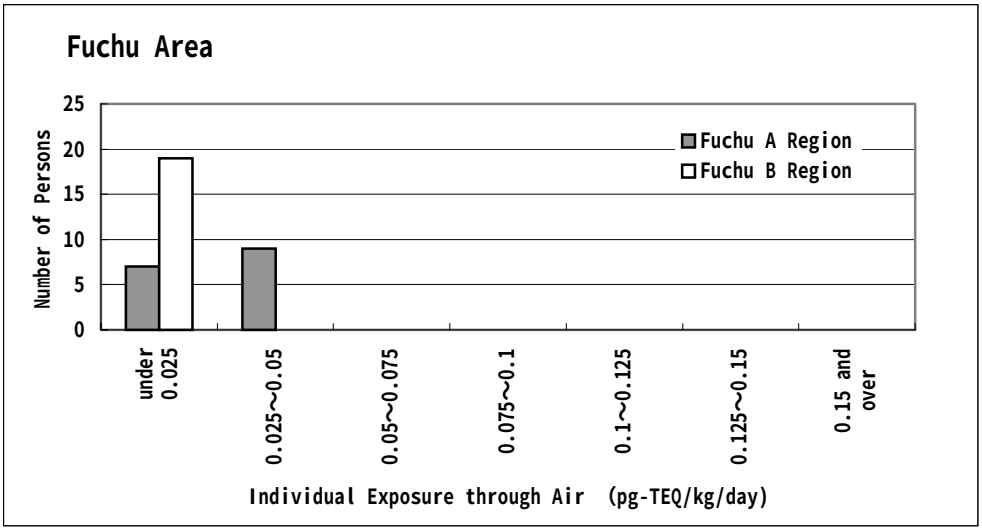
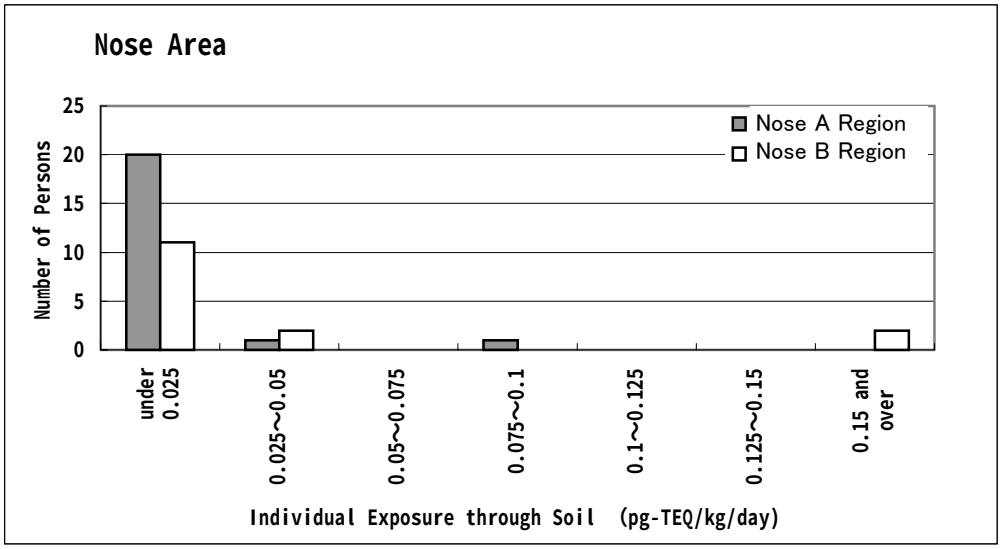
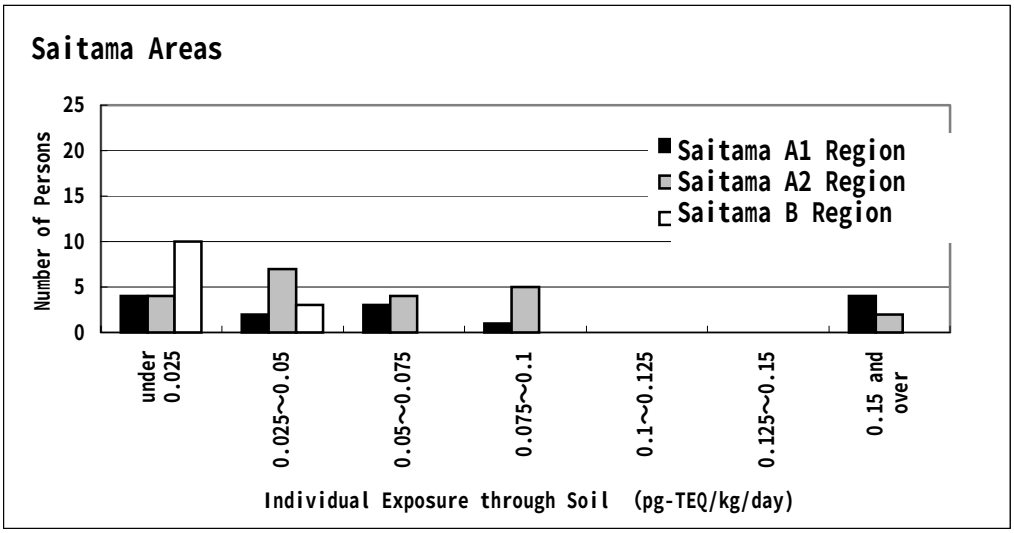


Figure 5-1. Histograms of Individual Exposure to Dioxins (through Air: Case 1)





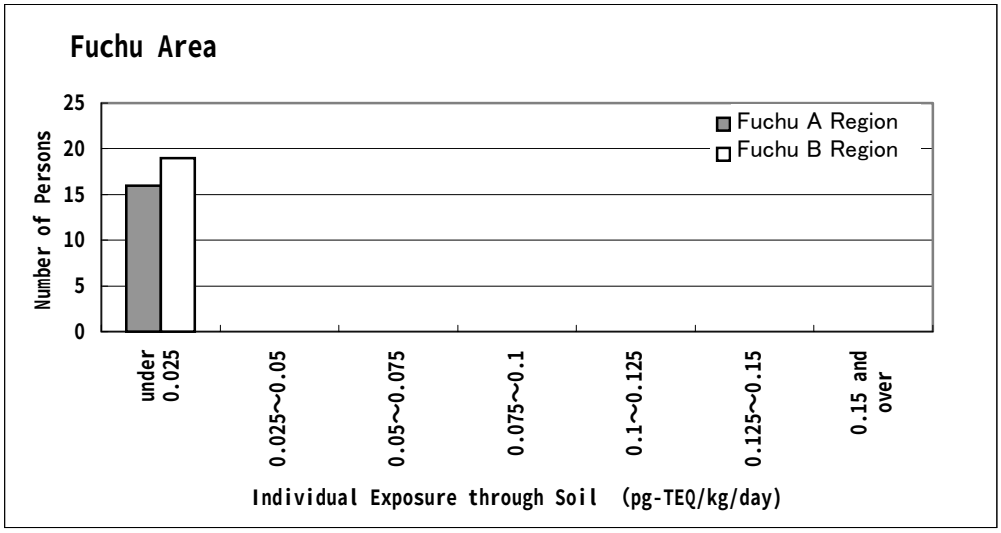
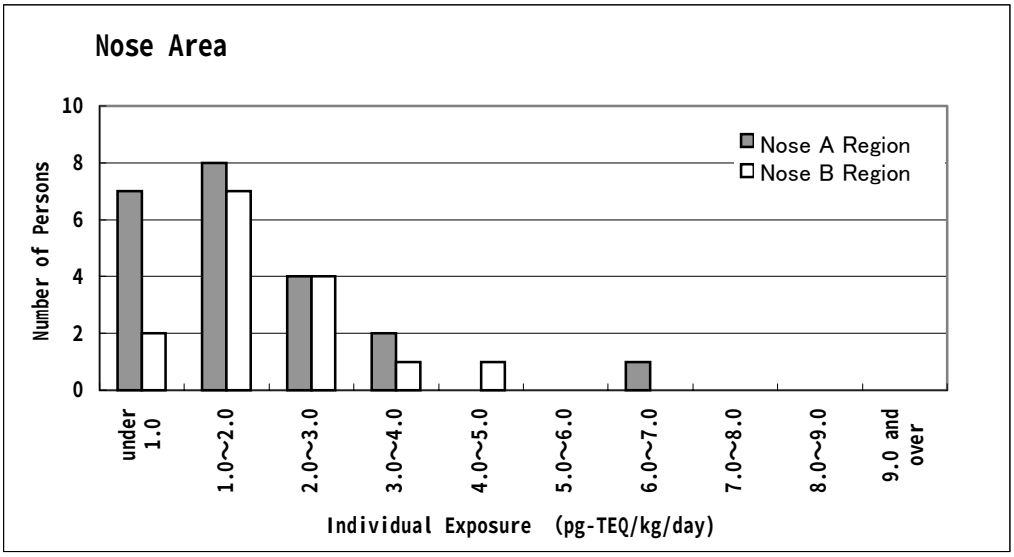
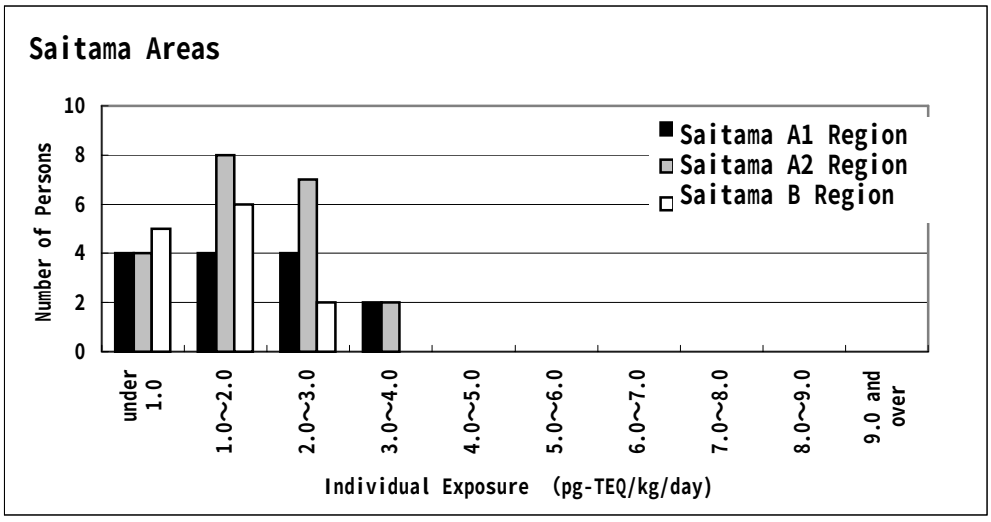


Figure 5-2. Histograms of Individual Exposure to Dioxins (through Soil: Case 1)





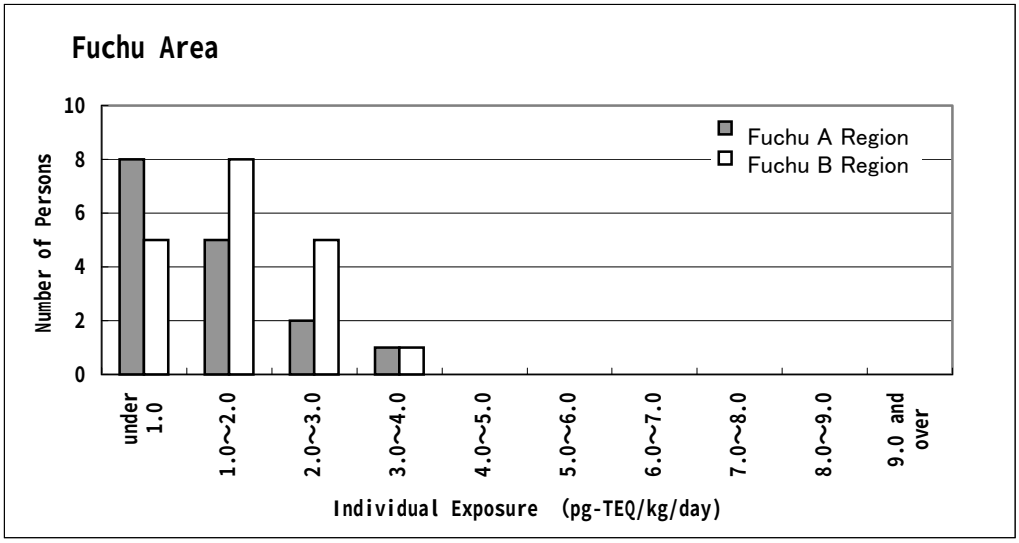


Figure 5-3. Histograms of Individual Exposure to Dioxins (through Air: Case 1+food+Soil: Case 1)

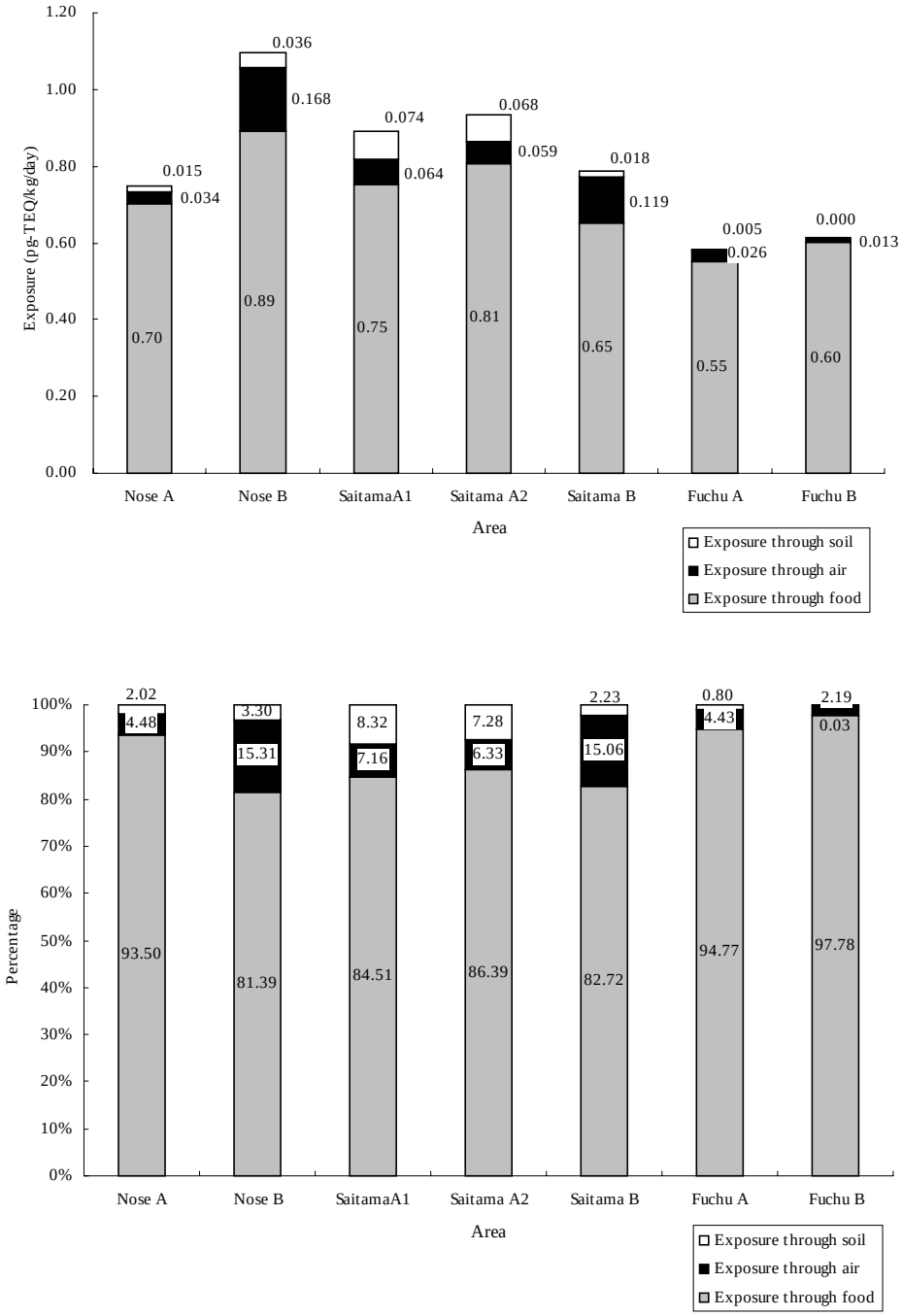


Figure 5-4-1. Estimated Exposure by Route (PCDD+PCDF)

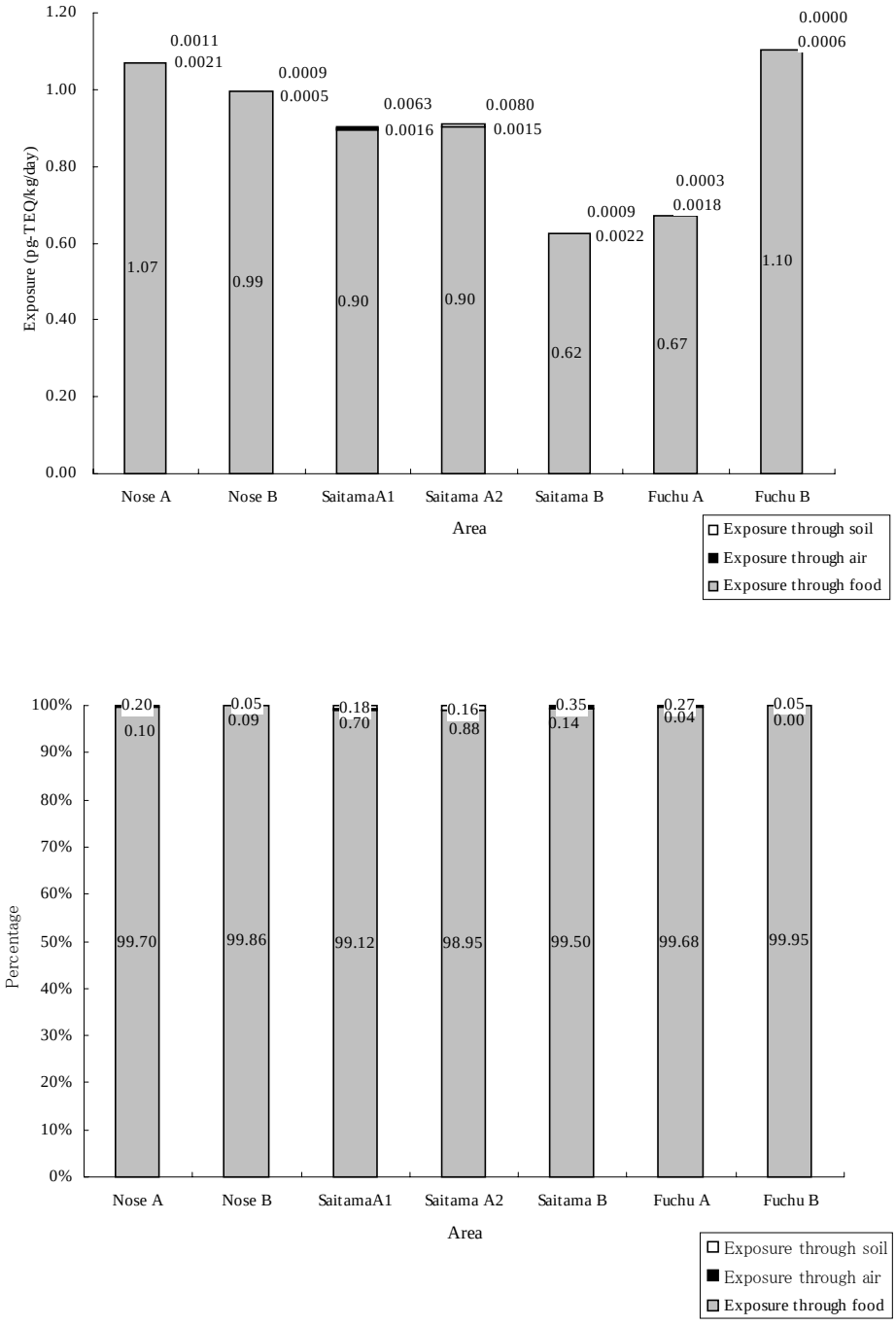


Figure 5-4-2. Estimated Exposure by Route（Co-PCB）

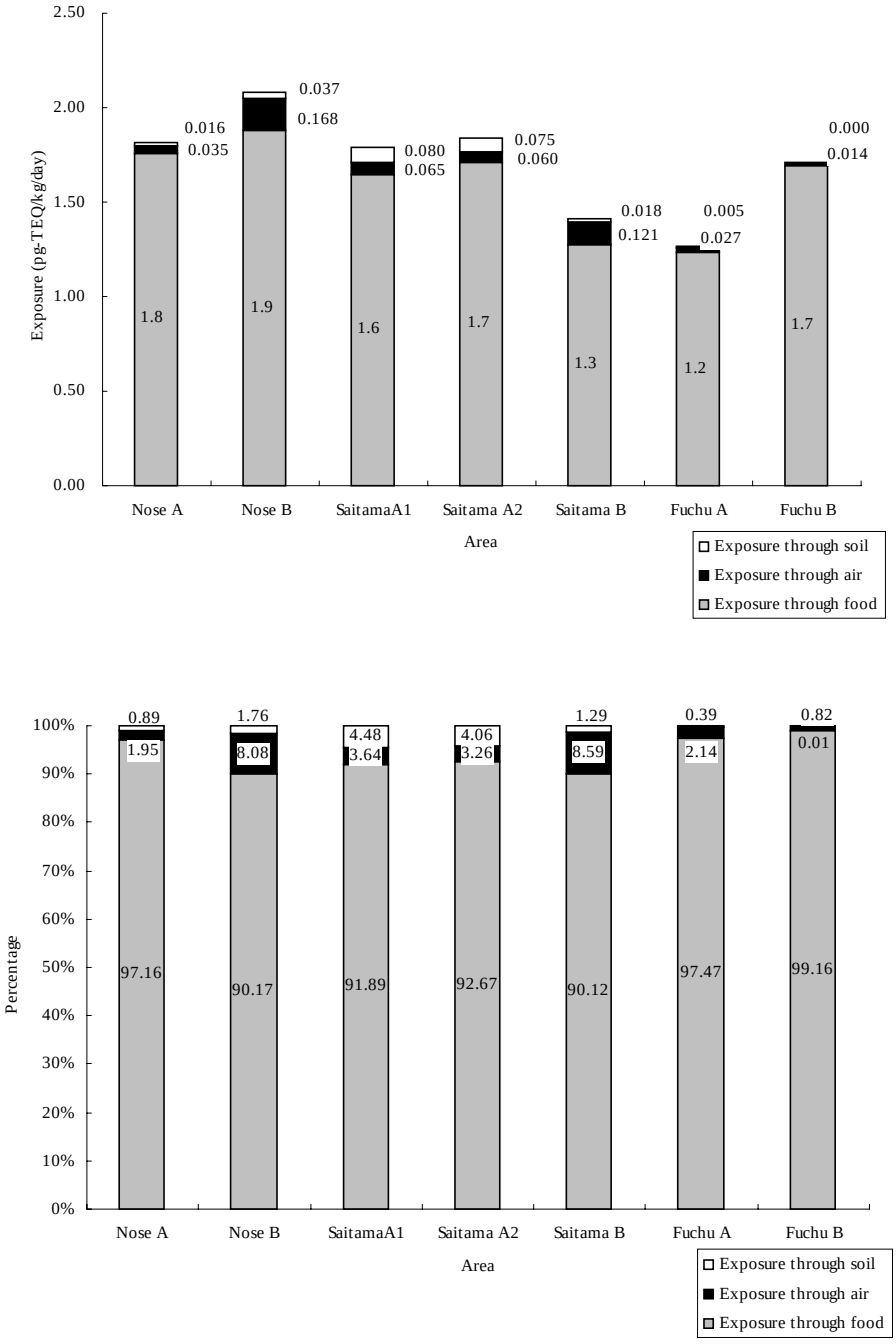


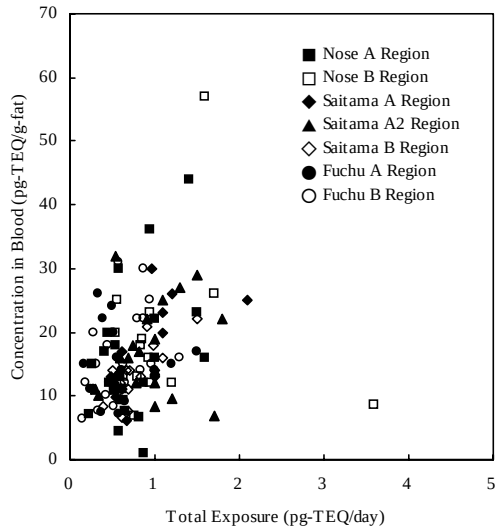
Figure 5-4-3. Estimated Exposure by Route（PCDD+PCDF+Co-PCB）

(2) Relationship between Exposure to Dioxins and Concentration of Dioxins in Blood

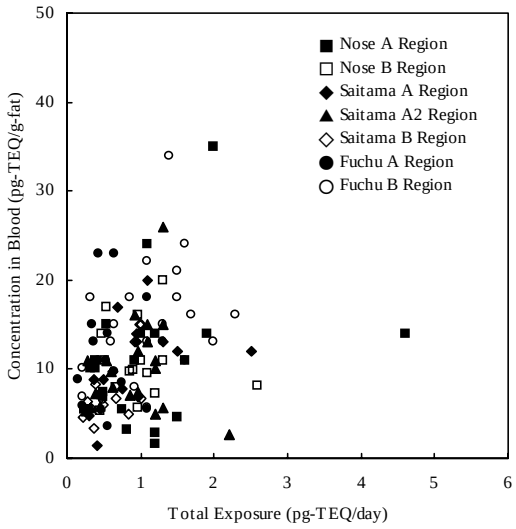
In addition to measuring the concentration in the blood of PCDD+PCDF+Co-PCB, which is considered an indicator of long-term exposure to dioxins, this survey also conducted a cross-sectional estimation of the exposure to PCDD+PCDF+Co-PCB by route of exposure during the survey period.

No significant correlation was found in any of the three areas between the cross-sectional estimated total exposure to PCDD+PCDF+Co-PCB during the survey period and the concentration in the blood of PCDD+PCDF+Co-PCB, which is considered an indicator of long-term exposure to PCDD+PCDF+Co-PCB (see Figure 6-1). This was also the case after adjusting for age (see Figure 6-2). One of the major reasons for this is thought to be that the cross-sectional view of exposure to PCDD+PCDF+Co-PCB obtained by this study does not necessarily represent long-term past exposure to PCDD+PCDF+Co-PCB.

PCDD+PCDF



Co-PCB



PCDD+PCDF＋Co-PCB

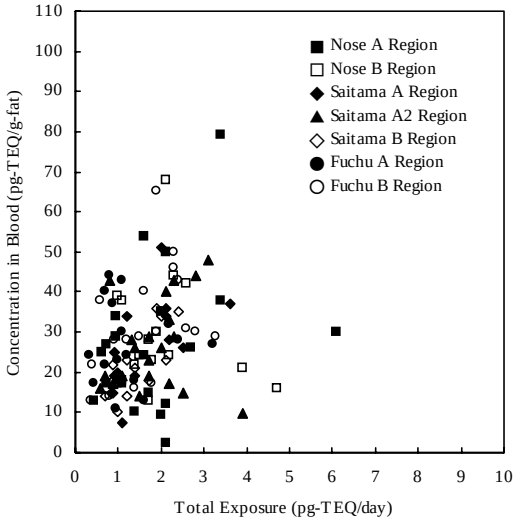
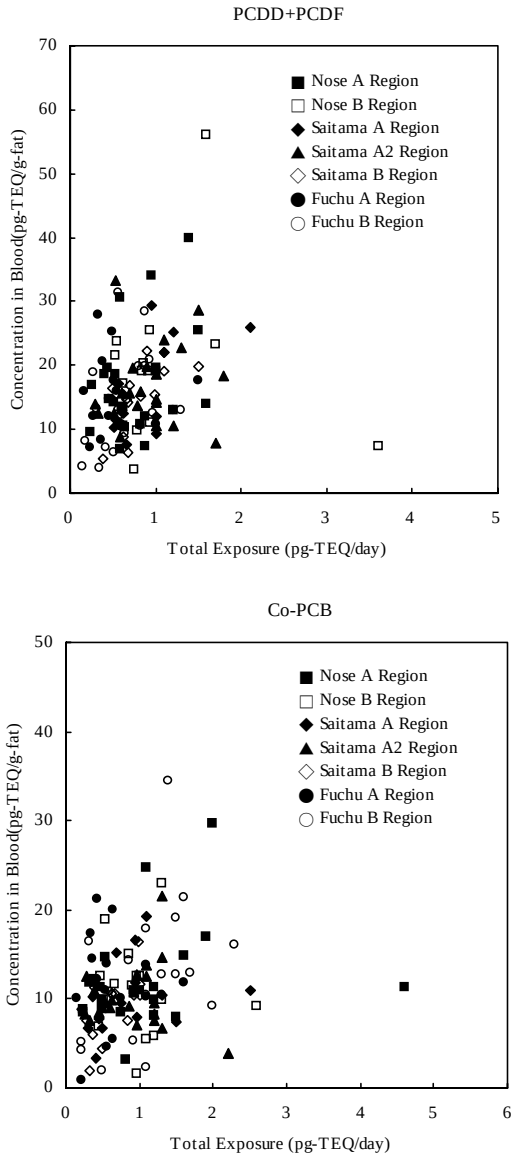


Figure 6-1. Relationship between Total Exposure and Concentration in Blood



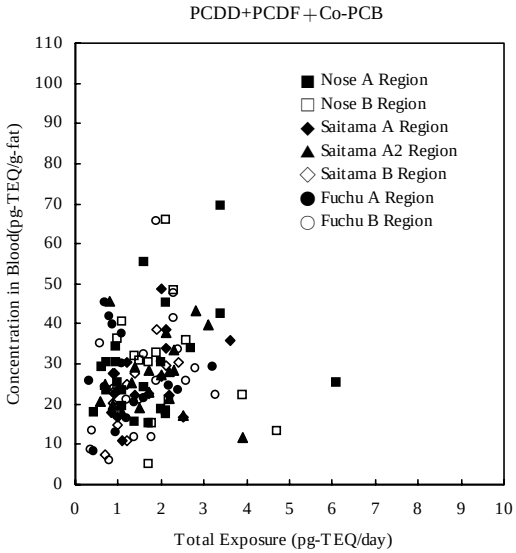


Figure 6-2. Relationship between Total Exposure and Concentration in Blood (Adjusted for Age)