The Exposure to chemical compounds in the Japanese People

- Survey of the Exposure to chemical compounds in Human (2011 ～) -

2015

Environmental Risk Assessment Office,
Environmental Health Department,
Ministry of the Environment, Japan

Introduction

The Environmental Risk Assessment Office, Environmental Health Department, Ministry of the Environment, Japan(MOE) has been conducting a survey titled "Survey of the Exposure to Dioxins and other chemical compounds in Humans" to determine the exposure and accumulation levels of chemical compounds in Japanese subjects since FY 2011. (Note that the survey was renamed "Survey of the Exposure to chemical compounds in Humans" since FY 2012).

The Environmental Risk Assessment Office has now compiled 4 years of survey results conducted during FY 2011–2014.

Summary of "Survey of the Exposure to chemical compounds in Humans"

Survey objectives

- Grasp accumulated levels of dioxins and other chemical compounds in Japanese people.
- Conduct a follow-up survey to observe chronological changes in the accumulation levels of chemical compounds in the previous participants.
- Conduct a monitoring survey of Persistent Organic Pollutants (POPs) in biological samples required by the Stockholm Convention.

Scope and methods of the survey

- Three areas were selected from the survey regions in "Survey on the accumulation of dioxins and other chemical compounds in humans" conducted during FY 2002–2010.
- Within each survey area, residents aged 40–59 who had lived in the area for a long period were recruited as survey subjects.
- Dioxins and other chemical compounds were measured in the blood and urine of the survey subjects.
- A survey on the lifestyle of the subjects was conducted by questionnaire.
- Food samples were collected over a three-day period from some survey subjects. The concentrations of chemical compounds in food were measured for calculating the intakes.

Results from the dioxins survey

- The average concentration of dioxins in the blood of 334 people was 12 pg-TEQ/g-fat, with a range of 0.40–56 pg-TEQ/g-fat. This result is similar to those reported in other surveys.
- Dioxin levels decreased in the blood of 65 out of people who participated in a previous study (6–9 years ago).
- The average intake of dioxins from food by 60 people was 0.53 pg-TEQ/kg body weight/day with a range of 0.035–2.4 pg-TEQ/kg body weight/day. No survey subjects exceeded the tolerable daily intake (TDI) of 4 pg-TEQ/kg body weight/day.

Results from the fluorine compounds survey

- The average perfluorooctanesulfonic acid (PFOS) and perfluorooctanoic acid (PFOA) in the blood of 250 people were 4.7 and 2.4 ng/mL, respectively. The ranges of PFOS and PFOA were 0.29–17 ng/mL and 0.27–13 ng/mL, respectively. These results are similar to those reported in other surveys.
- The average intakes of PFOS and PFOA from food by 15 people were 0.57 ng/kg body weight/day and 0.69 ng/kg body weight/day, respectively. The ranges of intake of PFOS and PFOA were below the detection limit (N.D.)–1.7 ng/kg body weight/day and ND–2.9 ng/kg body weight/day, respectively.

Results from the metals survey

- The average concentration of total mercury in the blood of 334 people was 8.5 ng/mL with a range of 1.5–41 ng/mL. In addition, were measured lead, cadmium, arsenic, copper, selenium, zinc, and manganese in blood.
- The average concentration of cadmium in the urine of 263 people was 0.81 μ g/g creatinine with a range of 0.11–3.9 μ g/g creatinine. In addition, arsenic species in urine were measured.
- Intakes of total mercury, methyl mercury, lead, cadmium, arsenic, copper, selenium, zinc, and manganese from food were measured for 60 people.

Results from other chemical compounds (including pesticides and plasticizers)

- Chemical compounds including pesticides and their metabolites and plasticizers, in blood and urine of 263 people were measured.

Results from the POPs survey

- The concentrations of POPs and candidates specified by Stockholm Convention were measured in the blood of 86 people. In addition, the intake of POPs from food was calculated for 15 people (conducted only in FY 2011).

Results from the radioactive substances survey

- The concentration of radioactive substances (cesium 134, cesium 137, and potassium 40) in blood, urine, and food were measured.

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1. Overview of "Survey of the Exposure to chemical compounds in Humans"

The Environmental Risk Assessment Office, Environmental Health Department, Ministry of the Environment, Japan, carried out a survey entitled "Survey on the accumulation of dioxins and other chemical compounds in humans" during FY 2002–2010. In this survey, blood dioxin concentrations were measured in 2,264 people living in typical environments in Japan. In addition, dioxin concentrations in the food of 625 people were measured and the intake from food was calculated (see Supplementary Information). "Survey of the Exposure to chemical compounds in Humans" began in FY 2011. Survey regions were selected from those that were surveyed previously. Blood and urine were collected from the participating residents, and the accumulation of dioxins and other chemical compounds were measured. Furthermore, a food study (duplicate portions study) was conducted for a subset of survey subjects. The concentrations of chemical compounds in the food were measured, and the intakes were calculated. During FY 2011–2014, blood and urine specimens of 334 people from 12 survey regions were analyzed, and the intakes of chemical compounds from food were estimated for 60 people.

"Survey of the Exposure to chemical compounds in Human"

Organization responsible for the survey	Environmental Risk Assessment Office, Environmental Health Department, Ministry of the Environment, Japan
Survey period	FY 2011 and thereafter
Survey regions	Three regions per year
Survey specimens	Blood (to ascertain the accumulation of chemical compounds in the body), urine (to ascertain the excreted amounts of rapidly-metabolized chemical compounds), and food (to ascertain the amount of intake of chemical compounds).
Number of subjects	334 people (FY 2011, 86 people; FY 2012, 84 people; FY 2013, 83 people; FY 2014, 81people; and 60 people participated in the food study).

2. Survey methods

2-1 Target regions and subjects

In “Survey on the accumulation of dioxins and other chemical compounds in humans” conducted during FY2002–2010, Japan was divided into five regions, of which one prefecture was selected for each fiscal year. In a prefecture, three areas each classified as urban, agricultural, or fishery area were selected. From FY 2011, three regions were selected from regions of participated in previous studies. The local administrative authorities recruited the study subjects who had participated in previous studies and fulfilled the following criteria. In addition, participants from previous studies who meet the condition below were recruited.

Study subject criteria

- Age: 40–59
- A resident of the survey region for 10 years or more
- Rarely absent from the survey region for work or other reasons
- Ability to provide blood samples with no restrictions（e.g., no anemia）

2-2 Methods

● Blood (all subjects)

Blood was collected from survey subjects by a nurse in the presence of a physician. Generally, fasting blood samples were taken.

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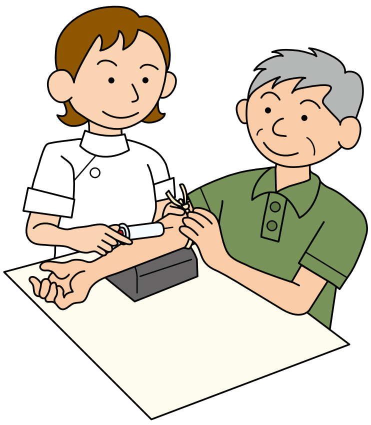


Analytes

Analytes	FY 2011	FY 2012	FY 2013	FY 2014
• Chlorinated dioxins	○	○	○	○
• Brominated dioxins		○		
• Organofluorine compounds	○		○	○
• Metals	○	○	○	○
• Hydroxylated polychlorinated biphenyls (PCB)		○	○	○
• POPs	○			
• Radioactive substances		○	○	○
• General health examination items: blood count, hepatic function, renal function, and glucose metabolism	○	○	○	○
• Health effect indexes: thyroidal function, allergic function, and fatty acids	○	○	○	○

● Urine (sampled from all subjects; analysis for a subset of the subjects)

Urine was collected in a container on the same day of blood sampling.

Analytes

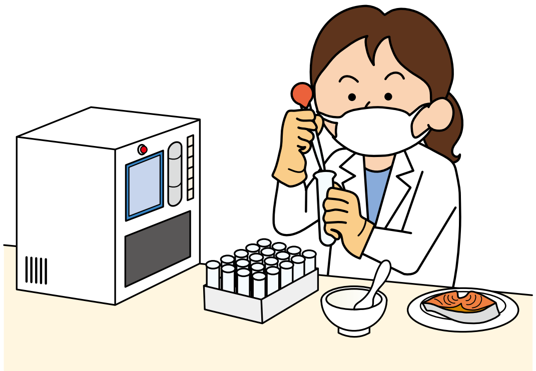
Analytes	FY 2011	FY 2012	FY 2013	FY 2014
• Pesticides and their matabolites (organophosphate, pyrethroid etc.)	○	○	○	○
• Plasticizers, phthalate metabolites, and bisphenol A	○	○	○	○
• Metals (cadmium and arsenic)	○	○	○	○
• Other chemical substances (PAH, cotinine, and caffeine)		○	○	○
• POPs	○			
• Radioactive substances		○	○	○
• General health examination items: specific gravity, glucose, and protein	○	○	○	○

Food (conducted on a subset of the subjects)

The food study was conducted over three days during the survey period. A "duplicate portions study" was conducted whereby duplicates of the subjects' meals were stored in containers and collected afterwards. Nutritionists checked the food items and weight. The meals were then homogenized, the chemical compounds were measured, and the intake of each chemical compound (kg body weight per day) was estimated.

Analytes

Analyzed chemicals	FY 2011	FY 2012	FY 2013	FY 2014
• Chlorinated dioxins	○	○	○	○
• Organofluorine compounds	○			
• Metals	○	○	○	○
• POPs	○			
• Radioactive substances		○	○	○

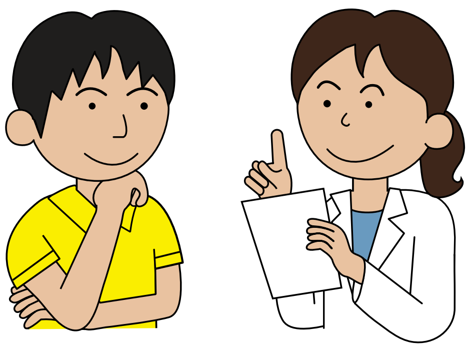


Lifestyle survey (questionnaire)

A public health nurse or a nutritionist investigated the lifestyles of survey subjects through individual interviews, referring to the questionnaire that was answered in advance.

Analytes

- Personal medical history, residential history, occupational history, smoking habit, dietary history, lifestyle, and birth history



3. Results and Discussion

3-1 Dioxins survey

3-1-1 Blood (chlorinated dioxins)

● Results summary

The blood dioxin concentrations are shown in Table 1. The average concentration of the 334 survey subjects was 12 pg-TEQ/g-fat. The range of the concentration was 0.40–56 pg-TEQ/g-fat.

☐ Table 1. Statistics for blood dioxin concentrations

(unit: pg-TEQ/g-fat)

	FY 2011 (n=86)	FY 2012 (n=84)	FY 2013 (n=83)	FY 2014 (n=81)	Total (n=334)
PCDDs+PCDFs +Co-PCBs					
Average	17	10	9.9	9.8	12
Standard deviation	10	6.9	6.6	5.9	8.4
Median	14	9.0	8.9	8.3	9.9
Range	0.83 ～ 56	0.42 ～ 40	0.40 ～ 33	1.1 ～ 34	0.40 ～ 56

● Comparison with previous survey results

Table 2 summarizes the comparison of the present results with the results from the "Survey on the accumulation of dioxins and other chemical compounds in humans (FY 2002 to FY 2010)," conducted on 2,264 subjects. Although it was difficult to compare in a simplified manner because the average age and number of subjects differed between the surveys, the blood dioxin concentrations obtained in the present survey were generally within the range of concentrations obtained in the previous surveys.

☐ Table 2. Comparison with previous survey results

(unit: pg-TEQ/g-fat)

Survey name	Survey on the Accumulation of Dioxins and other chemical compounds	This survey
Survey year	FY 2002 to FY 2010	FY2011 to FY2014
Subjects	People living in the general envionment	People living in the general envionment
Number of subjects	2,264	334
Age		
Average (years)	44.5	50.3
Range	15 ～ 76	26 ～ 77
PCDDs+PCDFs +Co-PCBs		
Average	19	12
Standard deviation	14	8.4
Median	16	9.9
Range	0.10 ～ 130	0.40 ～ 56

● Comparison of results for the same subjects

Sixty-nine people participated in both the present and previous surveys, and a comparison of the results are shown in Table 3. The dioxin concentrations in the blood decreased in most of the subjects.

☐ Table 3. Comparison of blood dioxin concentrations in the same subjects

(unit: pg-TEQ/g-fat)

Survey name	Past survey (n=69)	This survey (n=69)
Survey year	FY 2002 to FY2007	FY 2011 to FY 2014
PCDDs+PCDFs +Co-PCBs		
Average	22	12
Standard deviation	16	8.8
Median	18	9.9
Range	0.96 ～ 95	1.2 ～ 56

3-1-2　Food (chlorinated dioxins)

● Results summary

Table 4 summarizes the dioxin intake from food. The average intake was 0.53 pg-TEQ/kg bw/day with a range of 0.035–2.4 pg-TEQ/kg bw/day. In Japan, the tolerable daily intake (TDI) for dioxins is 4 pg-TEQ/kg bw/day as stipulated by the Law Concerning Special Measures against Dioxins. The TDI indicates the maximum ingestion of a given chemical substance per kg of body weight/day, and humans do not show adverse health effects even when the chemical is ingested below this level over a long period. No subjects in the survey exceeded this TDI value.

☐ Table 4. Statistics for intake of intake from food

(unit: pg-TEQ/kg bw/day)

	FY 2011 (n=15)	FY 2012 (n=15)	FY 2013 (n=15)	FY 2014 (n=15)	Total (n=60)
PCDDs+PCDFs +Co-PCBs					
Average	0.65	0.72	0.32	0.43	0.53
Standard deviation	0.71	0.55	0.41	0.35	0.53
Median	0.39	0.57	0.23	0.34	0.35
Range	0.035 ～ 2.4	0.071 ～ 2.3	0.046 ～ 1.6	0.086 ～ 1.3	0.035 ～ 2.4

● Comparison with previous survey results

Table 5 summarizes the comparison with the results of "Survey on the Accumulation of Dioxins and other chemical compounds (FY 2002 to FY 2010)" conducted on 625 subjects. The results from this survey were generally within the range of concentrations obtained in the previous surveys.

□ Table 5. Comparison with previous survey results

(unit: pg-TEQ/kg bw/day)

Survey name	Survey on the Accumulation of Dioxins and other chemical compounds	This survey
Survey year	FY 2002 to FY 2010	FY 2011 to FY 2014
Subjects	People living in the general envionment	People living in the general envionment
Number of subjects	625	60
PCDDs+PCDFs +Co-PCBs		
Average	0.82	0.53
Standard deviation	0.86	0.53
Median	0.56	0.35
Range	0.031 ～ 6.2	0.035 ～ 2.4

3-1-3 Blood (brominated dioxins)

● Results summary

Table 6 summarizes the brominated dioxin concentrations in the blood for FY 2012 survey, which were below the detection limit for all 84 subjects.

□ Table 6. Statistics for brominated dioxins in the blood

(unit: pg/g-fat)

	FY 2012 (n=84)
PBDDs+PBDFs	
Average	All N.D.
Standard deviation	
Median	
Range	

3-2 Fluorine compounds survey

3-2-1 Blood

● Results summary

The results for fluorine compound concentrations in the blood are shown in Table 7.

☐ Table 7. Statistics for fluorine compound concentrations in the blood

(unit: ng/mL)

	FY 2011 (n=86)	FY 2013 (n=83)	FY 2014 (n=81)	Total (PFOS・PFOA: n=250, and others:n=164)
PFOS				
Average	5.8	5.1	3.0	4.7
Standard deviation	3.1	2.9	1.6	2.9
Median	4.8	4.5	2.7	3.8
Range	1.5 ～ 17	1.3 ～ 16	0.29 ～ 11	0.29 ～ 17
PFOA				
Average	2.2	3.2	1.8	2.4
Standard deviation	1.4	2.4	1.1	1.8
Median	1.8	2.5	1.6	1.9
Range	0.66 ～ 9.6	0.27 ～ 13	0.43 ～ 8.4	0.27 ～ 13
PFHxA				
Median	—	All N.D.	All N.D.	All N.D.
Range	—			
PFHpA				
Median	—	N.D.	N.D.	N.D.
Range	—	N.D. ～ 1.2	N.D. ～ 0.39	N.D. ～ 1.2
PFHxS				
Median	—	0.54	0.42	0.46
Range	—	N.D. ～ 1.8	N.D. ～ 1.1	N.D. ～ 1.8
PFTeDA				
Median	—	N.D.	N.D.	N.D.
Range	—	N.D. ～ 0.33	N.D. ～ 0.41	N.D. ～ 0.41
PFNA				
Median	—	2.0	1.3	1.5
Range	—	0.60 ～ 7.7	0.35 ～ 5.9	0.35 ～ 7.7
PFDA				
Median	—	0.58	0.55	0.57
Range	—	0.23 ～ 2.0	0.092 ～ 2.7	0.092 ～ 2.7
PFUdA				
Median	—	1.4	1.1	1.3
Range	—	0.30 ～ 4.6	0.29 ～ 6.4	0.29 ～ 6.4
PFDS				
Median	—	N.D.	All N.D.	N.D.
Range	—	N.D. ～ 0.065		N.D. ～ 0.065
PFDoA				
Median	—	0.18	0.16	0.17
Range	—	N.D. ～ 0.66	N.D. ～ 0.89	N.D. ～ 0.89
PFTrDA				
Median	—	0.38	0.45	0.39
Range	—	N.D. ～ 1.3	N.D. ～ 2.7	N.D. ～ 2.7

● Comparison with previous survey results

Table 8 summarizes the comparison of the present results with the results from "Survey on the Accumulation of Dioxins and other chemical compounds in Humans" conducted from FY 2008 to FY 2010 on 609 subjects. Although it was difficult to compare in a simplified manner because the average age and the number of subjects differed between the surveys, the results of present survey were generally within the range of results obtained in the previous surveys.

□ Table 8. Comparison with previous survey results

(unit: ng/mL)

Survey name	Survey on the Accumulation of Dioxins and other chemical compounds	This survey
Survey year	FY 2008 to FY 2010	FY 2011, 2013, 2014
Subjects	People living in the general envionment	People living in the general envionment
Number of subjects	609	250
PFOS		
Average	7.8	4.7
Standard deviation	9.2	2.9
Median	5.8	3.8
Range	0.73 ～ 150	0.29 ～ 17
PFOA		
Average	3.0	2.4
Standard deviation	2.9	1.8
Median	2.1	1.9
Range	0.37 ～ 25	0.27 ～ 13

3-2-2　Food

The intake of fluorine compounds from food for 15 subjects is shown in Table 9. The average PFOS concentration was 0.57 ng/kg body weight/day with a range of N.D.-1.7 ng/kg body weight/day. The TDI has not been established for fluorine compounds in Japan.

□ Table 9. Statistics for the intake of fluorine compounds from food

(unit: ng/kg bw/day)

	FY 2011 (n=15)
PFOS	
Average	0.57
Standard deviation	0.51
Median	0.53
Range	N.D. ～ 1.7
PFOA	
Average	0.69
Standard deviation	0.70
Median	0.62
Range	N.D. ～ 2.9

3-3 Metals survey

3-3-1 Blood

● Results summary

The concentrations of metals (total mercury, lead, cadmium, arsenic, copper, selenium, zinc, and manganese) in the blood were measured (Table 10).

☐ Table 10. Statistics for blood metal concentrations

(unit: ng/mL)

Metals	FY 2011 (n=86)	FY 2012 (n=84)	FY 2013 (n=83)	FY 2014 (n=81)	Total (total mercury: n=334, manganese: n=164, and others: n=248)
Total mercury					
Median	9.1	9.0	7.3	7.2	8.5
Range	2.4 ～ 29	1.7 ～ 41	2.1 ～ 33	1.5 ～ 22	1.5 ～ 41
Lead					
Median	―	12	10	13	11
Range	―	5.0 ～ 28	4.8 ～ 31	5.2 ～ 37	4.8 ～ 37
Cadmium					
Median	―	1.1	1.1	0.97	1.1
Range	―	0.25 ～ 3.5	0.40 ～ 2.7	0.37 ～ 4.4	0.25 ～ 4.4
Arsenic					
Median	―	5.2	4.1	5.7	5.1
Range	―	1.4 ～ 35	1.2 ～ 19	1.0 ～ 110	1.0 ～ 110
Copper					
Median	―	800	870	890	850
Range	―	590 ～ 1,100	640 ～ 1,400	590 ～ 1,400	590 ～ 1,400
Selenium					
Median	―	180	180	200	190
Range	―	110 ～ 480	130 ～ 390	160 ～ 260	110 ～ 480
Zinc					
Median	―	6,300	6,500	6,400	6,400
Range	―	4,700 ～ 7,800	4,700 ～ 7,800	4,500 ～ 8,400	4,700 ～ 8,400
Manganese					
Median	―	―	13	14	13
Range	―	―	7.4 ～ 25	7.0 ～ 53	7.0 ～ 53

3-3-2 Urine

● Results summary

The concentrations in urine of cadmium and arsenic species [As(V), As(III), monomethylarsonic acid, dimethylarsinic acid, and arsenobetaine] were measured (Table 11).

□ Table 11. Statistics for urine metal concentrations

(unit: μg/g Cr)

Metals		Statistics	FY 2011 (n=15)	FY 2012 (n=84)	FY 2013 (n=83)	FY 2014 (n=81)	Total (n=263)
Cadmium		Median	0.97	0.89	0.64	0.81	0.81
		Range	0.25 ～ 3.9	0.20 ～ 3.1	0.11 ～ 3.1	0.16 ～ 2.8	0.11 ～ 3.9
Arsenic	As(V)	Median	0.30	N.D.	N.D.	N.D.	N.D.
		Range	N.D. ～ 2.5	N.D. ～ 2.9	N.D. ～ 2.2	N.D. ～ 1.6	N.D. ～ 2.9
	As(III)	Median	1.5	1.7	1.5	1.1	1.4
		Range	N.D. ～ 6.2	N.D. ～ 6.6	N.D. ～ 6.9	N.D. ～ 4.7	N.D. ～ 6.9
	MMA (monomethylarsonic acid)	Median	2.0	2.1	2.1	1.5	1.9
		Range	0.89 ～ 5.1	0.38 ～ 8.5	N.D. ～ 13	N.D. ～ 6.2	N.D. ～ 13
	DMA (dimethylarsinic acid)	Median	42	33	30	27	31
		Range	12 ～ 170	6.7 ～ 110	8.5 ～ 100	6.2 ～ 150	6.2 ～ 170
	AB (arsenobetaine)	Median	73	40	31	54	39
		Range	15 ～ 300	2.8 ～ 640	2.1 ～ 390	6.1 ～ 2,300	2.1 ～ 2,300

3-3-3 Food

● Results summary

Metals (total mercury, methyl mercury, lead, cadmium, arsenic, copper, selenium, zinc, and manganese) were measured in the food (Table 12). In Japan, the TDIs for heavy metals have only been established for methyl mercury (0.29 μg/kg body weight/day) and cadmium (7 μg/kg body weight/week) in Japan. No subjects in this survey exceeded these TDIs.

□ Table 12. Statistics for the intake of metals from food

(unit：μg/kg bw/day)

Metals	FY 2011 (n=15)	FY 2012 (n=15)	FY 2013 (n=15)	FY 2014 (n=15)	Total (total mercury・methyl mercury・lead・cadmium: n=60, manganese: n=30,and others:n=45)
Total mercury					
Median	0.063	0.079	0.039	0.061	0.062
Range	N.D. ～ 0.16	0.025 ～ 0.30	0.013 ～ 0.16	N.D. ～ 0.16	N.D. ～ 0.30
Methyl mercury					
Median	0.063	0.078	0.034	0.056	0.056
Range	N.D. ～ 0.14	0.022 ～ 0.29	N.D. ～ 0.15	N.D. ～ 0.15	N.D. ～ 0.29
Lead					
Median	0.094	0.11	0.083	0.064	0.082
Range	0.024 ～ 0.17	0.031 ～ 0.28	0.036 ～ 0.22	0.032 ～ 0.17	0.024 ～ 0.28
Cadmium					
Median	0.24	0.25	0.23	0.21	0.24
Range	0.059 ～ 0.39	0.11 ～ 0.57	0.11 ～ 0.56	0.13 ～ 0.47	0.059 ～ 0.57
Arsenic					
Median	—	2.8	1.8	2.8	2.6
Range	—	1.0 ～ 14	0.76 ～ 5.8	0.71 ～ 10	0.71 ～ 14
Copper					
Median	—	16	19	16	16
Range	—	8.2 ～ 26	12 ～ 23	8.2 ～ 24	8.2 ～ 26
Selenium					
Median	—	1.3	1.2	1.2	1.2
Range	—	0.90 ～ 1.8	0.64 ～ 2.5	0.74 ～ 1.9	0.64 ～ 2.5
Zinc					
Median	—	140	130	120	130
Range	—	80 ～ 170	99 ～ 190	65 ～ 160	65 ～ 190
Manganese					
Median	—	—	66	52	61
Range	—	—	38 ～ 110	34 ～ 72	34 ～ 110

3-4 Other chemical compounds (including pesticides and plasticizers)

3-4-1 Blood

The results for hydroxylated PCB concentrations in blood are shown in Table 13.

☐ Table 13. Statistics for hydroxylated PCB concentrations in blood

(unit：pg/g)

Chemical compounds		Statistics	FY 2012 (n=15)	FY 2013 (n=15)	FY 2014 (n=15)	Total (n=45)
Hydoroxyleted PCB	5Cl-HO-PCBs	Median	24	21	29	24
		Range	1.2 ～ 69	7.6 ～ 120	9.2 ～ 110	1.2 ～ 120
	6Cl-HO-PCBs	Median	27	30	34	32
		Range	1.6 ～ 120	12 ～ 200	11 ～ 110	1.6 ～ 200
	7Cl-HO-PCBs	Median	23	22	40	27
		Range	4.0 ～ 94	9.0 ～ 130	9.6 ～ 73	4.0 ～ 130

3-4-2 Urine

The results of pesticides, their metabolites, and plasticizers in urine are shown in Tables 14-1 to 14-4.

☐ Table 14-1. Statistics of pesticides, plasticizers, and others in urine (1)

(unit：μg/g Cr)

Classification	Chemical compounds		Statistics	FY 2011 (n=15)	FY 2012 (n=84)	FY 2013 (n=83)	FY 2014 (n=81)	Total (n=263)
Plasticizers	Phthalate mono-esters	MBP	Median	20	17	20	14	17
			Range	11 ～ 670	6.6 ～ 54	5.5 ～ 5,200	3.7 ～ 48	3.7 ～ 5,200
		MEHP	Median	4.2	2.9	3.2	1.9	2.8
			Range	0.98 ～ 8.1	0.61 ～ 21	0.54 ～ 22	0.23 ～ 13	0.23 ～ 22
		MEHHP	Median	15	9.9	11	7.4	9.7
			Range	5.7 ～ 44	2.7 ～ 59	2.8 ～ 58	1.8 ～ 42	1.8 ～ 59
		MEOHP	Median	9.6	6.3	7.1	4.7	6.0
			Range	4.6 ～ 18	1.6 ～ 31	1.1 ～ 35	1.0 ～ 25	1.0 ～ 35
		MBzP	Median	0.59	0.68	0.60	0.44	0.56
			Range	0.25 ～ 10	N.D. ～ 38	N.D. ～ 7.0	N.D. ～ 15	N.D. ～ 38
	Bisphenol A		Median	0.76	0.44	0.26	0.26	0.33
			Range	0.23 ～ 1.4	N.D. ～ 31	N.D. ～ 8.2	N.D. ～ 2.5	N.D. ～ 31

□ Table 14-2. Statistics of pesticides, plasticizers, and others in urine (2)

(unit：μg/g Cr)

Classification	Chemical compounds		Statistics	FY 2011 (n=15)	FY 2012 (n=30)	FY 2013 (n=30)	FY 2014 (n=30)	Total (n=105)
Pesticides	Organic phosphorus metabolites	DMP	Median	5.6	2.4	3.3	2.9	3.1
			Range	1.8 ～ 14	0.60 ～ 11	N.D. ～ 140	N.D. ～ 15	N.D. ～ 140
		DEP	Median	5.8	5.6	2.1	2.0	3.6
			Range	N.D. ～ 32	N.D. ～ 520	N.D. ～ 14	N.D. ～ 13	N.D. ～ 520
		DMTP	Median	12	7.7	3.5	5.1	6.8
			Range	N.D. ～ 62	N.D. ～ 82	N.D. ～ 110	N.D. ～ 61	N.D. ～ 110
		DETP	Median	N.D.	N.D.	N.D.	N.D.	N.D.
			Range	N.D. ～ 2.7	N.D. ～ 8.3	N.D. ～ 4.6	N.D. ～ 5.1	N.D. ～ 8.3
	Pyrethroid pesticide metabolites	PBA	Median	0.22	0.22	N.D.	0.42	0.24
			Range	N.D. ～ 3.4	N.D. ～ 1.6	N.D. ～ 3.3	N.D. ～ 2.0	N.D. ～ 3.4
		DCCA	Median	N.D.	N.D.	All N.D.	N.D.	N.D.
			Range	N.D. ～ 13	N.D. ～ 3.1		N.D. ～ 2.5	N.D. ～ 13
	Carbamate pesticide metabolite	Ethylenethiourea	Median	N.D.	N.D.	All N.D.	All N.D.	N.D.
			Range	N.D. ～ 0.23	N.D. ～ 0.50			N.D. ～ 0.50
	Triclosan		Median	1.3	1.3	1.1	1.2	1.2
			Range	0.27 ～ 79	0.15 ～ 120	0.15 ～ 380	0.17 ～ 130	0.15 ～ 380

□ Table 14-3. Statistics of pesticides, plasticizers, and others in urine (3)

(unit：μg/g Cr)

Classification	Chemical compounds		Statistics	FY 2012 (n=30)	FY 2013 (n=15)	FY 2014 (n=15)	Total (n=60)
Pesticides	Acephate		Median	N.D.	N.D.	N.D.	N.D.
			Range	N.D. ～ 0.30	N.D. ～ 1.9	N.D. ～ 0.61	N.D. ～ 1.9
	Methamidophos		Median	N.D.	All N.D.	All N.D.	N.D.
			Range	N.D. ～ 0.058			N.D. ～ 0.058
	Imidachloprid metabolite	6-Chloronicotinic acid	Median	N.D.	All N.D.	All N.D.	N.D.
			Range	N.D. ～ 1.8			N.D. ～ 1.8
	Fenitrothion metabolite	3-Methyl-4-nitrophenol	Median	N.D.	0.30	N.D.	N.D.
			Range	N.D. ～ 2.8	N.D. ～ 2.7	N.D. ～ 3.6	N.D. ～ 3.6
	p-Nitropheol		Median	0.67	0.97	0.44	0.67
			Range	0.23 ～ 4.6	0.49 ～ 2.4	N.D. ～ 2.6	N.D. ～ 4.6

☐ Table 14-4. Statistics of pesticides, plasticizers, and others in urine (4)

(unit：μg/g cr)

Classification	Chemical compounds		Statistics	FY 2012 (n=30)	FY 2013 (n=15)	FY 2014 (n=15)	Total (n=60)
Others	Deet		Median / Range	All N.D.	All N.D.	All N.D.	All N.D.
	Parabens	Methylparaben	Median	55	95	120	82
			Range	1.3 ～ 870	1.4 ～ 2,500	3.5 ～ 1,100	1.3 ～ 2,500
		Ethylparaben	Median	2.5	3.4	2.7	2.7
			Range	N.D. ～ 120	N.D. ～ 410	N.D. ～ 290	N.D. ～ 410
		Propylparaben	Median	1.0	2.0	1.1	1.2
			Range	N.D. ～ 71	N.D. ～ 77	N.D. ～ 4.1	N.D. ～ 77
		Butylparaben	Median	N.D.	N.D.	0.61	N.D.
			Range	N.D. ～ 25	N.D. ～ 64	N.D. ～ 87	N.D. ～ 87
		Benzylparaben	Median / Range	All N.D.	All N.D.	All N.D.	All N.D.
	Iodine		Median	310	290	300	300
			Range	110 ～ 3,000	75 ～ 9,100	73 ～ 3,400	75 ～ 9,100
	Perchloric acid		Median	3.5	4.7	3.1	3.7
			Range	1.2 ～ 10	N.D. ～ 67	N.D. ～ 12	N.D. ～ 67
	PAH metabolites	1-Hydoroxypyrene	Median	0.19	0.071	0.098	0.14
			Range	0.045 ～ 0.76	N.D. ～ 0.54	0.022 ～ 4.7	N.D. ～ 4.7
		1&9- Hydroxyphenanthrene	Median	0.15	0.085	0.060	0.12
			Range	0.038 ～ 0.60	0.029 ～ 0.21	N.D. ～ 0.69	N.D. ～ 0.69
		2- Hydroxyphenanthrene	Median	0.14	0.066	N.D.	0.080
			Range	0.031 ～ 0.39	N.D. ～ 0.19	N.D. ～ 0.46	N.D. ～ 0.46
		3- Hydroxyphenanthrene	Median	0.24	0.079	0.057	0.16
			Range	0.077 ～ 0.65	N.D. ～ 0.37	N.D. ～ 0.57	N.D. ～ 0.65
		4- Hydroxyphenanthrene	Median	N.D.	N.D.	N.D.	N.D.
			Range	N.D. ～ 0.20	N.D. ～ 0.043	N.D. ～ 0.12	N.D. ～ 0.20
	Cotinine		Median	0.92	N.D.	0.11	0.34
			Range	0.060 ～ 1,600	N.D. ～ 2.0	N.D. ～ 1,400	N.D. ～ 1,600
	Caffeine		Median	1,100	3,200	1,900	2,000
			Range	0.36 ～ 9,100	100 ～ 22,000	360 ～ 14,000	0.36 ～ 22,000
	Benzophenone-3		Median	N.D.	N.D.	N.D.	N.D.
			Range	N.D. ～ 120	N.D. ～ 190	N.D. ～ 2.0	N.D. ～ 190
	Phytoestrogens	Genistein	Median	1,700	880	940	1,300
			Range	360 ～ 5,700	190 ～ 3,800	74 ～ 4,700	74 ～ 5,700
		Daidzein	Median	2,700	1,600	1,500	1,800
			Range	240 ～ 7,800	97 ～ 19,000	200 ～ 17,000	97 ～ 19,000
		Equol	Median	690	170	12	180
			Range	6.1 ～ 28,000	N.D. ～ 11,000	4.1 ～ 3,100	N.D. ～ 28,000

3-5 POPs survey

3-5-1 Blood and food

The results for POPs concentrations in blood and the intake of POPs from food for the FY 2011 survey are shown in Tables 15-1 and 15-2.

□Table 15-1. Statistics for blood POPs concentrations and the intake of POPs from food (1)

Chemical compounds		Statistics	Blood concentration FY 2011(n=86)	Intake from food FY 2011(n=15)
		Unit	pg/g-fat	pg/kg bw/day
PCB	MoCBs	Median	N.D.	7.4
		Range	N.D. ～ 430	3.0 ～ 89
	DiCBs	Median	100	200
		Range	N.D. ～ 800	100 ～ 620
	TrCBs	Median	920	400
		Range	210 ～ 3,700	180 ～ 1,400
	TeCBs	Median	6,400	750
		Range	650 ～ 33,000	230 ～ 4,100
	PeCBs	Median	18,000	930
		Range	1,900 ～ 140,000	130 ～ 8,200
	HxCBs	Median	87,000	980
		Range	12,000 ～ 670,000	100 ～ 14,000
	HpCBs	Median	62,000	420
		Range	10,000 ～ 520,000	37 ～ 7,500
	OcCBs	Median	13,000	71
		Range	2,600 ～ 110,000	4.1 ～ 1,100
	NoCBs	Median	1,300	11
		Range	370 ～ 6,600	1.1 ～ 91
	DeCB	Median	630	6.0
		Range	220 ～ 2,500	0.74 ～ 50
	Total PCB	Median	190,000	5,100
		Range	31,000～1,400,000	820 ～ 35,000
DDT	o,p'-DDD	Median	N.D.	39
		Range	N.D. ～ 500	4.1 ～ 550
	p,p'-DDD	Median	730	380
		Range	N.D. ～ 5,000	19 ～ 4,900
	o,p'-DDE	Median	200	27
		Range	N.D. ～ 1,100	4.8 ～ 210
	p,p'-DDE	Median	120,000	1,600
		Range	17,000 ～ 1,000,000	240 ～ 8,200
	o,p'-DDT	Median	600	66
		Range	N.D. ～ 4,500	8.5 ～ 1,400
	p,p'-DDT	Median	6,100	300
		Range	1,100 ～ 29,000	28 ～ 7,600
Chlordane	*cis*-Chlordane	Median	100	490
		Range	N.D. ～ 800	63 ～ 1,400
	trans-Chlordane	Median	N.D.	170
		Range	N.D. ～ 400	41 ～ 800
	Oxychlordane	Median	10,000	95
		Range	1,600 ～ 43,000	22 ～ 340
	cis-Nonachlor	Median	3,700	130
		Range	600 ～ 29,000	10 ～ 950
	trans-Nonachlor	Median	23,000	440
		Range	3,000 ～ 110,000	59 ～ 2,100
Drins	Aldrin	Median	All N.D.	N.D.
		Range		N.D. ～ 5.2
	Dieldrin	Median	3,200	510
		Range	1,300 ～ 40,000	71 ～ 1,800
	Endrin	Median	All N.D.	69
		Range		N.D. ～ 200
Hexachlorobenzene (HCB)		Median	14,000	630
		Range	3,400 ～ 39,000	160 ～ 2,100

□Table 15-2. Statistics for blood POPs concentrations and the intake of POPs from food (2)

Chemical compounds		Statistics	Blood concentration FY 2011(n=86)	Intake from food FY 2011(n=15)
		Unit	pg/g-fat	pg/kg bw/day
Heptachlor	Heptachlor	Median	All N.D.	13
		Range		4.5 ～ 47
	cis-Heptachlor epoxide	Median	1,800	110
		Range	600 ～ 6,500	63 ～ 430
	trans-Heptachlor epoxide	Median	All N.D.	All N.D.
		Range		
Toxaphene	parlar-26	Median	790	52
		Range	N.D. ～ 3,500	N.D. ～ 340
	parlar-50	Median	1,100	98
		Range	N.D. ～ 4,300	1.5 ～ 550
	parlar-62	Median	N.D.	73
		Range	N.D. ～ 3,400	N.D. ～ 430
Mirex		Median	1,800	14
		Range	400 ～ 6,600	2.2 ～ 190
PBDE	TeBDEs	Median	520	290
		Range	180 ～ 1,100	160 ～ 1,500
	PeBDEs	Median	210	150
		Range	N.D. ～ 870	63 ～ 710
	HxBDEs	Median	800	36
		Range	N.D. ～ 2,600	8.9 ～ 510
	HpBDEs	Median	All N.D.	N.D.
		Range		N.D. ～ 40
	OcBDEs	Median	300	25
		Range	N.D. ～ 3,400	N.D. ～ 110
	NoBDEs	Median	N.D.	36
		Range	N.D. ～ 2,000	N.D. ～ 120
	DeBDEs	Median	700	230
		Range	N.D. ～ 5,100	72 ～ 980
	Total PBDEs	Median	2,600	780
		Range	500 ～ 8,600	530 ～ 3,000
Pentachlorobenzene		Median	300	63
		Range	40 ～ 1,500	31 ～ 220
HCH	α -HCH	Median	120	160
		Range	N.D. ～ 1,200	64 ～ 1,000
	β -HCH	Median	27,000	250
		Range	2,800 ～ 240,000	48 ～ 2,000
	γ -HCH	Median	N.D.	47
		Range	N.D. ～ 1,000	23 ～ 430
	δ -HCH	Median	All N.D.	14
		Range		3.7 ～ 29
Chlordecone		Median	N.D.	All N.D.
		Range	N.D. ～ 1.0	
Hexabromobiphenyl		Median	N.D.	N.D.
		Range	N.D. ～ 700	N.D. ～ 6.3
Endosulfan	α - Endosulfan	Median	1,300	570
		Range	N.D. ～ 3,700	390 ～ 1,300
	β - Endosulfan	Median	N.D.	280
		Range	N.D. ～ 1,200	130 ～ 810
HBCD	α -HBCD	Median	N.D.	N.D.
		Range	N.D. ～ 10	N.D. ～ 9.0
	β -HBCD	Median	All N.D.	All N.D.
		Range		
	γ -HBCD	Median	N.D.	All N.D.
		Range	N.D. ～ 3.4	
	δ -HBCD	Median	All N.D.	All N.D.
		Range		
	ε -HBCD	Median	All N.D.	All N.D.
		Range		

3-6 Radioactive substances survey

3-6-1 Blood, urine, and food

The results for the concentrations of radioactive substances for the FY 2014 survey are shown in Table 16.

☐ Table 16 Statistics for the radioactive substances

(unit：Bq/kg)

Classification	Chemical compounds	Statistics	Blood concentration FY 2014 (n=81)	Urine concentration FY2014 (n=81)	Food concentration FY2014 (n=15)
Cesium	Cesium 134	Median / Range	All N.D.	All N.D.	All N.D.
	Cesium 137	Median / Range	All N.D.	All N.D.	All N.D.
Potassium	Potassium 40	Median	67	31	27
		Range	37 ～ 96	9.3 ～ 111	13 ～ 39

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Supplementary Information

Overview of the Survey on the Accumulation of Dioxins and other chemical compounds in Humans (FY 2002–2010)

(1) Nationwide survey

● Blood dioxin concentrations

☐ Table 17. Blood dioxin concentrations according to the fiscal year of the study

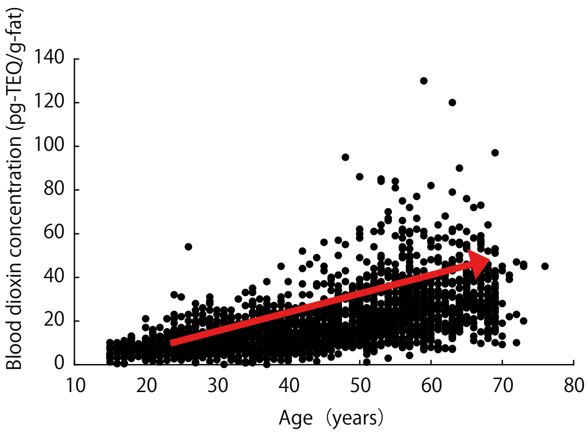
(unit: pg-TEQ/g-fat)

Survey year	FY 2002	FY 2003	FY 2004	FY 2005	FY 2006	FY 2007	FY 2008	FY 2009	FY 2010	Nine-year average
Subjects (N)	259	272	264	288	291	282	257	178	175	Total:2,264
Age (years)										
Average	44.4	41.7	45.2	44.3	43.0	44.2	47.6	46.3	44.4	44.5
Range	16～72	15～69	15～70	15～70	15～72	15～69	17～70	18～76	16～70	15～76
PCDDs+PCDFs Co-PCBs										
Average	22	19	19	22	17	20	21	17	14	19
Standard deviation	14	12	13	15	12	15	15	12	13	14
Median	19	17	16	17	14	16	17	14	11	16
Range	0.96～95	2.7～97	0.64～85	1.5～75	0.82～67	1.6～120	0.43～130	1.1～59	0.10～82	0.10～130

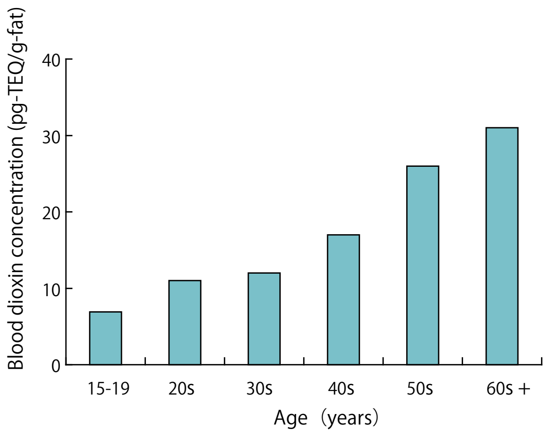
(According to WHO 2006 TEFs)

● Relationship to age

Figure 1. Relationship between age and blood dioxin concentrations



☐ Figure 2. Blood dioxin concentrations by age group



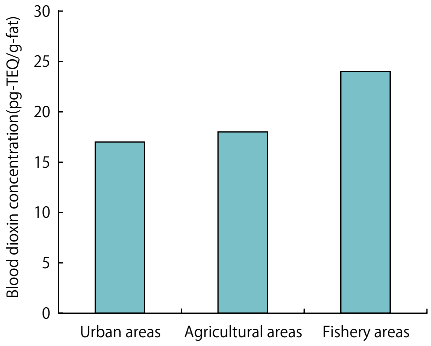
(According to WHO 2006 TEFs)

Differences in blood dioxin concentrations by area

☐ Table 18. Blood dioxin concentrations by types of survey area

	Urban areas	Agricultural areas	Fishery areas
Subjects (N)	938	675	651
Average age (years)	43.5	45.4	44.8
Blood dioxin concentration (pg-TEQ/g-fat)			
Average	17	18	24
Standard deviation	11	12	17
Median	15	15	19
Range	0.11～77	0.10～97	0.43～130

(According to WHO 2006 TEFs)



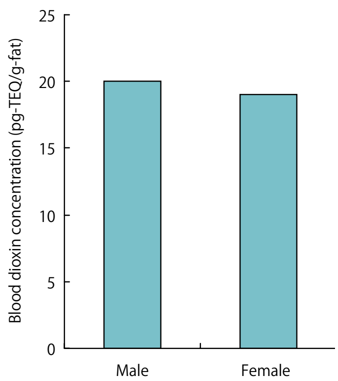
(According to WHO 2006 TEFs)

Difference in blood dioxin concentrations by gender

☐ Table 19. Blood dioxin concentrations by gender

	Male	Female
Subjects (N)	1,063	1,201
Average age (years)	43.5	45.3
Blood dioxin concentration (pg-TEQ/g-fat)		
Average	20	19
Standard deviation	15	13
Median	16	16
Range	0.64～130	0.10～95

(According to WHO 2006 TEFs)



Intake of dioxin from food by survey

☐ Table 20. Intake of dioxin from food according to the fiscal year of the study

Survey year	FY 2002	FY 2003	FY 2004	FY 2005	FY 2006	FY 2007	FY 2008	FY 2009	FY 2010	Nine-year average
Subjects (N)	75	75	75	75	75	75	75	50	50	Total: 625
Dioxin intake from food (pg-TEQ/kg bw/day)										
Average	1.1	1.1	0.89	0.89	0.57	0.75	0.68	0.79	0.44	0.82
Standard deviation	1.1	0.92	0.66	0.89	0.44	0.90	0.75	1.2	0.42	0.86
Median	0.75	0.91	0.68	0.59	0.41	0.46	0.39	0.43	0.34	0.56
Range	0.058～5.6	0.14～5.6	0.16～3.7	0.13～5.2	0.099～2.2	0.060～6.2	0.054～4.8	0.055～6.2	0.031～2.0	0.031～6.2

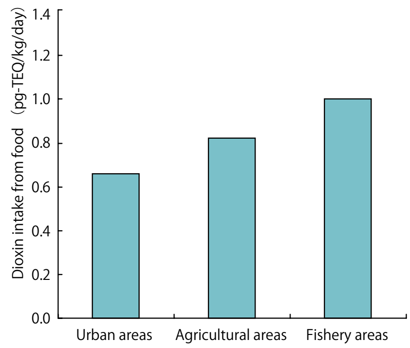
(According to WHO 2006 TEFs)

Differences in the intake of dioxin from food by area

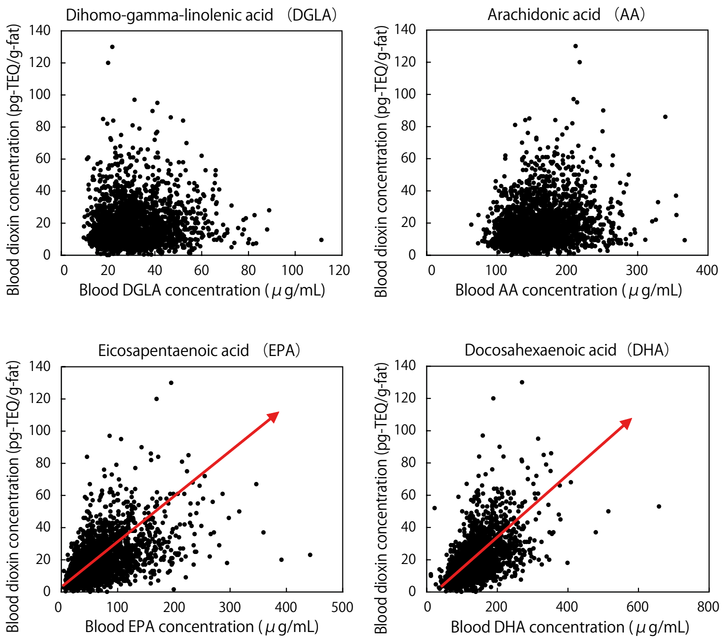
☐ Table 21. Intake of dioxin from food by area

	Urban areas	Agricultural areas	Fishery areas
Subjects (N)	229	201	195
Dioxin intake from food (pg-TEQ/kg wg/day)			
Average	0.66	0.82	1.0
Standard deviation	0.65	0.86	1.0
Median	0.46	0.53	0.71
Range	0.031～6.2	0.080～5.6	0.054～6.2

(According to WHO 2006 TEFs)

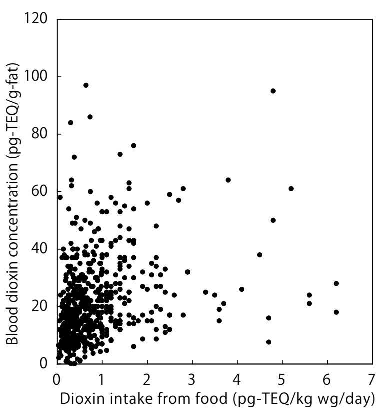


☐ Figure 3. Relationship between fatty acids and blood dioxin concentrations



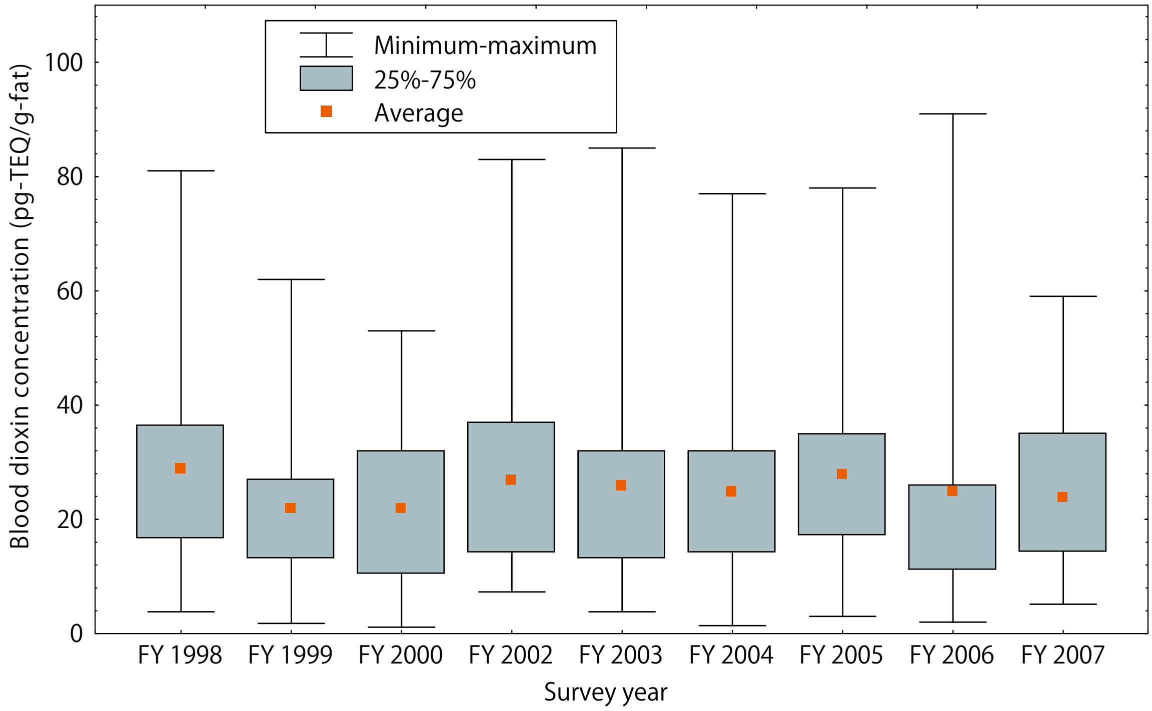
Relationship between blood concentrations and intake from food

☐ Figure 4. Relationship between dioxin intake from food and blood dioxin concentrations

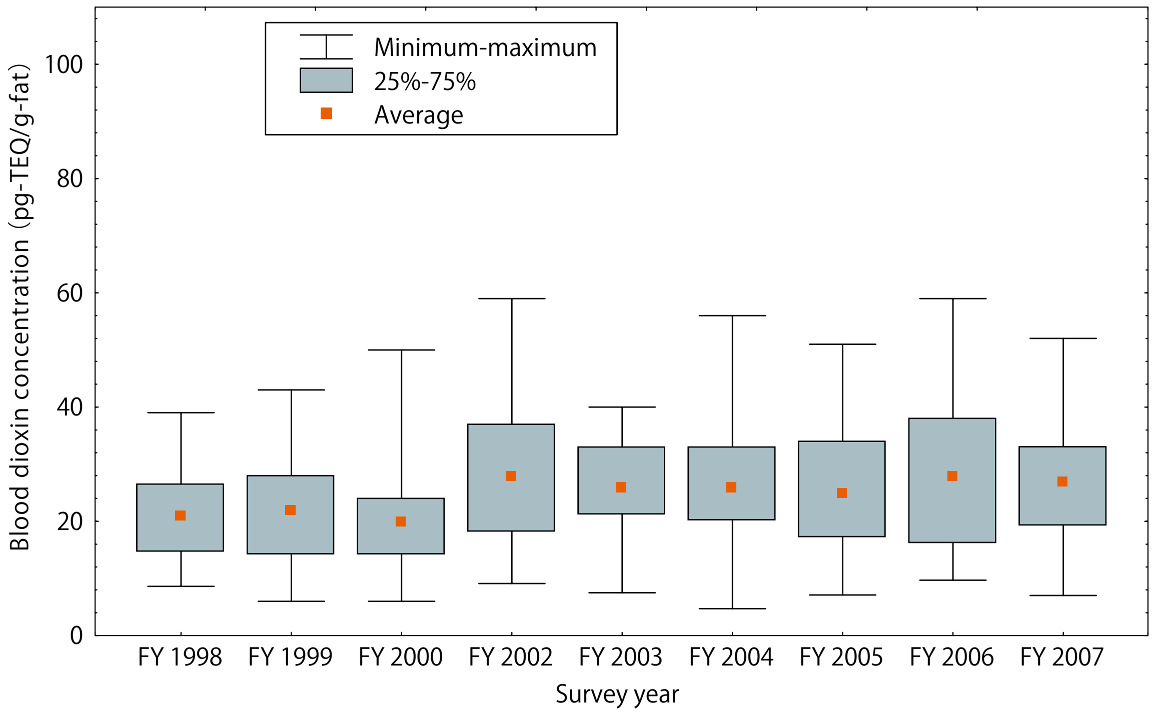


(2) Follow-up survey

☐ Figure 5. Chronological change in blood dioxin concentrations in Nose, Osaka Prefecture



☐ Figure 6. Chronological change in blood dioxin concentrations in Saitama Prefecture

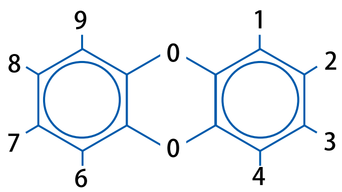


Chemical compounds measured in this survey

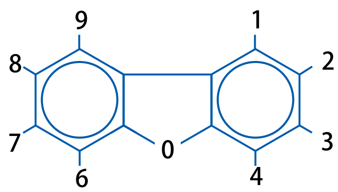
1．Dioxins

1.1 Structure of dioxins

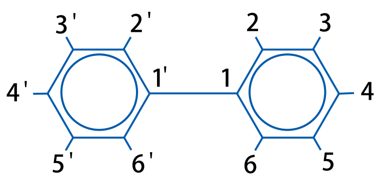
Polychlorodibenzo-p-dioxins (PCDDs) and polychlorinated dibenzofurans (PCDFs) are collectively called dioxins. Co-planar polychlorinated biphenyls (co-planar PCBs) possess toxicity similar to those of dioxins, therefore are also known as dioxin-like compounds. Dioxins by definition include PCDDs, PCDFs, and co-planar PCBs according to Japan's Law Concerning Special Measures against Dioxins, promulgated on July 16, 1999. Accordingly, throughout this report, the term "dioxins" refers to PCDDs, PCDFs, and co-planar PCBs. The chemical structure of a dioxin molecule is generally composed of two rings of six-carbon atoms (benzene rings; the figure below) bound by oxygen atom(s) (shown as "O" in the figure below) with chlorine or hydrogen atoms attached (at numbered positions 1–9 and 2'–6' in the figure below). There are 75 types of PCDDs, 135 types of PCDFs, and 12 types of coplanar PCBs, and the variations depend on the numbers and locations of the attached chlorine atoms. Among these dioxins, 29 types have toxicities similar to 2,3,7,8-TCDD.



PCDDs



PCDFs



PCBs※

※ PCB compounds with two benzene rings on the same plane, are known as co-planar PCBs. Note that some PCBs without the planar structure but possess dioxin-like toxicity, are also classified as co-planar PCBs for a regulatory purpose.

1.2 Properties of dioxins

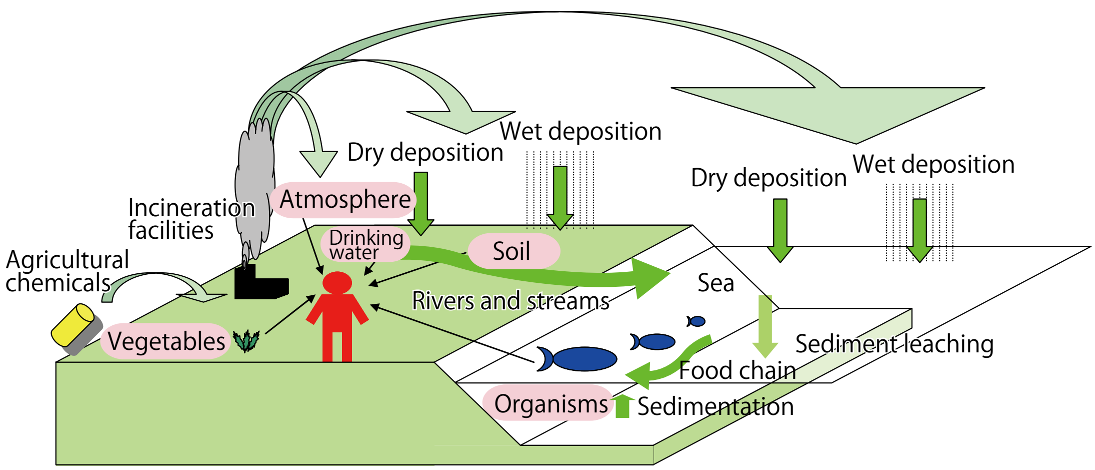
Dioxins are generally colorless solids of very low water solubility and low vapor pressure, but characteristically exhibit a high degree of solubility in fats and oils. They are generally stable, do not react easily with other compounds, acids, and alkalis, and are considered to decompose gradually in the presence of solar ultraviolet light.

1.3 Dioxin toxicity

Carcinogenicity and chronic toxicity are health risks posed by dioxins. In rats, dioxins have been reported to show carcinogenicity, such as the production of hepatocellular carcinoma, follicular adenoma of the thyroid, lymphoma, and other cancers. Dioxins are known to act as promoters for the carcinogenic mechanism; that is, dioxins do not act directly on genes, instead they promote the carcinogenic activity of other carcinogens. At present, the International Agency for Research on Cancer (IARC) and the World Health Organization (WHO) have classified 2,3,7,8-TCDD as a human carcinogen. In terms of hepatotoxicity, it is recognized to cause elevated liver enzymes and hyperlipidemia. However, for assessing the consequences of dioxin exposure during fetal stages, reproductive organ toxicity, central nervous system toxicity, and immune system toxicity received attentions when the WHO reevaluated the risks of dioxins and related compounds in 1998, as well as risk assessments that are being conducted both nationally and internationally. Shortened anogenital distance in males, congenital abnormalities in vagina, diminished learning ability, diminished resistance to viral infection, and other outcomes in laboratory animals. At present, the effects of dioxins are widely recognized to develop due to endocrine disruption through the arylhydrocarbon receptor (AhR) within cells. However, further studies are required because there is limited data available regarding the appearance of these diverse toxicities.

1.4 Generation and behavior of dioxins in the environment

Dioxins are not produced intentionally except for research purposes, such as the production of standard materials for dioxin analysis. Dioxins are by-products generated when substances containing carbon, oxygen, hydrogen, and chlorine are heated. The major source of dioxins today is waste incineration, particularly the incineration of plastic waste and other products made from fossil fuels. Dioxins are formed in combustion processes and emitted into the air when they are not captured by waste-gas mechanisms. Other sources include emissions from electric steel-making furnaces, cigarette smoke, and automobile exhaust. Some reports indicate that dioxins may have accumulated in bottom sediment in aquatic environments owing to the past use of PCBs and some types of agricultural chemicals, which contain dioxins as impurities. The behavior of dioxins in the environment is not fully known. Dioxins in the air presumably are adsorbed to particulate matter, fall to the ground, and then pollute soil and water. It is considered that over long period of time, these dioxins and others are released into the environment by various other pathways, and they ultimately accumulate in aquatic sediments and enter the food chain when ingested by plankton and fish, thereby accumulating in various organisms. Although dioxins are mostly anthropogenically produced, small amounts are generated in nature through forest fires and volcanic activities.



1.5 Brominated dioxins

Brominated dioxins have a similar structure to chlorinated dioxins, whereby some chlorines are substituted with bromines. Similar to chlorinated dioxins, brominated dioxins are not produced intentionally except for research purposes and are by-products that occur when heat is applied to organobromine compounds and in combustion processes. They are mainly produced through heating processes during the production and processing of plastics including brominated flame retardants. Their toxicity and health effects are less understood than chlorinated dioxins.

2． Fluorine compounds

PFOS and PFOA are organofluorine compounds that have fluoride atom(s) bound to carbon. Carbon and fluoride are strongly bound to each other, and the compounds are highly resistant to heat and chemicals. These compounds have been used widely as “surfactants” because they are readily soluble in oil and water, and are used in water-repellent sprays, foam fire extinguishers, and until very recently, in coatings of nonstick frying pans. However, it has been reported that they are resistant to decomposition in the environment and in living organisms, and that they have substantial bioaccumulation properties. PFOS is listed as a POPs in the Stockholm Convention on Persistent Organic Pollutants. In the present survey, fluorine compounds including PFOS and PFOA were studied in blood and food.

☐ Table 22. Fluorine compounds

Chemical compound	Usage	Measurement case in Japan (average)	Standard; Tolerable intake
Fluorine compounds	Used in water-repellent sprays and foam fire extinguishers as surfactants. (PFOS, PFOA)	< Blood> PFHxA: N.D. ng/mL (60 females; Kashino et al., 2011 ※ salem) PFHpA: N.D. ng/mL (60 females; Kashino et al., 2011 ※ salem) N.D. ng/mL (14 females; Nakai et al.,2008) PFOA: 0.48 ～ 6.93 ng/mL (60 females; Kashino et al., 2011 ※ salem) 1.72 ng/mL (14 females; Nakai et al.,2008) 4.0 ng/mL (97 males; Harada et al., 2003-2004 ※ salem) 4.4 ng/mL (103 females; Harada et al., 2003-2004 ※ salem) PFNA: 0.43 ～ 3.16 ng/mL (60 females; Kashino et al., 2011 ※ salem) 0.87 ng/mL (14 females; Nakai et al.,2008) PFDA: 0.18 ～ 1.17 ng/mL (60 females; Kashino et al., 2011 ※ salem) PFTeDA: N.D. ng/mL (60 females; Kashino et al., 2011 ※ salem) PFOS : 0.86 ～ 10.96 ng/mL (60 females; Kashino et al., 2011 ※ salem) 2.86ng/mL (14 females; Nakai et al.,2008) 18.3 ng/mL (97 males; Harada et al., 2003-2004 ※ salem) 11.7 ng/mL (103 females; Harada et al., 2003-2004 ※ salem) <Food> PFOS: 0.98 ng/kg bw/day （ND and/or below = 0） 12.1 ng/kg bw/day （ND and/or below = 1/2 ND） （Maitani et al., 2007 market-basket system; Mitani et al.） PFOA: 0.06 ng/kg bw/day （ND and/or below = 0） 11.5 ng/kg bw/day （ND and/or below = 1/2 ND） （Maitani et al., 2007 market-basket system）	※ Tolerable intake is not established.

3． Metals

Metals are widely distributed on the earth and are used for various purposes. However, some metals are potentially toxic to organisms. In the past, Japan has experienced damage to the health of people by environmental heavy metal pollution, such as Minamata disease caused by methyl mercury and Itai-Itai Disease caused by cadmium.

☐ Table 23. Metals studied in this survey

Chemical compounds	Usage	Measurement case in Japan (average)	Standard; Tolerable intake
Total mercury/Methyl mercury	Metal mercury is used in fluorescent lights, amalgam, batteries, catalysts, and others. Methyl mercury is produced by methylation of metal mercury. Methyl mercury have higher toxicity.	＜ Total mercury / blood ＞ 5.4 ng/mL (600 mothers; Shimada et al., 2008) 5.18 ng/mL (115 mothers; Sakamoto et al., 2007) 18.2 ng/mL (56 females Yamauchi et al., 1994) ＜ Total mercury / food ＞ 0.225 μ g/kg bw/day (Tokyo, 2005; 10 samples by duplicated portion method) 0.18 μ g/kg bw/day (Tokyo, 2013 market-basket system) ＜ Methyl mercury / food ＞ 0.198 μ g/kg bw/day (Tokyo, 2005; 10 samples by duplicated portion method) 0.13 μ g/kg bw/day (Tokyo, 2013; market-basket method)	＜ Methyl mercury ＞ 0.29 μ g/kg bw/day 2.0 μ g/kg bw/week
Lead	Used widely in electrodes, weight, glass products , solder, and others.	＜ Blood ＞ 1.07 μ g/dL (352 Yoshinaga et al., 2008-2010) 1.3 μ g/dL (137 people including infant; Tokyo, 2006) ＜ Food ＞ 0.129 μ g/kg bw/day (319 samples by duplicated portion method; Food safety commission of Japan, 2006-2010) 0.25 μ g/kg bw/day (Tokyo, 2013; maket-basket method)	※ Tolerable intake is not established.
Cadmium	Used in watch batteries, plating materials , and others. Cadmium is produced and recovered during the zinc refinery process.	<Blood> 2.54 μ g/L (1243 females; kayama et al., 2010-2011) ＜ Urine ＞ 3.46 μ g/g Cr (1243 females; Kayama et al., 2000 – 2001) 1.26 μ g/g Cr (10753 females; Ikeda et al., 2000 – 2001) ＜ Food ＞ 0.320 μ g/kg bw/day (Tokyo, 2005 10 samples by duplicated portion method) 0.41 μ g/kg bw/day (Tokyo, 2013; market-basket method)	7 μ g/kg bw/week

Chemical compounds	Usage	Measurement case in Japan (average)	Standard; Tolerable intake
Arsenic	In the past, arsenic compounds were used in rat poisons. Organic arsenic is found in seafood (seaweeds, shrimps, and crabs) but are basically non-toxic. Inorganic arsenic is highly toxic.	＜ Total Arsenic / blood> 0.5 μ g/dL (137 people including infant; Tokyo, 2006) ＜ Arsenic speciation / urine ＞ MMA: 2.01 μ g/g Cr DMA: 40 μ g/g Cr （248 residents near metropolitan area Chiba et al., 2001） As (V) 0.2 μ g/g Cr As (III) 4.0 μ g/g Cr MMA: 3.2 μ g/g Cr DMA: 38.5 μ g/g Cr AB: 71.4 μ g/g Cr （142 males; Nakajima et al., 2001） ＜ Total Arsenic / food ＞ 3.44 μ g/kg bw/day (319 samples by duplicated portion method Food safety commission of Japan, 2006-2010)	※ Tolerable intake is not established.
Copper	Used widely in electric wire, roofing, and others.	＜ Blood ＞ 950 ng/mL (145 males) 970 ng/mL (163 females) (Saitoh et al., 1980) ＜ Food ＞ 1,060 μ g/day (3,483 samples; Ministry of Health, Labour and Welfare 2009)	10 mg/day (tolerable upper intake level)
Selenium	Used in photo sensitive drum of copier, colorant for glass , and soil amendments for place of selenium deficiency.	＜ Blood ＞ 157 ng/g : males 157 ng/g : females (331 subjects Seki et al., 1981) ＜ Food ＞ 170 μ g/day（39 males) 190 μ g/day（40 females) (Duplicated portion method Chiba et al., 2003)	330 ～ 460 μ g/day (tolerable upper intake level ; males and females 18 years or older)
Zinc	Used widely in corrugated galvanised iron, pigment, alloy material and cosmetic , and others.	＜ Blood ＞ 8,540 ng/mL (145 males) 8,150 ng/mL (163 females) (Saitoh et al., 1980) ＜ Food ＞ 7.02 mg/day (3,483 samples; Ministry of Health, Labour and Welfare, 2009)	35 ～ 45 mg/day (tolerable upper intake level ; males and females 18 years or older)
Manganese	Used in Battery materials and fertilizer raw materials.	＜ blood ＞ 13.2 μ g/L (1,420 females; Ikeda et al., 2010) ＜ Food ＞ 5,530 μ g/day (39 males) 6,110 μ g/day (40 females) (Duplicated portion method Chiba et al., 2003)	11 mg/day (tolerable upper intake level ; males and females 18 years or older)

4．Other chemical compounds (including pesticides and plasticizers)

□ Table 24. Pesticides, plasticizers, and others studied in this survey

Chemical compound	Usage	Measurement case in Japan (average)
Hydroxylated PCB	Metabolite of PCB.	＜ Blood ＞ 120 pg/g（128 pregnant women; Hisada et al., 2009-2011）
Phthalate monoesters	Used as plasticizer in plastic, adhesive agents, and others.	＜ Urine ＞ MBP：52.2 μ g/g Cr (48.1 ng/mL) MEHP：5.84 μ g/g Cr (4.44 ng/mL) MEHHP：10.1 μ g/g Cr (8.61 ng/mL) MEOHP：11.0 μ g/g Cr (9.2 ng/mL) MBzP：4.70 μ g/g Cr (3.46 ng/mL) (149 pregnant women; Suzuki et al., 2010) ※ median
Bisphenol A	Used as monomer or ingredients in plastic manufacturing.	＜ Urine ＞ N.D. μ g/g Cr (39 out of 56 pregnant women) 1.7 μ g/g Cr（median ; 17 out of 56 pregnant women） (Fujimaki et al., 2003)
Organophosphorous compound metabolites	Used in pesticides, disinfectant, wood preservatives, and others (metabolites were measured).	＜ Urine ＞ DMP：1.5 μ g/L（73 subjects, Toyama） ：3.1 μ g/L（60 subjects, Tokyo） DMTP：3.2 μ g/L（73 subjects, Toyama） ：5.8 μ g/L（60 subjects, Tokyo） DEP：0.8 μ g/L（73 subjects, Toyama） ：1.2 μ g/L（60 subjects, Tokyo） DETP：<0.5 μ g/L（73 subjects, Toyama） ：<0.5 μ g/L（60 subjects, Tokyo） （Toyama Institute of Health）
Pyrethroid pesticide metabolites	Used in pesticides, insecticides, and others (metabolites were measured).	＜ Urine ＞ PBA：0.40 μ g/g Cr （42 males　Toshima et al., 2010） PBA：0.73 μ g/g Cr （448 subjects　Ueyama et al., 2009）
Carbamate pesticide metabolites	Used in pesticides, insecticides, and others (metabolites were measured).	―
Triclosan	Used as disinfectant	―
Acephate	A type of organophosphorus pesticides. Used widely as pesticides and insecticides, known as “Orthoran”.	―
Methamidophos	A type of organophosphorus pesticide. Used as pesticides and insecticides (banned to use in Japan).	―
Imidachloprid metabolite	Metabolite of neonicotinoid pesticide.	―
Fenitrothion metabolite	Metabolite of fenitrothion.	―
p-nitrophenol	Metabolite of pesticides.	―
Deet	Used as mosquito and mite repellent.	―

Chemical compound	Usage	Measurement case in Japan (average)
Parabens	Used as antiseptic (antibacterial) agent in food, medicine, cosmetics, etc.	< Urine > Methylparaben : 109 μ g/g Cr Ethylparaben : 8.0 μ g/g Cr Propylparaben : 33.5 μ g/g Cr Butylparaben : 0.743 μ g/g Cr (111 pregnant women Shirai et al., 2007-2010) ※ median
Iodine	Essential element for human and is the main component of thyroid hormone. Found abundantly in sea weeds. Deficiency causes hyperthyroidism, but excessive intake also causes thyroid abnormalities as well.	< Urine > 259.5 μ g/g Cr (622 pregnant women; Orito et al., 2005-2006) ※ median
Perchloric acid	Has strong oxidizing effect. Used as analytical chemistry reagent, metal/ alloy/ mineral ore solvent, organic synthesis catalysis, and as manufacturing material of perchloric acid and its derivatives.	–
PAHs metabolites	Metabolite of PAHs, found mainly as mixtures in tar, crude oil, and in petroleum.	< Urine > 1-Hydoroxypyrene：124 μ g/g Cr (149 pregnant women; Suzuki et al., 2010) ※ median
Cotinine	Metabolite of nicotine found in tobacco.	< Urine > 16 μ g/g Cr（smoking parents) 12 μ g/g Cr (Only the mother smokes) 3 μ g/g Cr (only the father smokes) 1 μ g/g Cr (non-smoking parents) (927 three year old children Tateishi et al.) 3,048 μ g/g Cr (smoking) 28.7 μ g/g Cr (non-smoking and passive smoking) 33.9 μ g/g Cr (non-smoking and non- passive smoking) (504 adults; Sakanashi et al., 2009)
Caffeine	Naturally derived organic compound found abundantly in coffee, tea, and chocolate.	–
Benzophenone-3	Used in sunscreen cosmetics due to its ultraviolet absorption effect.	–
Phytoestrogens	Found abundantly in leguminous plants (bean plants) such as soy beans, and act as female hormone .	< Urine > Daizein: 1,000 μ g/g Cr Genistein: 860 μ g/g Cr (80 adult women Tsukane et al.)

5． POPs and their candidates

POPs is the abbreviation of Persistent Organic Pollutants and have the following properties:

○ they remain intact for exceptionally long period of time,
○ they accumulate in bodies of organisms,
○ they can be transported long distances and are widely distributed on the earth,
○ they have toxic effects within organisms.

The Stockholm Convention on Persistent Organic Pollutants is an international treaty. Initially, 12 POPs were recognized, which has now added up to 22. These compounds include those produced and used intentionally as pesticides and others. On the other hand, there are compounds like dioxins, which could be produced in the process of combustion or manufacturing of other chemicals. In the Convention, each member State is to prohibit the production, use, import and export of POPs, and to take every measure possible to eliminate and reduce the unintentional production of compounds. Furthermore, each member State is encouraged to undertake measures for POPs under the Stockholm Convention. Considering this, monitoring surveys on the environment and biological samples are conducted by Ministry of the Environment, Japan. In the present survey, all POPs listed in the Stockholm Convention were measured in blood and food.

☐ Table 25. POPs studied in this survey

Chemical compounds	Usage
Dioxins	Produced unintentionally due to combustion, as well as during the manufacture of chlorinated substances
PCBs	Used as heat exchange fluids, in electric transformers, and as additives in carbonless copy papers and such
DDT	Used as hygiene pesticides and insecticides
Chlordane	Used to control termites and as pesticides
Aldrin	Used as pesticides
Dieldrin	Used as pesticides, insecticides, and termite control
Endrin	Used as pesticides
Hexachlorobenzene (HCB)	Used as material for herbicide manufacturing
Heptachlor	Used as pesticide and termite control
Toxaphene	Used as pesticides overseas
Mirex	Used as pesticides overseas
PBDE	Used as fire-retardant
Pentachlorobenzene	Used as chemical intermediate of agricultural fungicides
HCH	Used as pesticides
Chlordecone	Used as insecticides overseas
Hexabromobiphenyl	Used as fire-retardant
Endosulfan	Used as pesticides and insecticides
HBCD	Used as fire-retardant

6. Radioactive substances

Radioactive substances emit radiation with radioactive decay over time. These substances are present in nature, but are also emitted into the environment through explosion of nuclear weapon and nuclear power plant accidents. We measured concentrations of potassium 40, cesium 134, and cesium 137.

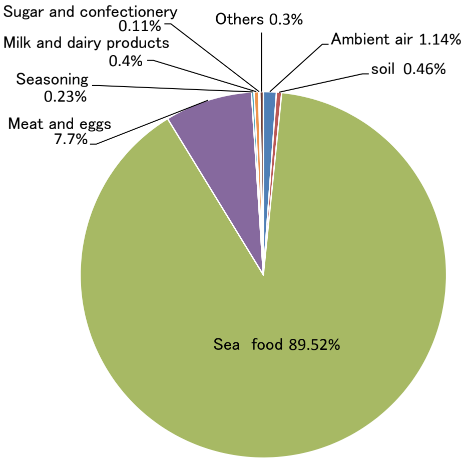
7. Dioxin intake

In Japan in June 1999, the TDI of dioxins was set at 4 pg-TEQ/kg bw/day based on the available scientific information at the time. The safety of the total amount of dioxins ingested by humans is evaluated by comparisons with this value.

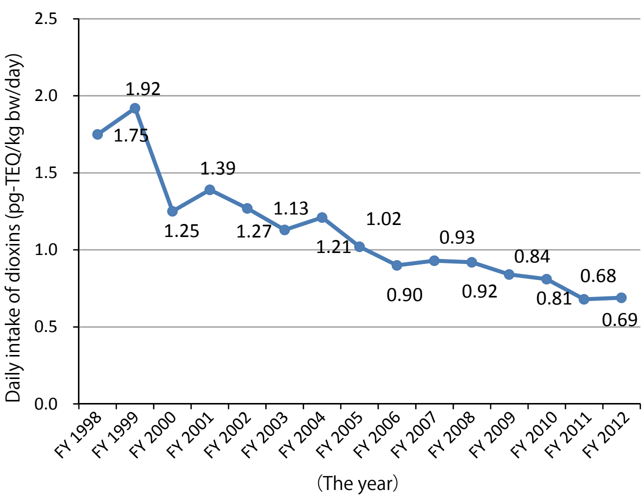
On average, the total daily intake of dioxins by the Japanese people is estimated to be approximately 0.69 pg-TEQ/kg bw/day. These levels are below the TDI and therefore considered to be below the level that can cause adverse effects on human health. Conceivable routes of intake include food, ambient air, and soil, but the intake from food is estimated to account for the largest portion (Figure 7). Figure 8 shows the chronological change in estimated total daily intake of dioxins by the Japanese people using the results of "Survey on the Daily Intake of Dioxins from Food" (Ministry of Health, Labour and Welfare, Japan). Enforcement of the "Law Concerning Special against Dioxins (January, 2000)" has greatly decreased emission of dioxins to environment. Dioxin concentrations in food and the environment (ambient air and soil) have also has decreased. As a result, the total daily intake of dioxins by the Japanese people showed a trend of decrease.

It is anticipated that the total daily intake will be reduced further owing to continuous measures against reduced emissions of dioxins.

□ Figure 7 Specifications for the average daily intake of dioxins by the Japanese people Note1



□ Figure 8 Chronological change in the average daily intake of dioxins by Japanese people Note2



Note 1 : Graphed by MOE from the data of "Environmental Survey of Dioxins" (MOE) and "Survey on the Daily Intake of Dioxins from Food, Health and Labour Sciences Research" (Ministry of Health, Labour, and Welfare, Japan).
Note 2 : "Survey on the Daily Intake of Dioxins from Food, Health and Labour Sciences Research."(MHLW).

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