Dioxin Emission Inventory

2000

December 2001

Ministry of the Environment, Japan

Dioxin Emission Inventory

1. Basic Principle

The Dioxin Emission Inventory is prepared annually based on the Government Plan to Reduce Dioxin Levels Resulting from Business Activities in Japan, as mandated by the Basic Guidelines of Japan for the Promotion of Measures against Dioxins and Paragraph 1, Article 33 of the Law Concerning Special Measures against Dioxins (hereinafter referred to as the "Law").

To compile the 1999 Emission Inventory last fiscal year, the following two methods of emission estimation were used, depending on the survey data available. For the 2000 Emission Inventory, only method (1) was used in the estimation.

(1) Estimation of dioxins, including coplanar PCBs, using the WHO-TEF (1998)—method stipulated by the Law Concerning Special Measures against Dioxins
(2) Estimation of PCDD (polychlorinated dibenzo-p-dioxins)/PCDF (polychlorinated dibenzofurans) using the I-TEF (1988)

2. Selection of Sources

The same principle as that of last year was used in the selection of sources for the Emission Inventory: sources that had actually been identified as releasing dioxins into the environment, and sources from which the amounts of dioxins emitted could be estimated.

3. Method for Indicating the Estimation Years and Emission Amounts

(1) The Emission Inventory was prepared to show the annual amounts of dioxins (chemical substances defined in the Law as "dioxins") released in 1997, 1998, 1999 and 2000. Each dioxin compound's toxicity is shown using a Toxic Equivalency Factor, or TEF, developed by the World Health Organization in 1998. In cases where new scientific knowledge had become available, the annual amounts of emissions for 1997, 1998 and 1999, which were calculated in June 2000, were revised.
(2) The sources of data serving as the basis of the estimations are shown by year in the Remarks column.

4. Results of the Estimated Emission Amounts

Based on the above, the results of the estimations were compiled into the Dioxin Emission Inventory as shown in Table 1. The amounts of dioxins emitted have been in a downward trend year by year. The emission for 2000 registered 2,198–2,218 g-TEQ, close to a 70% decline from 1997.

Table 1. Dioxins Release Inventory

Sources	Amount of releases				Remarks			
	1997	1998	1999	2000	1997	1998	1999	2000
(1) Releases to air								
Domestic waste incineration facilities	5,000	1,550	1,350	1,019	①	①	①	④
Industrial waste incineration	1,500	1,100	690	555	①	①	①	④
Small incinerators, etc.	368 - 619	368 - 619	307 - 509	353 - 370	→	④	④	④
(Installed at business sites. Incineration capacity: less than 200								
Crematoria	2.1 - 4.6	2.2 - 4.8	2.2 - 4.9	2.2 - 4.9	②	②	⑤	←
Electric furnaces for steel making	228.0	139.9	141.5	131.1	③	③	③	⑥
Sintering process for steel making	135.0	113.8	101.3	69.8	③	③	③	⑥
Zinc recovery facilities	47.4	25.4	21.8	26.5	⑥	⑥	⑥	⑥
Aluminum-alloy manufacturing	21.3	19.4	13.6	12.8	③	③	③	⑥
Aluminum scrap melting process for aluminum rolling industry	3.42	3.42	3.42	3.42	→	→	→	⑥
Aluminum scrap melting process for aluminum casting/die-casting Industry	0.036	0.036	0.036	0.036	→	→	→	⑥
Paper manufacturing (kraft pulp recovery boilers)	0.041	0.038	0.039	0.041	⑥	⑥	⑥	⑥
PVC monomer manufacturing facilities	0.20	0.20	0.20	0.19	→	⑥	⑥	⑥
Cement manufacturing facilities	4.03	3.48	3.38	3.44	⑥	⑥	⑥	⑥
Refractory material manufacturing facilities	0.0013	0.00104	0.00101	0.001	⑥	⑥	⑥	⑥
Fire brick manufacturing facilities	0.035	0.028	0.027	0.029	⑥	⑥	⑥	⑥
Roof tile manufacturing facilities	0.41	0.35	0.34	0.35	⑥	⑥	⑥	⑥
Sheet glass manufacturing facilities	0.0048	0.004	0.0042	0.004	⑥	⑥	⑥	⑥
Glass fiber manufacturing facilities	0.0053	0.0048	0.0048	0.0051	⑥	⑥	⑥	⑥
Electric glass manufacturing	0.055	0.052	0.056	0.061	⑥	⑥	⑥	⑥
Optical glass manufacturing facilities	0.058	0.061	0.06	0.061	⑥	⑥	⑥	⑥
Frit (roof tile glazing materials) manufacturing facilities	0.0049	0.0039	0.0037	0.0039	⑥	⑥	⑥	⑥
Frit (enamel-glazing materials) manufacturing facilities	0.0009	0.0009	0.0009	0.0009	→	→	→	⑥
Glass container manufacturing	0.27	0.25	0.24	0.23	⑥	⑥	⑥	⑥
Glass tableware manufacturing	0.018	0.017	0.015	0.015	⑥	⑥	⑥	⑥
Tile manufacturing facilities	0.0013	0.0011	0.001	0.001	⑥	⑥	⑥	⑥
Sanitary earthenware manufacturing facilities	0.029	0.024	0.022	0.021	⑥	⑥	⑥	⑥
Kiln furniture manufacturing	0.006	0.001	0.005	0.005	⑥	⑥	⑥	⑥
Ceramic tableware manufacturing	0.022	0.019	0.017	0.015	⑥	⑥	⑥	⑥
Insulator manufacturing facilities	0.0079	0.0076	0.0068	0.0064	⑥	⑥	⑥	⑥
Lime manufacturing facilities	1.01	0.95	0.95	1.01	⑥	⑥	⑥	⑥
Cast and forged steel manufacturing facilities	1.98	1.98	1.53	1.40	→	⑥	⑥	⑥
Primary copper smelting facilities	4.88	4.88	0.45	0.59	→	⑥	⑥	⑥
Primary lead smelting facilities	0.055	0.055	0.038	0.189	→	⑥	⑥	⑥
Primary zinc smelting facilities	0.33	0.33	0.13	0.12	→	⑥	⑥	⑥
Copper recovery facilities	0.053	0.053	0.048	0.038	→	⑥	⑥	⑥
Lead recovery facilities	1.25	1.23	0.44	0.54	→	⑥	⑥	⑥
Precious metals recovery facilities	0.031	0.031	0.046	0.055	→	⑥	⑥	⑥
Wrought copper product manufacturing facilities	3.16	3.16	1.16	1.28	→	③	③	⑥
Aluminum rolling (light metal rolling, etc.)	1.61	1.61	1.46		→	③	③	
Aluminum rolling (extrusion process)	0.052	0.052	0.043		→	③	③	
Wire and cable manufacturing facilities	1.25	1.25	1.21	1.3	→	③	③	⑥
Aluminum casting/die-casting facilities	0.36	0.36	0.37	0.39	→	⑥	⑥	⑥
Automobile manufacturing (aluminum casting/die-casting) facilities	1.02	1.02	1.02	1.02	→	→	→	⑥
Automobile parts manufacturing (aluminum casting/die-casting)	0.56	0.56	0.56	0.56	→	→	→	⑥
Thermal power plants	1.63	1.55	1.64	1.71	③	③	③	⑥
Tobacco smoke	0.1 - 0.2	0.1 - 0.2	0.1 - 0.2	0.1 - 0.2	①	①	①	④
Exhaust gas from automobiles	1.61	1.61	1.61	1.61	→	→	→	④
(2) Releases into water								
Domestic waste incineration facilities	0.044	0.044	0.035	0.035	→	④	④	④
Industrial waste incineration	5.27	5.27	5.29	2.47	→	④	④	④
Bleaching facilities for pulp making	0.74	0.71	0.74	0.73	⑦	⑦	⑦	⑥
PVC monomer manufacturing facilities	0.54	0.53	0.55	0.2	⑥	⑥	⑥	⑥
Aluminum alloy manufacturing (rolling, etc.)	0.338	0.066	0.091	0.054	⑥	⑥	⑥	⑥
Aluminum alloy manufacturing (automobiles and automobile parts	0.002	0.002	0.002	0.0015	⑥	⑥	⑥	⑥
Caprolactam manufacturing (using nitrosyl chloride) facilities	2.5	2.52	2.53	1.80	⑥	⑥	⑥	⑥
Chlorobenzene manufacturing facilities	0.011	0.011	0.011	0.012	⑥	⑥	⑥	⑥
Potassium sulphate manufacturing facilities	0.078	0.074	0.076	0.081	⑥	⑥	⑥	⑥
Acetylene manufacturing (dry process) facilities	1.8	1.61	1.63	1.76	⑥	⑥	⑥	⑥
Short alumina fiber manufacturing facilities								
Terminal sewage treatment facilities	1.09	1.09	1.09	1.09	→	→	→	④
Joint wastewater treatment facilities	0.126	0.126	0.126	0.126	→	→	→	④
Final landfill sites	0.093	0.093	0.093	0.056	→	①	←	④
Total	7,344 - 7,598	3,360 - 3,613	2,660 - 2,865	2,198 - 2,217				
Of which, releases into water	12.632	12.1	12.3	8.4				

Notes: 1. Unit of the releases: g-TEQ/year

: 2. Arrows in the Remarks column indicate that releases for the year are considered the same as the estimated amounts of the year shown by the arrow.

: 3. Numbers in the Remarks column correspond to estimates made by:

① Environment Agency, June 2000

② Ministry of Health and Welfare, June 2000

③ Ministry of International Trade and Industry, June 2000

④ Ministry of the Environment, December 2001

⑤ Ministry of Health, Labor and Welfare, December 2001

⑥ Ministry of Economy, Trade and Industry, December 2001

⑦ Ministry of the Environment and Ministry of Economy, Trade and Industry, June 2001

Table 1. Dioxins Release Inventory

Sources	Amount of releases				Remarks			
	1997	1998	1999	2000	1997	1998	1999	2000
(1) Releases to air								
Domestic waste incineration facilities	5000	1550	1350	1019	②	②	②	⑧
Industrial waste incineration facilities	1500	1100	690	555	①	②	②	⑧
Small incinerators, etc.	368 - 619	368 - 619	307 - 509	353 - 370	→	④	④	④
(Installed at business sites. Incineration capacity: less than 200 kg)								
Crematoria	2.1 - 4.6	2.2 - 4.8	2.2 - 4.9	2.2 - 4.9	②	②	⑤	←
Electric furnaces for steel making	228.5	139.9	141.5	131.1	③	③	③	⑥
Sintering process for steel making	135.0	113.8	101.3	69.8	③	③	③	⑥
Zinc recovery facilities	47.4	25.4	21.8	26.5	⑥	⑥	⑥	⑥
Aluminum-alloy manufacturing facilities	21.3	19.4	13.6	12.8	③	③	③	⑥
Aluminum scrap melting process for aluminum rolling industry	3.73	3.73	3.73	3.73	→	→	→	⑥
Aluminum scrap melting process for aluminum casting/die-casting Industry	0.036	0.036	0.036	0.036	→	→	→	⑥
Paper manufacturing (kraft pulp recovery boilers)	0.041	0.038	0.039	0.041	⑥	⑥	⑥	⑥
PVC monomer manufacturing facilities	0.20	0.20	0.20	0.19	→	⑥	⑥	⑥
Cement manufacturing facilities	4.03	3.48	3.38	3.44	⑥	⑥	⑥	⑥
Refractory material manufacturing facilities	0.00129	0.00104	0.00101	0.00096	⑥	⑥	⑥	⑥
Fire brick manufacturing facilities	0.035	0.028	0.027	0.029	⑥	⑥	⑥	⑥
Roof tile manufacturing facilities	0.41	0.35	0.34	0.35	⑥	⑥	⑥	⑥
Sheet glass manufacturing facilities	0.0048	0.0040	0.0042	0.0040	⑥	⑥	⑥	⑥
Glass fiber manufacturing facilities	0.0053	0.0048	0.0048	0.0051	⑥	⑥	⑥	⑥
Electric glass manufacturing facilities	0.055	0.052	0.056	0.061	⑥	⑥	⑥	⑥
Optical glass manufacturing facilities	0.058	0.061	0.060	0.061	⑥	⑥	⑥	⑥
Frit (roof tile glazing materials) manufacturing facilities	0.0049	0.0039	0.0037	0.0039	⑥	⑥	⑥	⑥
Frit (enamel-glazing materials) manufacturing facilities	0.00089	0.00089	0.00089	0.00089	→	→	→	⑥
Glass container manufacturing facilities	0.27	0.25	0.24	0.23	⑥	⑥	⑥	⑥
Glass tableware manufacturing facilities	0.018	0.017	0.015	0.015	⑥	⑥	⑥	⑥
Tile manufacturing facilities	0.00130	0.00108	0.00096	0.00097	⑥	⑥	⑥	⑥
Sanitary earthenware manufacturing facilities	0.029	0.024	0.022	0.021	⑥	⑥	⑥	⑥
Kiln furniture manufacturing facilities	0.00063	0.00054	0.00050	0.00045	⑥	⑥	⑥	⑥
Ceramic tableware manufacturing facilities	0.022	0.019	0.017	0.015	⑥	⑥	⑥	⑥
Insulator manufacturing facilities	0.0079	0.0076	0.0068	0.0064	⑥	⑥	⑥	⑥
Lime manufacturing facilities	1.01	0.95	0.95	1.01	⑥	⑥	⑥	⑥
Cast and forged steel manufacturing facilities	1.98	1.98	1.53	1.40	→	⑥	⑥	⑥
Primary copper smelting facilities	4.88	4.88	0.45	0.59	→	⑥	⑥	⑥
Primary lead smelting facilities	0.055	0.055	0.038	0.189	→	⑥	⑥	⑥
Primary zinc smelting facilities	0.33	0.33	0.13	0.12	→	⑥	⑥	⑥
Copper recovery facilities	0.053	0.053	0.048	0.038	→	③	③	⑥
Lead recovery facilities	1.23	1.23	0.44	0.54	→	⑥	⑥	⑥
Precious metals recovery facilities	0.031	0.031	0.046	0.055	→	⑥	⑥	⑥
Wrought copper product manufacturing facilities	3.16	3.16	1.16	1.28	→	③	③	⑥
Wire and cable manufacturing facilities	1.25	1.25	1.21	1.30	→	③	③	⑥
Aluminum casting/die-casting facilities	0.36	0.36	0.37	0.39	→	⑥	⑥	⑥
Automobile manufacturing (aluminum casting/die-casting) facilities	1.02	1.02	1.02	1.02	→	→	→	⑥
Automobile parts manufacturing (aluminum casting/die-casting) facilities	0.58	0.58	0.58	0.58	→	→	→	⑥
Thermal power plants	1.63	1.55	1.64	1.71	③	③	③	⑥
Tobacco smoke	0.1 - 0.2	0.1 - 0.2	0.1 - 0.2	0.1 - 0.2	①	①	①	④
Exhaust gas from automobiles	1.61	1.61	1.61	1.61	→	→	→	④
(2) Releases into water								

Sources	Amount of releases				Remarks			
	1997	1998	1999	2000	1997	1998	1999	2000
Domestic waste incineration facilities	0.044	0.044	0.035	0.035	→	④	④	④
Industrial waste incineration facilities	5.27	5.27	5.29	2.47	→	④	④	④
Bleaching facilities for pulp making	0.74	0.71	0.74	0.73	⑦	⑦	⑦	⑥
PVC monomer manufacturing facilities	0.54	0.53	0.55	0.20	⑥	⑥	⑥	⑥
Aluminum alloy manufacturing (rolling, etc.)	0.338	0.066	0.091	0.054	⑥	⑥	⑥	⑥
Aluminum alloy manufacturing (automobiles and automobile parts manufacturing)	0.0015	0.0015	0.0015	0.0015	→	→	→	⑥
Caprolactam manufacturing (using nitrosyl chloride) facilities	2.50	2.52	2.53	1.80	⑥	⑥	⑥	⑥
Chlorobenzene manufacturing facilities	0.011	0.011	0.011	0.012	⑥	⑥	⑥	⑥
Potassium sulphate manufacturing facilities	0.078	0.074	0.076	0.081	⑥	⑥	⑥	⑥
Acetylene manufacturing (dry process) facilities	1.80	1.61	1.63	1.76	⑥	⑥	⑥	⑥
Short alumina fiber manufacturing facilities	0.074	0.087	0.082	0.096	⑥	⑥	⑥	⑥
Terminal sewage treatment facilities	1.09	1.09	1.09	1.09	→	→	→	④
Joint wastewater treatment facilities	0.126	0.126	0.126	0.126	→	→	→	④
Final landfill sites	0.093	0.093	0.093	0.056	→	①	←	④
Total	7,343 - 7,597	3,358 - 3,612	2,659 - 2,864	2,198 - 2,218				
Of which, releases into water	12.7	12.2	12.3	8.5				

Notes: 1. Unit of the releases: g-TEQ/year

: 2. Arrows in the Remarks column indicate that releases for the year are considered the same as the estimated amounts of the year shown by the arrow.

: 3. Numbers in the Remarks column correspond to estimates made by:

① Environment Agency, June 2000

② Ministry of Health and Welfare, June 2000 - 2000

④ Ministry of the Environment, December 2001

⑤ Ministry of Health, Labor and Welfare, December 2001

⑥ Ministry of Economy, Trade and Industry, December 2001

⑦ Environment Agency and Ministry of International Trade and Industry, June 2000

⑧ Ministry of the Environment, July 2001

5. Methods of Estimating the Amounts of Dioxins Released from Individual Sources

The amounts of dioxins emitted were estimated for 1997, 1998, 1999 and 2000. The emission amount from each source was estimated for only the years that had data for calculation. The same emission amount was applied to other years that do not have sufficient data for estimation.

The following shows the methods of estimating emission amounts from individual sources. In this report, dioxin amounts were shown in Toxic Equivalents (TEQs) using WHO-TEF (1998). With a few exceptions, amounts of PCDD/PCDF were shown in TEQs using I-TEF (1988), as was done in the previous estimation.

(I) Releases to the Air

1) Domestic Waste Incineration Facilities

① 1997

In the Guidelines to Prevent the Generation of Dioxins, Etc. from Waste Treatment, formulated in January 1997 by the Ministry of Health and Welfare, the amount of PCDD/PCDF (I-TEF (1988)) contained in gases emitted from waste incineration facilities in municipalities nationwide was 4,320 g-TEQ, estimated using the following equation.

Total emissions (g-TEQ/year) = emission concentration (ng-TEQ/m^3N) × per-unit gas emission (m^3N/t) × amount of waste incinerated (t/year)

For the calculation, the actual figure from FY 1993 was used for the amount of waste incinerated, and the figure 5,000 m^3N/t was used as the per-unit gas emission (amount of dry gas emitted from the incineration of one ton of waste).

The annual emission amount of dioxins (WHO-TEF (1998)), including coplanar PCBs, was estimated to be 5,000 g-TEQ. The figure was derived from multiplying the amount of PCDD/PCDF (I-TEF (1988))—calculated from the results of survey conducted by the Ministry of Health and Welfare—by the factor of 1.157 for conversion into dioxins (WHO-TEF (1998)).

② 1998 and 1999

The amount of PCDD/PCDF (I-TEF (1988)) in gas emitted from each facility was calculated by multiplying the annual incinerated amount at each incineration facility by the concentration of PCDD/PCDF (I-TEF (1988)) and the per-unit gas emission. The total annual amount of PCDD/PCDF (I-TEF (1988)) emitted was estimated by adding up the amounts of all facilities.

The annual emission amounts of dioxins (WHO-TEF (1998)), including coplanar PCBs, were estimated to be 1,550 g-TEQ (1998) and 1,350 g-TEQ (1999), respectively. The figures were derived from multiplying the amounts of PCDD/PCDF (I-TEF (1988) by the factor of 1.157 for conversion into dioxins (WHO-TEF (1998)).

Since 1998 and 1999, the amounts of dioxins contained in gases emitted from domestic waste incineration facilities set up by businesses was also included in the calculation. The amounts from those facilities were estimated using the same method of calculation for the industrial waste incineration facilities in the same annual periods described later.

③ 2000

At incineration facilities where the concentrations of dioxins (WHO-TEF (1998)) were measured, the amount of dioxins (WHO-TEF (1998)) in gas emitted from each facility was calculated by multiplying the annual incinerated amount at each facility by the concentration of dioxins in the emitted gas and the per-unit gas emission. The total annual amount of dioxins (WHO-TEF (1998)) emitted was estimated by adding up the amounts of all facilities.

For incineration facilities where only the concentrations of PCDD/PCDF (I-TEF (1988)) were available, to estimate the annual amount of dioxins (WHO-TEF (1998)) emitted, the relevant concentrations were converted to dioxins (WHO-TEF (1998)) using the factor of 1.193 calculated from the measured values of 2000.

The amounts of dioxins (WHO-TEF (1998)) contained in gases emitted from domestic waste incineration facilities set up by businesses were estimated using the same methods of calculation for industrial waste incineration facilities described later.

Based on the above, the annual emission amount of dioxins (WHO-TEF (1998)), including coplanar PCBs, from domestic waste incineration facilities in 2000 was estimated to be 1,019 g-TEQ.

2) Industrial Waste Incineration Facilities

① 1997

The annual PCDD/PCDF (I-TEF (1988)) emission was estimated to be 1,300 g-TEQ, calculated by multiplying the concentrations of PCDD/PCDF (I-TEF (1988)) for each type of waste—obtained from the results of surveys conducted by the Environment Agency until FY 1996—by the estimated incinerated amount in 1998 and the per-unit gas emission. Standard emission amounts (amounts of dry gas emitted) sorted by type

of waste incinerated were used as the basic units of gas emission. In the case where no data was available, the data of a similar facility would be used for the estimation.

The annual emission of dioxins (WHO-TEF (1998)), including coplanar PCBs, was estimated to be 1,500 g-TEQ. The value was derived from multiplying PCDD/PCDF (I-TEF (1988) by the factor of 1.166 for conversion to dioxins (WHO-TEF (1998)).

② 1998 and 1999

The PCDD/PCDF (I-TEF (1988)) emission from each facility was calculated by multiplying the annual incinerated amount at each incineration facility by the concentration of PCDD/PCDF (I-TEF (1988)) and the per-unit gas emission. The total annual PCDD/PCDF (I-TEF (1988)) emission was estimated by adding up the amounts of all facilities.

The annual emissions of dioxins (WHO-TEF (1998)), including coplanar PCBs, were estimated to be 1,100 g-TEQ (1998) and 690 g-TEQ (1999), respectively. The values were derived from multiplying PCDD/PCDF (I-TEF (1988) by the factor of 1.166 for conversion to dioxins (WHO-TEF (1998)).

③ 2000

At incineration facilities where the concentrations of dioxins (WHO-TEF (1998)) were measured, the emission of dioxins (WHO-TEF (1998)) from each facility was obtained by multiplying the annual incinerated amount at each facility by the relevant concentrations in the emitted gas and by the per-unit gas emission. The total annual amount of dioxins (WHO-TEF (1998)) emitted was estimated by adding up the amounts of all facilities.

At incineration facilities where only the concentrations of PCDD/PCDF (I-TEF (1988)) were measured, the relevant concentrations were converted (using the factor of 1.166) to dioxins (WHO-TEF (1998)) to estimate the annual amount of dioxins (WHO-TEF (1998)) emitted.

Based on the above, the annual amount of dioxins (WHO-TEF (1998)), including coplanar PCBs, emitted from industrial waste incineration facilities in 2000 was estimated to be 555 g-TEQ.

3) Small Incinerators, etc.

Until recently, only those incinerators installed at business sites with incineration capacity of less than 200 kg per hour, which were neither included in the categories of 1) domestic waste incineration facilities, nor 2) industrial waste incineration facilities, were

categorized as the "small incinerators" (hereinafter referred to as "small incinerators"), and their emission amounts were estimated. However, since the enforcement of the Law in January 2000, sludge incinerators at night soil treatment facilities and terminal sewage treatment facilities (hereinafter referred to as "sludge incinerators at night soil treatment facilities"), which had not previously been included in estimation under this category, were included this year for estimation.

The amount of dioxins emitted from "small incinerators" in 2000 was calculated by estimating the amounts emitted from both specified facilities and facilities not meeting the conditions of specified facilities. Of the specified facilities, the amounts of dioxins emitted from sludge incinerators at night soil treatment facilities, etc. before 1999 were considered to have the same amount as in 2000. In this new estimation, the amounts of emissions from 1997 to 1999 were estimated by adding the amount of dioxins emitted from sludge incinerators at night soil treatment facilities, etc. to the values of the previous estimation (June 2000).

From the above results, the annual emissions of dioxins (WHO-TEF (1998)) from small incinerators were estimated to be 368–619 g-TEQ (1998), 307–509 g-TEQ (1999), and 353–370 g-TEQ (2000), respectively.

① 1998 and 1999

The annual amount of dioxins (WHO-TEF (1998)) emitted from small incinerators was estimated based on the assumption that they were installed mainly at business sites and used on a regular basis for business operations. The estimation was based on surveys of the actual state of emission conducted in FY 1998 and 1999, a FY 1999 survey to investigate the operation condition of small incinerators, results of on-the-spot inspections and surveys of emission status, and the state of submission of notification by operators for setting up facilities as required by the Law Concerning Special Measures against Dioxins. The following two estimation methods were used.

(1) The annual amount of dioxins emitted from small incinerators was calculated by multiplying the per-unit gas emission per hour (derived from surveys of the actual state of emission conducted in FY 1998 and 1999) by the average days of operation of small incinerators in the year (derived from surveys and on-the-spot inspections), the average operating hours per day, and the number of small incinerators in the country (derived from legally submitted notifications) (Tables 2 & 3).

(2) The annual amount of dioxins emitted from small incinerators was obtained by multiplying the dioxin emission per amount of incineration (derived from surveys of the actual state of emission conducted in FY 1998 and 1999) by the annual amount of

incineration (derived from surveys and on-the-spot inspections) and by the number of small incinerators in the country (derived from legally submitted notifications) (Tables 2, 3, & 4).

Table 2 Number of Small Incinerators nationwide

Incineration capacity	1998	1999
0 – 50 kg/h	31,107	23,937
50–100 kg/h	10,000	6,829
100–200 kg/h	7,317	6,352

※ Information on sludge incinerators at night soil treatment facilities, etc. is shown below in ② 2000.

Table 3 Basic Units of Operation

Incineration capacity	Average operating hours per day (hour/day)	Average operating days per year (day/year)	Annual incineration amount (ton/year)
0–50 kg/h	1.4	115	4.2
50–100 kg/h	1.9	135	13.4
100–200 kg/h	3.5	174	78.7

Table 4 Per-unit Dioxin Emissions

Incineration capacity	Emission of dioxins per hour (μg-TEQ/hour)	Emission of dioxins per amount of incineration (μg-TEQ/kg)
0–50 kg/h	10.4	0.640
50–100 kg/h	23.2	0.918
100–200 kg/h	51.1	0.666

② 2000

(1) Small Incinerators/Sludge Incinerators at Night Soil Treatment Facilities Mandated by the Law (Specified Facilities)

Of the small incinerators, those with incineration capacity of 50–200 kg/hr or hearth area of 0.5 m^2 or above are required by Law since January 15, 2000 to measure the concentration of dioxins in emitted gas more than once a year. Based on the results of these voluntary measurements by business operators, facilities subject to administrative inspection by local governments were determined. The annual amounts of dioxins emitted from those facilities were calculated to give an estimate of the annual emission amount for 2000. During the period between the enactment of the Law and March 31, 2001, facilities were considered to be operating only six months a year if their operation had been abandoned, if they were newly established, or if their operational status could not be determined (suspended operation).

Annual amount of dioxin emissions (g-TEQ/year) = Dioxin concentration in emitted gas (ng-TEQ/m^3N) ×amount of gas emitted per day (m^3N/day) ×days of operation per month (day/month) × number of operating months per year (month) $\times 10^{-9}$

The measured value of dioxin concentration in emitted gas Cs (ng-TEQ/m^3N) was calculated as follows:

Cs = Cn • (21-Os)/(21-On)

Cn = reported value of dioxin concentration in emitted gas by voluntary measurement (ng-TEQ/ m^3N)

On = standard concentration of oxygen (waste incinerators: 12%)

Os = concentration of oxygen in emitted gas (%), Os =20% when the oxygen concentration exceeds 20%

The amount of dioxin emissions from sludge incinerators at night soil treatment facilities was not included (even if such facilities had the incineration capacity of over 200 kg/hr) in the estimation of the amount emitted from facilities specified by the Waste Disposal and Public Cleansing Law, namely, 1) domestic waste incineration facilities, and 2) industrial waste incineration facilities. Therefore, their emission amount for 2000 was calculated based on the results of voluntary measurement, as mandated by the Law for small incinerators.

For those facilities without data on dioxin concentration in emitted gas, the amount of gas emitted per day, or the days of operation per month, their annual amounts of dioxin emissions were estimated using the average annual amounts of emissions in Table 5. These values were calculated based on facilities (5,921 facilities) with obtainable data. The facilities were classified by capacity.

Table 5 Annual Average Amounts of Dioxin Emissions

(g-TEQ/year)

Incineration capacity	Annual average amounts of dioxin emissions
Over 0.5 m^2–50 kg/h	0.00832
50–100 kg/h	0.01746
100–200 kg/h	0.02327
Over 200 kg/h (sludge incinerators at night soil treatment facilities, etc.)	0.03499

(2) Small Incinerators Not Regulated by Law

As in the estimation for 1998 and 1999, the annual amount of dioxins emitted from these incinerators was estimated using the per-unit dioxin emissions, basic units of operation, and the number of small incinerators in this category as shown in Tables 6, 7, and 8.

Table 6 Per-unit Dioxin Emissions

Incineration capacity	Dioxins emitted per hour (μg-TEQ/hour)	Dioxins emitted per incineration amount (μg-TEQ/kg)
0–50 kg/h	10.4	0.640

Table 7 Basic Units of Operation

Incineration capacity	Average hours of operation per day (hour/day)	Average days of operation per year (day/year)	Annual amount of incineration (t/year)
0–50 kg/h	1.4	115	4.2

Table 8 Number of Small Incinerators nationwide

Incineration capacity	2000
0–50 kg/h	16,408

※ Excluding the specified small incinerators with hearth area above 0.5 m^2

4) Crematoria

The concentration of dioxins in gases emitted from 27 crematoria (10 crematoria in 1997 and 17 crematoria in 1998) was measured in the Welfare and Science Studies conducted in FY 1997 and 1998.

The annual amount of dioxins (WHO-TEF (1998)) emitted in FY 1997 was estimated to be 2.1–4.6 g-TEQ, calculated by multiplying the amount of dioxins released from one body (arithmetical mean of 4,800 ng-TEQ/body and geometric mean of 2,200 ng-TEQ/body)—which was derived from the FY 1998 Welfare and Science Study—by the actual number of cremations (967,061 bodies) performed in FY 1997.

Similarly, the annual amounts of dioxins emitted in FY 1998 and 1999 were estimated to be 2.2–4.8 g-TEQ (1998) and 2.2–4.9 g-TEQ (1999), calculated by multiplying the amount of dioxins released from one body by the actual numbers of cremations (1,015,057 bodies in 1998 and 1,017,917 bodies in 1999).

For FY 2000, the annual amount of dioxins emitted was estimated using the same number of cremations as in FY 1999.

5) Electric Furnaces for Steel Making

The dioxin emission per ton of steel produced by electric furnaces was 3,542.4 ng-TEQ/t. This value was obtained by dividing the annual amount of dioxin emissions—which was calculated from 104 sets of measurement data (0.0000072–16 ng-TEQ/m^3N) of 98 facilities—by the annual amount of steel produced by electric furnaces at the 98 facilities. The 104 sets of measurement data were the sum of 94 sets of data (0.0000072–16 ng-TEQ/ m^3N) contributed by business operators through voluntary measurements at 98 facilities and 10 sets of data (0.00052–2.5 ng-TEQ/ m^3N) contributed by local governments through measurements taken at the inspection of 11 facilities.

The annual amount of dioxins emitted in 2000 was 109.6 g-TEQ, calculated by multiplying the dioxin emission per ton of steel produced by the 30,936,000 tons of steel produced by electric furnaces in 2000.

Furthermore, adding the 21.5 g-TEQ annual emission amount of through building ventilation calculated based on the 13 sets of data (0.0043–3.8 ng-TEQ/ m^3N) contributed by those operators through voluntary measurements at 23 facilities that used the split-flow method, the total annual amount of dioxins emitted in 2000 was estimated to be 131.1 g-TEQ.

The dioxin emission per ton of steel produced by electric furnaces was 4,238.3 ng-TEQ/t, a figure obtained by dividing the total annual amount of dioxin emissions—which included the emission amount of through building ventilation—by the amount of steel produced by electric furnaces nationwide in 2000.

6) Sintering Process for Steel Making

The total annual amount of dioxins emitted was estimated to be 69.8 g-TEQ in 2000, which was obtained by adding up the annual amounts of dioxins emitted from each facility, calculated using the values (before the 15% conversion of oxygen concentration) of 31 sets of measurement data (0.0011–0.96 ng-TEQ/m^3N, using 15% as the conversion value for oxygen concentration) taken at 26 facilities. The data included 28 sets of data (0.0016–0.96 ng-TEQ/m^3N, using 15% as the conversion value for oxygen concentration) contributed by business operators through voluntary measurements at 26 facilities and 3 sets of data (0.0011–0.065 ng-TEQ/m^3N, using 15% as the conversion value for oxygen concentration) contributed by local governments through measurements taken at the inspection of 3 facilities.

Dividing the total annual amount of dioxin emissions by the 106,866,163 tons of sintering steel produced in 2000, the dioxin emission per ton of sintering steel produced was 653.4 ng-TEQ/t.

7) Zinc Recovery Facilities

The total annual amount of dioxins emitted in 2000 was estimated to be 26.5 g-TEQ, derived from adding up the annual amounts of dioxins emitted from each facility, based on 18 sets of measurement data (0.014–49.4 ng-TEQ/m^3N) contributed by business operators through voluntary measurements at 17 facilities.

Dioxin emission per ton of dust treated by electric furnaces was 81,282.1 ng-TEQ/t, obtained by dividing the total annual amount of dioxin emissions by the 325,682 tons of dust treated by electric furnaces in 2000.

Last year's estimation of the total annual amounts of dioxin emissions for 1997, 1998 and 1999 were the sums of dioxins emitted from 11 facilities. Since annual amounts of dioxins emitting from six more facilities were included in the estimation in 2000, these values were added to last year's estimation. Therefore, the total annual amounts of dioxins emitted were re-estimated to be 47.4 g-TEQ in 1997, 25.4 g-TEQ in 1998, and 21.8 g-TEQ in 1999.

8) Aluminum Alloy Manufacturing Facilities

The following per-unit dioxin emissions were calculated using the 107 sets of measurement data (0–8.594 ng-TEQ/m^3N) of 145 facilities, derived from adding up the 104 sets of data (0–8.594 ng-TEQ/m^3N) contributed by business operators through voluntary measurements at 145 facilities and 3 sets of data (0.0004–0.9 ng-TEQ/m^3N) contributed by local governments through measurement taken at the inspection of 3 facilities. Thus, the dioxin emissions were 17,973.4 ng-TEQ/t for one ton of dry kiln chips, 144.2 ng-TEQ/t for treating one ton of roasting furnace can scraps, 8,908.6 ng-TEQ/t for producing one ton of smelter products with the metal melting process, and 174.0 ng-TEQ/t for one ton of smelter chlorinated treatment in the refining process.

The amounts of dioxins emitted annually from these processes were calculated by multiplying the above-mentioned per-unit dioxin emissions by 107,000 tons of the annual amount of chips produced in 2000, 100,000 tons of the annual amount of can scraps treated, 1,213,000 tons of the annual amount of products manufactured, and 249,000 tons of the annual amount of chlorinated treatment performed, respectively. The total annual amount of dioxin emission for 2000 was estimated to be 12.8 g-TEQ, calculated by adding up the amounts of dioxins emitted from each of these processes (1.92 g-TEQ from dry kiln, 0.01 g-TEQ from roasting furnace, 10.81 g-TEQ from the metal melting process and 0.04 g-TEQ from the refining process.

9) Aluminum Scrap Melting Process for Aluminum Rolling Industry

The total annual amount of dioxins emitted in 2000 was estimated to be 3.73 g-TEQ, derived from adding up the annual amounts of dioxins emitted from each facility, calculated using 79 sets of measurement data (0–9.27 ng-TEQ/m^3N) from 114 facilities, including 75 sets of data (0–9.27 ng-TEQ/m^3N) contributed by business operators through voluntary measurement at 114 facilities and 4 sets of data (0.000099–0.095 ng-TEQ/m^3N) contributed by local governments through measurement taken at the inspection of 5 facilities.

Dividing the total annual amount of dioxin emission by the 2,081,725 tons of annual production in 2000, the dioxin emission per ton of products was 1,791.3 ng-TEQ/t.

10) Aluminum Scrap Melting Process for Aluminum Casting/Die-casting Industry

The total annual amount of dioxins emitted in 2000 was estimated to be 0.036 g-TEQ, derived from adding up the annual amounts of dioxins emitted from each facility calculated using 4 sets of data (0–22 ng-TEQ/m^3N) contributed by business operators through voluntary measurements at 4 facilities.

11) Paper Manufacturing (Kraft paper (KP) recovery boilers)

The dioxin emission from each ton of black liquor treated was 2.67 ng-TEQ/t. This value was obtained by dividing the annual amount of dioxin emissions—which was calculated from 11 sets of data (0–0.01 ng-TEQ/m^3N, using 12% as the conversion value for oxygen concentration) contributed by business operators through voluntary measurements at 11 facilities—by the annual amount of black liquor treated at the 11 facilities.

The total annual amount of dioxins emitted was estimated to be 0.041 g-TEQ, calculated by multiplying the per-unit emission by 15,224,842 tons of black liquor treated in 2000.

In last year's estimation, the total amounts of dioxins emitted each year from 1997 to 1999 were calculated, based on the concentrations of PCDD/PCDF (I-TEF (1988)) measured at 4 KP recovery boilers in 1997, by multiplying the PCDD/PCDF emissions from industrial waste incineration facilities in 1999 and the ratio of annual dioxin emissions. Thus, the total annual amounts of dioxin emissions were recalculated by multiplying the amounts of black liquor treated nationwide in 1997, 1998, and 1999, respectively, by the per-unit dioxin emission for 2000. The estimated total annual dioxin emissions were 0.041 g-TEQ in 1997, 0.038 g-TEQ in 1998, and 0.039 g-TEQ in 1999.

12) PVC Monomer Manufacturing Facilities

The dioxin emissions per ton of products manufactured were 53.4 ng-TEQ/t from the incineration of liquid waste, 8.7 ng-TEQ/t from the incineration of waste gas, and 9.3 ng-TEQ/t from other waste gases. These per-unit emissions were derived from adding up the

annual amounts of dioxins emitted from each facility, calculated using the results of voluntary measurements of gas emitted from the incineration of liquid waste by business operators (8 facilities: 0.000566–1.296 ng-TEQ/m^3N), the results of voluntary measurements of gas emitted from the incineration of waste gas by business operators (2 facilities: 0.013005–0.043ng-TEQ/m^3N), and the results of voluntary measurement of gas emissions from the incineration of other gases by business operators (1 facility: 0.0901ng-TEQ/m^3N), and then dividing the sum of these annual amounts by the sum of the annual amounts of products manufactured at each facility.

The total annual amount of dioxins emitted in 2000 was estimated to be 0.19g-TEQ, calculated by adding the annual amounts of dioxin emission (0.161 g-TEQ from the incineration of liquid waste, 0.014 g-TEQ from the incineration of waste gas, and 0.014 g-TEQ from other gas incinerations). These values were derived from multiplying the above-mentioned per-unit dioxin emissions by the amounts of products manufactured in 2000 (a total of 3,020,580 tons from facilities emitting gas from the incineration of liquid waste, a total of 1,612,101 tons from facilities emitting gas from the incineration of waste gas, and a total of 1,473,925 tons from other gas incineration facilities).

In last year's estimation, the total amounts of dioxins emitted each year in 1998 and 1999 were calculated based on the concentrations of PCDD/ PCDF (I-TEF (1988)) measured in 1998, converted to the total annual amounts of dioxin emissions by multiplying the amounts of PCDD/PCDF measured at mock RDF experimental furnaces containing polyvingyl chloride by the ratio of dioxin concentrations. For this reason, the total annual amounts of dioxin emissions were recalculated by multiplying the amounts of products manufactured in 1998 and 1999, respectively, by the per-unit dioxin emission for 2000, giving the estimated total annual dioxin emissions of 0.20g-TEQ for 1998 and 0.20g-TEQ for 1999.

13) Cement Manufacturing Facilities

The per-unit dioxin emission was 45.6 ng-TEQ/t for each ton of clinkers produced, derived from dividing the annual amount of dioxins emitted from 37 facilities—calculated using 37 sets of data (0–0.0941 ng-TEQ/m^3N) contributed by business operators through voluntary measurements taken at 37 facilities—by the annual amount of clinkers produced at these 37 facilities.

The total annual amount of dioxin emissions was estimated to be 3.44 g-TEQ, calculated by multiplying the per-unit dioxin emissions by the 75,499,000 tons of clinkers produced nationwide in 2000.

In last year's estimation, the total amounts of dioxins emitted each year in 1998 and 1999 were calculated, based on the concentration of PCDD/PCDF (I-TEF (1988)), by multiplying

the amounts of PCDD/PCDF emitted in the sintering process of the iron and steel industry in 1999 by the ratio of dioxin concentration. Thus, the total annual amounts of dioxin emissions were recalculated by multiplying the amounts of clinkers produced in 1997, 1998 and 1999, respectively, by the per-unit dioxin emission for 2000, giving the estimated total annual dioxin emissions of 4.03 g-TEQ for 1997, 3.48 g-TEQ for 1998, and 3.38 g-TEQ for 1999.

14) Refractory Materials Manufacturing Facilities

The total annual amount of dioxins emitted in 2000 was estimated to be 0.00096 g-TEQ, derived from one set of measurement data (0.0029 ng-TEQ/m^3N) taken at one facility in a 2000 study conducted by the Ministry of Economy, Trade and Industry.

The per-unit dioxin emissions was 9.6 ng-TEQ/t for each ton of products manufactured, calculated by dividing the total annual amount of dioxin emissions by the annual amount of 99,572 tons of products manufactured in 2000.

Multiplying the per-unit dioxin emissions for 2000 by the amounts of products manufactured in 1997, 1998, and 1999, the annual amounts of dioxins emitted were estimated to be 0.00129 g-TEQ in 1997, 0.00104 g-TEQ in 1998, and 0.00101 g-TEQ in 1999.

15) Fire Brick Manufacturing Facilities

The per-unit dioxin emission was 288.8 ng-TEQ/t for each ton of products manufactured. This value was derived from dividing the annual amount of dioxins emitted from 8 facilities—calculated using 8 sets of measurement data (0.00024–0.10 ng-TEQ/m^3N) taken at 8 facilities in a 2000 study conducted by the Ministry of Economy, Trade and Industry and the Ministry of the Environment—by the annual amount of products manufactured at these 8 facilities.

The total annual amount of dioxin emissions was estimated to be 0.029 g-TEQ, calculated by multiplying the per-unit dioxin emissions by the 102,093 tons of products manufactured nationwide in 2000.

Multiplying the per-unit dioxin emission for 2000 by the amounts of products manufactured in 1997, 1998, and 1999, the total annual amounts of dioxins emitted were estimated to be 0.035 g-TEQ in 1997, 0.028 g-TEQ in 1998, and 0.027 g-TEQ in 1999.

16) Roof Tile Manufacturing Facilities

The per-unit dioxin emission was 0.36 ng-TEQ/t piece for each piece of tile manufactured. The value was derived from dividing the annual amount of dioxins emitted from 3

facilities—which was calculated using 3 sets of measurement data（0.00043–0.10 ng-TEQ/m^3N）taken at 3 facilities in a 2000 study conducted by the Ministry of Economy, Trade and Industry and the Ministry of the Environment—by the annual amount of tiles manufactured at these 3 facilities.

The total annual amount of dioxin emissions was estimated to be 0.35 g-TEQ, calculated by multiplying the per-unit dioxin emission by the 973,900,000 pieces of tile manufactured nationwide in 2000.

Multiplying the per-unit dioxin emission for 2000 by the amounts of tiles manufactured in 1997, 1998, and 1999, the total annual amounts of dioxins emitted were estimated to be 0.41 g-TEQ in 1997, 0.35g-TEQ in 1998, and 0.34g-TEQ in 1999.

17) Sheet Glass Manufacturing Facilities

The per-unit dioxin emission was 3.3 ng-TEQ/t for each ton of the product manufactured. The value was derived from dividing the annual amount of dioxins emitted from 4 facilities—which was calculated using 4 sets of measurement data（0.0000067–0.0024 ng-TEQ/m^3N）taken at 4 facilities in a 2000 study conducted by the Ministry of Economy, Trade and Industry and the Ministry of the Environment—by the annual amount of the product manufactured at these facilities.

The total annual amount of dioxin emissions was estimated to be 0.0040 g-TEQ, calculated by multiplying the per-unit dioxin emissions by the 1,206,000 tons of the product manufactured nationwide in 2000.

Multiplying the per-unit dioxin emission for 2000 by the amounts of the product manufactured in 1997, 1998, and 1999, the total annual amounts of dioxins emitted were estimated to be 0.0048 g-TEQ in 1997, 0.0040 g-TEQ in 1998, and 0.0042 g-TEQ in 1999.

18) Glass Fiber Manufacturing Facilities

The per-unit dioxin emission was 11.5 ng-TEQ/t for each ton of products manufactured, derived from dividing the annual amount of dioxins emitted from 3 facilities—which was calculated using 3 sets of measurement data（0.0000039–0.0054 ng-TEQ/m^3N）taken at 3 facilities in a 2000 study conducted by the Ministry of Economy, Trade and Industry and the Ministry of the Environment—by the annual amount of products manufactured at these 3 facilities.

The total annual amount of dioxin emissions was estimated to be 0.0051 g-TEQ, calculated by multiplying the per-unit dioxin emission by the 447,084 tons of products manufactured nationwide in 2000.

Multiplying the per-unit dioxin emission for 2000 by the amounts of products manufactured in 1997, 1998, and 1999, the total annual amounts of dioxins emitted were estimated to be 0.0053 g-TEQ in 1997, 0.0048 g-TEQ in 1998, and 0.0048 g-TEQ in 1999.

19) Electric Glass Manufacturing Facilities

The per-unit dioxin emission was 71.4 ng-TEQ/t for each ton of the product manufactured, derived from dividing the annual amount of dioxins emitted from 6 facilities—which was calculated using 6 sets of measurement data (0.000034–0.090 ng-TEQ/m^3N) taken at 6 facilities in a 2000 study conducted by the Ministry of Economy, Trade and Industry and the Ministry of the Environment—by the annual amount of the product manufactured at these 6 facilities.

The total annual amount of dioxin emission was estimated to be 0.061 g-TEQ, calculated by multiplying the per-unit dioxin emissions by the 850,754 tons of the product manufactured nationwide in 2000.

Multiplying the per-unit dioxin emission for 2000 by the amounts of the product manufactured in 1997, 1998, and 1999, the total annual amounts of dioxins emitted were estimated to be 0.055 g-TEQ in 1997, 0.052 g-TEQ in 1998, and 0.056 g-TEQ in 1999.

20) Optical Glass Manufacturing Facilities

The per-unit dioxin emission was 6,868.9 ng-TEQ/t for each ton of the product manufactured, derived from dividing the annual amount of dioxins emitted from 2 facilities—which was calculated using 2 sets of measurement data (0.000090–0.063 ng-TEQ/m^3N) taken at 2 facilities in a 2000 study conducted by the Ministry of Economy, Trade and Industry—by the annual amount of products manufactured at these 2 facilities.

The total annual amount of dioxin emission was estimated to be 0.061 g-TEQ, calculated by multiplying the per-unit dioxin emissions by the 8,829 tons of the product manufactured nationwide in 2000.

Multiplying the per-unit dioxin emission for 2000 by the amounts of the product manufactured in 1997, 1998, and 1999, the total annual amounts of dioxins emitted were estimated to be 0.058 g-TEQ in 1997, 0.061 g-TEQ in 1998, and 0.060 g-TEQ in 1999.

21) Frit (Roof Tile Glazing Materials) Manufacturing Facilities

The per-unit dioxin emission was 733.8 ng-TEQ/t for each ton of product manufactured. The value was derived from dividing the annual amount of dioxins emitted from 3 facilities—which was calculated using 3 sets of measurement data (0.00013–0.12

ng-TEQ/m^3N) taken at 3 facilities in a 2000 study conducted by the Ministry of Economy, Trade and Industry and the Ministry of the Environment—by the annual amount of the product manufactured at these 3 facilities.

The total annual amount of dioxin emissions was estimated to be 0.0039 g-TEQ, calculated by multiplying the per-unit dioxin emissions by the 5,260 tons of the product manufactured nationwide in 2000.

Multiplying the per-unit dioxin emissions for 2000 by the amounts of the product manufactured in 1997, 1998, and 1999, the total annual amounts of dioxins emitted were estimated to be 0.0049 g-TEQ in 1997, 0.0039 g-TEQ in 1998, and 0.0037 g-TEQ in 1999.

22) Frit (Enamel Glazing Materials) Manufacturing Facilities

The total annual amount of dioxins emitted in 2000 was estimated to be 0.00089 g-TEQ, derived from adding up the annual amounts of dioxins emitted from each facility—which were calculated using 4 sets of measurement data (0.0000035–0.0060 ng-TEQ/m^3N) taken at 4 facilities in a 2000 study conducted by the Ministry of Economy, Trade and Industry and the Ministry of the Environment.

The per-unit dioxin emission was 70.8 ng-TEQ/t for each ton of the product manufactured, derived from dividing the total annual amount of dioxin emissions by the 12,612 tons of the product manufactured in 2000.

23) Glass Container Manufacturing Facilities

The per-unit dioxin emission was 126.9 ng-TEQ/t for each ton of products manufactured, derived from dividing the annual amount of dioxins emitted from 5 facilities—which was calculated using 5 sets of measurement data (0.000074–0.55 ng-TEQ/m^3N) taken at 5 facilities in a 2000 study conducted by the Ministry of Economy, Trade and Industry and the Ministry of the Environment—by the annual amount of products manufactured at these 5 facilities.

The total annual amount of dioxin emissions was estimated to be 0.23 g-TEQ, calculated by multiplying the per-unit dioxin emission by the 1,819,399 tons of products manufactured nationwide in 2000.

Multiplying the per-unit dioxin emission for 2000 by the amounts of products manufactured in 1997, 1998, and 1999, the total annual amounts of dioxins emitted were estimated to be 0.27 g-TEQ in 1997, 0.25 g-TEQ in 1998, and 0.24 g-TEQ in 1999.

24) Glass Tableware Manufacturing Facilities

The per-unit dioxin emission was 162.6 ng-TEQ/t for each ton of the product manufactured, derived from dividing the annual amount of dioxins emitted from 5 facilities—which was calculated using 5 sets of measurement data (0.00016–0.050 ng-TEQ/m^3N) taken at 5 facilities in a 2000 study conducted by the Ministry of Economy, Trade and Industry and the Ministry of the Environment—by the annual amount of the product manufactured at these 5 facilities.

The total annual amount of dioxin emission for 2000 was estimated to be 0.015 g-TEQ, calculated by multiplying the per-unit dioxin emission by the 91,653 tons of the product manufactured nationwide in 2000.

Multiplying the per-unit dioxin emission for 2000 by the amounts of the product manufactured in 1997, 1998, and 1999, the total annual amounts of dioxins emitted were estimated to be 0.018 g-TEQ in 1997, 0.017 g-TEQ in 1998, and 0.015 g-TEQ in 1999.

25) Tile Manufacturing Facilities

The per-unit dioxin emission was 0.018 ng-TEQ/m^2 for each square meter of tiles manufactured, derived from dividing the annual amount of dioxins emitted from 6 facilities—which was calculated using 6 sets of measurement data (0.000062–0.0020 ng-TEQ/m^3N) taken at 6 facilities in a 2000 study conducted by the Ministry of Economy, Trade and Industry and the Ministry of the Environment—by the annual amount of tiles manufactured at these 6 facilities.

The total annual amount of dioxin emission for 2000 was estimated to be 0.00097g-TEQ, calculated by multiplying the per-unit dioxin emission by the 54,048,639 m^2 of tiles manufactured nationwide in 2000.

Multiplying the per-unit dioxin emission for 2000 by the amounts of tiles manufactured in 1997, 1998, and 1999, the total annual amounts of dioxins emitted were estimated to be 0.00130 g-TEQ in 1997, 0.00108 g-TEQ in 1998, and 0.00096 g-TEQ in 1999.

26) Sanitary Earthenware Manufacturing Facilities

The per-unit dioxin emission was 2.7 ng-TEQ/piece for each piece of sanitary earthenware manufactured, derived from dividing the annual amount of dioxins emitted from 3 facilities—which was calculated using 3 sets of measurement data (0.003–0.018 ng-TEQ/m^3N) taken at 3 facilities in a 2000 study conducted by the Ministry of Economy, Trade and Industry and the Ministry of the Environment—by the annual amount of the product manufactured at these 3 facilities.

The total annual amount of dioxin emission for 2000 was estimated to be 0.021 g-TEQ,

calculated by multiplying the per-unit dioxin emission by the 7,876,901 pieces manufactured nationwide in 2000.

Multiplying the per-unit dioxin emission for 2000 by the amounts of the product manufactured in 1997, 1998, and 1999, the total annual amounts of dioxins emitted were estimated to be 0.029 g-TEQ in 1997, 0.024 g-TEQ in 1998, and 0.022 g-TEQ in 1999.

27) Kiln Furniture (Sagger) Manufacturing Facilities

The per-unit dioxin emission was 45.3 ng-TEQ/t for each ton of products manufactured, derived from dividing the annual amount of dioxins emitted from 2 facilities—which was calculated using 2 sets of measurement data (0.00024–0.018 ng-TEQ/m^3N) taken at 2 facilities in a 2000 study conducted by the Ministry of Economy, Trade and Industry—by the annual amount of products manufactured at these facilities.

The total annual amount of dioxin emission was estimated to be 0.00045 g-TEQ, calculated by multiplying the per-unit dioxin emission by the 10,000 tons of products manufactured nationwide in 2000.

Multiplying the per-unit dioxin emission for 2000 by the amounts of products manufactured in 1997, 1998, and 1999, the total annual amounts of dioxins emitted were estimated to be 0.00063 g-TEQ in 1997, 0.00054 g-TEQ in 1998, and 0.00050 g-TEQ in 1999.

28) Ceramic Tableware Manufacturing Facilities

The per-unit dioxin emission was 78.1 ng-TEQ/t for each ton of the product manufactured, derived from dividing the annual amount of dioxins emitted from 4 facilities—which was calculated using 4 sets of measurement data (0.0000067–0.056ng-TEQ/m^3N) taken at 4 facilities in a 2000 study conducted by the Ministry of Economy, Trade and Industry and the Ministry of the Environment—by the annual amount of the product manufactured at these 4 facilities.

The total annual amount of dioxin emission was estimated to be 0.015 g-TEQ, calculated by multiplying the per-unit dioxin emission by the 198,233 tons of products manufactured nationwide in 2000.

Multiplying the per-unit dioxin emission for 2000 by the amounts of products manufactured in 1997, 1998, and 1999, the total annual amounts of dioxins emitted were estimated to be 0.022 g-TEQ in 1997, 0.019 g-TEQ in 1998, and 0.017 g-TEQ in 1999.

29) Insulator Manufacturing Facilities

The per-unit dioxin emission was 87.3 ng-TEQ/t for each ton of products manufactured,

derived from dividing the annual amount of dioxins emitted from 3 facilities—which was calculated using 3 sets of measurement data (0.0014–0.0080 ng-TEQ/m^3N) taken at 3 facilities in a 2000 study conducted by the Ministry of Economy, Trade and Industry—by the annual amount of products manufactured at these 3 facilities.

The total annual amount of dioxin emission was estimated to be 0.0064 g-TEQ, calculated by multiplying the per-unit dioxin emission by the 73,440 tons of products manufactured nationwide in 2000.

Multiplying the per-unit dioxin emission for 2000 by the amounts of products manufactured in 1997, 1998, and 1999, the total annual amounts of dioxins emitted were estimated to be 0.0079 g-TEQ in 1997, 0.0076 g-TEQ in 1998, and 0.0068 g-TEQ in 1999.

30) Lime Manufacturing Facilities

The per-unit dioxin emission was 124.6 ng-TEQ/t for each ton of the product manufactured, derived from dividing the annual amount of dioxins emitted from 8 facilities—which was calculated using 8 sets of measurement data (0.0000042–0.099 ng-TEQ/m^3N) taken at 8 facilities in a 2000 study conducted by the Ministry of Economy, Trade and Industry and the Ministry of the Environment—by the annual amount of the product manufactured at these 8 facilities.

The total annual amount of dioxin emission was estimated to be 1.01 g-TEQ, calculated by multiplying the per-unit dioxin emission by the 8,106,064 tons of the product manufactured nationwide in 2000.

Multiplying the per-unit dioxin emission for 2000 by the amounts of the product manufactured in 1997, 1998, and 1999, the total annual amounts of dioxins emitted were estimated to be 1.01 g-TEQ in 1997, 0.95 g-TEQ in 1998, and 0.95 g-TEQ in 1999.

31) Cast and Forged Steel Manufacturing Facilities

The per-unit dioxin emission was 929.3 ng-TEQ/t for each ton of the steel scrap charged, derived from dividing the hourly amount of dioxins emitted from 9 facilities—which was calculated using 9 sets of data (0.00065–0.050 ng-TEQ/m^3N) taken by business operators through voluntary measurements at the 9 facilities—by the daily amounts of steel scrap charged at these 9 facilities.

The total annual amount of dioxin emission was estimated to be 1.40 g-TEQ, calculated by multiplying the per-unit dioxin emission by the 1,508,509 tons of the annual steel scrap charged in 2000.

The total annual amounts of dioxins emitted in 1998 and 1999 were recalculated adding one new set of data from this year. Thus, the total annual amounts of dioxins emitted were estimated to be 1.98 g-TEQ in 1998 and 1.53 g-TEQ in 1999.

32) Primary Copper Smelting Facilities

The total annual amount of dioxins emitted in 2000 was estimated to be 0.59g-TEQ, derived from adding up the annual amounts of dioxins emitted from each of the facilities, which were calculated using 10 sets of measurement data (0–0.0392 ng-TEQ/m^3N) gathered by business operators through voluntary measurements at 11 facilities.

The per-unit dioxin emission was 440.2 ng-TEQ/t for each ton of the material charged, derived from dividing the total annual amount of dioxin emission for 2000 by 1,345,211 tons of the material charged in 2000.

In last year's estimation, the total amounts of dioxin emitted each year in 1998 and 1999 were calculated using the concentration ratios of dioxins (WHO-TEF (1998)) and PCDD/PCDF (WHO-TEF (1998)) at 4 facilities in 1999. The concentration ratios of dioxins (WHO-TEF (1998)) and PCDD/PCDF (WHO-TEF (1998)) of the ten new sets of data used this year were also added to the calculation. The total annual amounts of dioxin emissions were re-estimated to be 4.88 g-TEQ for 1998 and 0.45 g-TEQ for 1999.

33) Primary Lead Smelting Facilities

The total annual amount of dioxins emitted in 2000 was estimated to be 0.189 g-TEQ, derived from adding up the annual amounts of dioxins emitted from each of the facilities, calculated using 2 sets of data (0.00121–0.82 ng-TEQ/m^3N) gathered by business operators through voluntary measurements at 2 facilities.

The per-unit dioxin emitted was 1,534.2 ng-TEQ/t for each ton of the material charged, derived from dividing the total annual amount of dioxin emission by 123,132 tons of the material charged in 2000.

In last year's estimation, the total amounts of dioxins emitted each year from 1998 to 1999 were calculated using the concentration ratios of dioxins (WHO-TEF (1998)) and PCDD/PCDF (WHO-TEF (1998)) at 1 facility in 1999. This year, the concentration ratios of dioxins (WHO-TEF (1998)) and PCDD/PCDF (WHO-TEF (1998)) of the two new sets of data were also added to the calculation. The total annual amounts of dioxin emissions were re-estimated to be 0.055 g-TEQ for 1998 and 0.038 g-TEQ for 1999.

34) Primary Zinc Smelting Facilities

The total annual amount of dioxins emitted in 2000 was estimated to be 0.12 g-TEQ,

derived from adding up the annual amounts of dioxins emitted from each facility calculated using 2 sets of data (0.0000029–0.035002 ng-TEQ/m^3N) gathered by business operators through voluntary measurements at 10 facilities.

The per-unit dioxin emission was 167.2 ng-TEQ/t for each ton of the material charged. The value was derived from dividing the total annual amount of dioxin emissions by 723,552 tons of the material charged in 2000.

In last year's estimation, the total amounts of dioxins emitted each year for 1998 and 1999 were estimated by multiplying the average emission ratios of PCDD/PCDF (I-TEF (1988)) and dioxins (WHO-TEF (1998)) of the primary copper smelting, primary lead smelting, copper recovering and zinc recovering processes in 1999, by the PCDD/PCDF (I-TEF (1988)) emission from the primary zinc smelting process in 1999. This year, the concentration ratios of dioxins (WHO-TEF (1998)) and PCDD/PCDF (WHO-TEF (1998)) of two new sets of data were also added to the calculation. The total annual amounts of dioxin emissions were re-estimated to be 0.33 g-TEQ for 1998 and 0.13 g-TEQ for 1999.

35) Copper Recovering Facilities

The total annual amount of dioxins emitted in 2000 was estimated to be 0.038 g-TEQ, using 1 set of data (0.354 ng-TEQ/m^3N) gathered by business operators through voluntary measurement at 1 facility.

The per-unit dioxin emission was 1,911,600 ng-TEQ/t for each ton of the material charged, derived from dividing the total annual amount of dioxin emission by 20 tons of the material charged in 2000.

36) Lead Recovery Facilities

The total annual amount of dioxins emitted in 2000 was estimated to be 0.54 g-TEQ, derived from adding up the annual amounts of dioxins emitted from each of the facilities calculated using 3 sets of data (0.234–0.738 ng-TEQ/m^3N) gathered by business operators through voluntary measurements at 4 facilities.

The per-unit dioxin emission was 5,271.1 ng-TEQ/t for each ton of the material charged, derived from dividing the total annual amount of dioxin emissions by 103,310 tons of the material charged in 2000.

In last year's estimation, the total amounts of dioxins emitted each year for 1998 and 1999 were calculated using the concentration ratios of dioxins (WHO-TEF (1998)) and PCDD/PCDF (WHO-TEF (1998)) at 2 facilities in 1999. This year, the concentration ratios of dioxins (WHO-TEF (1998)) and PCDD/PCDF (WHO-TEF (1998)) of two new sets of

data were added to the calculation. The total annual amounts of dioxin emissions were re-estimated to be 1.23 g-TEQ for 1998 and 0.44 g-TEQ for 1999.

37) Precious Metals Recovery Facilities

The total annual amount of dioxins emitted in 2000 was estimated to be 0.055 g-TEQ, derived from adding up the annual amounts of dioxins emitted from each facility calculated using 4 sets of data (0.000031–1.26 ng-TEQ/m^3N) gathered by business operators through voluntary measurements at 4 facilities.

The per-unit dioxin emission was 5,245.9 ng-TEQ/t for each ton of the material charged, derived from dividing the total annual amount of dioxin emissions by 10,582 tons of the material charged in 2000.

In last year's estimation, the total annual amounts of dioxins emitted each year for 1998 and 1999 were estimated by multiplying the average emission ratios of PCDD/PCDF (I-TEF (1988)) and dioxins (WHO-TEF (1998)) from the primary copper smelting, primary lead smelting, copper recovering and zinc recovering processes in 1999, by the PCDD/PCDF (I-TEF (1988)) emission from the precious metal recovering process in 1999. This year, using the concentration ratios of dioxins (WHO-TEF (1998)) and PCDD/PCDF (WHO-TEF (1998)) derived from four new sets of data for calculation, the total annual amounts of dioxin emission were re-estimated to be 0.031 g-TEQ for 1998 and 0.046 g-TEQ for 1999.

38) Wrought Copper Products Manufacturing Facilities

Since last year's estimation, no new measurements had been taken. For this reason, the annual amounts of dioxin emissions emitted by furnace type (0.14 g-TEQ for shaft kiln, 0.60 g-TEQ for copper electric furnace, and 0.54 g-TEQ for brass electric furnace) were calculated by multiplying the dioxin emission per ton of copper and brass produced in 1999 (395.5 ng-TEQ/t for shaft kiln, 2809.3 ng-TEQ/t for copper electric furnace, and 899.1 ng-TEQ/t for brass electric furnace) by the annual amounts of production by the corresponding furnace type in 2000 (358,499 tons by shaft kiln, 213,698 tons by copper electric furnace, and 595,552 tons by brass electric furnace). Summing up the annual amounts of dioxin emissions by these furnace types, the total annual amount of dioxin emission for 2000 was estimated to be 1.28 g-TEQ.

39) Wire and Cable Manufacturing Facilities

The per-unit dioxin emission from shaft kilns was 1,573.3 ng-TEQ/t per ton of electric wires and cables produced. The per-unit emission was derived from dividing the annual amount of dioxin emission—calculated using 1 set of data (0.25 ng-TEQ/m^3N) taken by a business operator through voluntary measurement at 1 shaft kiln facility—by the annual amount of production. Since last year's estimation, no new measurements of reverberating furnaces,

DIP furnaces, and aluminum melting furnaces had been taken. For this reason, the per-unit dioxin emissions from 1999 (870.7 ng-TEQ/t for reverberating furnaces, 0.43 ng-TEQ/t for DIP furnaces, and 471.3 ng-TEQ/t for aluminum melting furnaces) were used.

The annual amounts of dioxin emissions by furnace type (1.25 g-TEQ from shaft kilns, 0.02 g-TEQ from reverberating furnaces, 0.00 g-TEQ from DIP furnaces, and 0.03 g-TEQ from aluminum melting furnaces) were calculated by multiplying the per-unit dioxin emission of each furnace type by the annual amounts of electric wires and cables produced by the corresponding furnace types (791,107 tons by shaft kiln, 25,700 tons by reverberating furnace, 63,512 tons by DIP furnace, and 62,891 tons by aluminum melting furnace). Summing up the amounts of dioxins emitted by these furnace types, the total annual amount of dioxin emission for 2000 was estimated to be 1.30 g-TEQ.

40) Aluminum Casing/Die-casting Facilities

The dioxin emissions per ton of production were 355.6 ng-TEQ/t from reverberating furnace and 306.6 ng-TEQ/t from crucible furnace. The figures were derived from dividing the one-hour amounts of dioxins emitted from 28 reverberating furnace facilities and 4 crucible furnace facilities—calculated using 25 sets of data (0.001–1.8 ng-TEQ/ m^3N) taken by business operators through voluntary measurements at 28 reverberating furnace facilities and 4 sets of data (0.012–0.18 ng-TEQ/ m^3N) taken at 4 crucible furnace facilities—by the amounts of production per hour at the 28 reverberating furnace facilities and 4 crucible furnace facilities, respectively.

The annual amounts of dioxin emission by furnace type (0.345 g-TEQ from reverberating furnaces and 0.048 g-TEQ from crucible furnaces) were calculated by multiplying the dioxin emission per ton of production by each furnace type by the annual amounts of production by the corresponding furnace type (971,000 tons by reverberating furnaces and 155,000 tons by crucible furnaces). Summing up the amounts of dioxins emitted by these furnace types, the total annual amount of dioxin emission for 2000 was estimated to be 0.39 g-TEQ.

In last year's estimation, the total annual amounts of dioxins emitted each year for 1998 and 1999 were calculated using the concentration ratios of dioxins (WHO-TEF (1998)) and PCDD/PCDF (I-TEF (1988)) at 10 reverberating furnace facilities and 3 crucible furnace facilities in 1999. Adding 15 new sets of data for reverberating furnace facilities from 2000 for calculation, the total annual amounts of dioxin emissions were re-estimated to be 0.36 g-TEQ for 1998 and 0.37 g-TEQ for 1999.

41) Automobile Manufacturing (Aluminum Casting and Die-casting) Facilities

The dioxin emission per ton of production was 2,686.1 ng-TEQ/t, derived from dividing the

annual amount of dioxins emitted from 72 facilities by the annual amount of production of the 72 facilities. The annual amount of dioxins emitted from the 72 facilities was calculated using 53 sets of data (0–1.2 ng-TEQ/ m^3N) from 72 facilities, including 52 sets of data (0–1.2 ng-TEQ/ m^3N) contributed by business operators through voluntary measurements at 72 facilities and 1 set of data (0.044 ng-TEQ/ m^3N) contributed by a local government through measurement taken at the inspection of 1 facility.

Multiplying the per- unit dioxin emission by the total amount of 379,155.4 tons produced nationwide in 2000, the total annual amount of dioxin emission was estimated to be 1.02g-TEQ.

42) Automobile Parts Manufacturing (Aluminum Casting and Die-casting) Facilities

The total amount of dioxins emitted in 2000 was estimated to be 0.58 g-TEQ, derived from adding together the annual amounts of dioxins emitted from 43 facilities using 43 sets of data (0–11 ng-TEQ/ m^3N), including 41 sets of data (0–11 ng-TEQ/ m^3N) contributed by business operators through voluntary measurements at 43 facilities and 2 sets of data (0.033 –2.5 ng-TEQ/ m^3N) contributed by local governments through measurements taken at the inspection of 2 facilities.

The dioxin emission per ton of production was 3,287.6 ng-TEQ/t, calculated by dividing the total annual amount of dioxin emission by the annual amount of 176,178 tons produced in 2000.

43) Thermal Power Plant

Since last year's estimation, no new measurements had been taken. The annual amounts of dioxin emission by fuel type (1.01 g-TEQ from coal, 0.51 g-TEQ from oil, and 0.19 g-TEQ from LNG) were calculated by multiplying the dioxin emission per kWh of thermal power generated from 1997 to 1999 (0.0071 ng-TEQ/kWh for coal, 0.0067 ng-TEQ/kWh for oil, and 0.00076 ng-TEQ/kWh for LNG) by the annual amounts of electricity generated from each of the fuel types in 2000 (142,572 million kWh from coal, 76,303 million kWh from oil, and 247,790 million kWh from LNG). Summing up the annual amounts of dioxins emitted by these fuel types, the total annual amount of dioxin emission for 2000 was estimated to be 1.71 g-TEQ.

44) Cigarette Smoke

Table 9 shows the annual consumption of cigarettes from FY 1997 to FY 2000.

Table 9 Cigarette Consumption (Unit:100 million/year)

	FY 1997	FY 1998	FY 1999	FY 2000

Annual cigarette consumption	3,280	3,366	3,322	3,245

There is a report compiled by Matsueda et al. regarding the amount of dioxins contained in cigarettes[1)].

In 1992, Matsueda et el. conducted a survey on cigarettes produced in different countries that were on sale in the market to determine their dioxin contents. Using the amount of dioxins contained in cigarettes of Japanese brands, and assuming that 1) the part of cigarette burnt to ashes weighed 0.6 g/cigarette, and 2) all dioxins were emitted into the environment through cigarette smoking without generating dioxins anew or causing changes in the profile of isomers as a result of burning cigarettes, the per-unit dioxin emission was determined to be 0.293 pg-TEQ/cigarette. The amounts of dioxin emission were calculated by multiplying the per-unit emission by the numbers of cigarettes consumed in the respective years. The estimated amounts of dioxin emission are shown in Table 10.

Table 10 Report by Matsueda et el. (Unit: g-TEQ/year)

	1997	1998	1999	2000
Dioxins	0.0961	0.0986	0.0973	0.0951

According to Bump et al., the amount of PCDD/PCDF emitted from cigarette smoke was reported to be 33–67 pg/g. Although the amount of coplanar PCBs emission was not mentioned in the report by Bump et el. [2)], using WHO-TEF (1998) to convert the amount of PCDD/PCDF into toxic equivalents (TEQs) and assuming that the part of cigarette burnt to ashes weighed 0.6 g/cigarette, the amount of PCDD/PCDF amounted to 0.295–0.537 pg-TEQ/cigarette. Adding this amount to 0.040 pg-TEQ/cigarette—the per-unit coplanar PCBs obtained by Matsueda et el. using WHO-TEF (1998), the per-unit dioxins (WHO-TEF (1998)) emitted was estimated to be 0.335–0.577 pg-TEQ/cigarette. Multiplying the per-unit emission by the corresponding annual consumption of cigarettes, the annual amounts of dioxins emitted were estimated, as shown in Table 11.

Table 11 Report by Bump et el. (Unit: g-TEQ/year)

	1997	1998	1999	2000
Dioxins	0.110–0.189	0.113–0.194	0.111–0.192	0.109–0.187

From the results of these two estimation methods, the amounts of dioxin emission were estimated as follows in Table 12.

Table 12 Amounts of Dioxin Emission from Cigarettes (Unit: g-TEQ/year)

	1997	1998	1999	2000
Dioxins	0.0961–0.189	0.0986–0.194	0.0973–0.192	0.0951–0.187

Although data on the active mass (amount of cigarettes consumed) were highly reliable, the per-unit dioxin emissions were derived mainly from estimation, making the overall amount of dioxin emissions less than reliable.

Notes

1) Matsueda et al. "Concentration of PCDDs, PCDFs and Coplanar PCBs in Cigarettes From Various Countries." *ORGANOHALOGEN COMPOUNDS*, Vol.20 (1994)
2) R. R. Bump, et al. "Trace chemistries of fire: a source of chlorinated dioxins." *Science* 210(4468)385-390 (1980)

45) Exhaust from Automobiles

The Ministry of the Environment, the Japan Automobile Manufacturers Association, Inc., and the Petroleum Energy Center conducted independent measurements of the concentration of dioxins (WHO-TEF (1998)) in automobile exhaust using equipment such as the chassis dynamometer system. Converting the measurement results into an emission amount per fuel consumption, the average value for diesel-fueled vehicles was 36.01 pg-TEQ/l (1.2–173.5 pg-TEQ/l) and the average value for gasoline-fueled vehicles was 2.93 pg-TEQ/l (0.34–16.42 pg-TEQ/l) (Table 13). Assuming these values were representative of vehicles in Japan and multiplying these values by the fuel consumption of automobile (39,878,697 kl of light oil and 60,393,690 kl of gasoline) in 2000, the total annual amount of dioxins emitted from automobiles was 1.61 g-TEQ (1.436 g-TEQ from diesel-fueled vehicles and 0.177 g-TEQ from gasoline-fueled vehicles).

This time, five vehicles were added to the previous trial calculation of ten vehicles. Although the data were obtained from the actual measurement of 15 vehicles, the small number of measurement examples and unproven measurement methods made estimation of the annual amount of dioxin emission largely dependent on assumption, making the final estimation less than reliable.

Table 13 Survey Results Showing the State of Dioxin Emissions from Automobiles

WHO-TEF(1998)

Vehicle type		Test condition	Emission concentration (ng-TEQ/m^3)	Emission per fuel (pg-TEQ/ l)
Diesel	Truck	① 13-mode[1]	0.00341	99.63
		② 80 km constant speed, 40% rotation/load[2]	0.00015 0.00208	4.99 103.36
		③ 13-mode	0.00012	8.65
		④[3] 13-mode 80 km constant speed 40% rotation/load	0.00011 0.00004 0.00006	3.48 1.20 1.70
	Car	⑤ 80 km constant speed	0.00041	4.28
		⑥ 80 km constant speed	0.00042	4.63
		⑦ 80 km constant speed	0.00020	2.21
		⑧ 80 km constant speed 10/15-mode[4]	0.00006 0.00017	1.47 3.70
		⑨ 80 km constant speed 10/15-mode	0.0100 0.0145	121.0 173.5
		⑩ 80 km constant speed	0.00069	6.39
Gaso-line	Truck	⑪ 80 km constant speed Actual running mode[5]	0.00025 0.00004	0.99 0.42
	Car	⑫ 80 km constant speed 10/15-mode	0.00166 0.00044	16.42 4.50
		⑬ 80 km constant speed 10/15-mode	0.00007 0.00013	0.69 1.25
		⑭ 80 km constant speed 10/15-mode	0.00035 0.00003	3.6 0.34
		⑮ 80 km constant speed 10/15-mode	0.00008 0.00004	0.77 0.36

(Major Assumptions)

- Diesel-fueled trucks tested were all direct-ingestion types that conformed to the 1994 exhaust emission standards. ③ used 2-ton class vehicles, others used 10-ton class.
- ⑥⑦⑩ diesel vehicles were direct-ingestion types. ⑨ used a divided-chamber type vehicle that conformed to the 1998 exhaust emission standards. ⑤⑧ used divided-chamber type vehicles that conformed to the 1997 exhaust emission standards.
- Gasoline-fueled trucks conformed to the 1998 exhaust emission standards.
- ⑮ of the gasoline-fueled vehicles conformed to the 2000 exhaust emission standards.

Other gasoline-fueled vehicles conformed to the 1978 exhaust emission standards.

- Trucks were measured at 50% loadage and vehicles were measured at 110 kg loading condition.
- ①⑨⑪⑭⑮ were data measured by the Ministry of the Environment. ②⑤⑥⑦⑩⑫ were data measured by the Japan Automobile Manufacturers Association, Inc. ③④⑧⑬ were data measured by the Petroleum Energy Center. Among them, ⑨⑩⑪⑭⑮ were newly added data for this report.

（Notes）

1) “13-mode” referred to the same operating condition as the 13-mode cycle test procedure for diesel-fueled vehicles, the legally mandated method for measuring exhaust emissions of large-size vehicles.
2) “40% speed/load” referred to the operating condition at which the speed was at 40% of the nominal, and the load was at 40%.
3) Measurement data in ④ were taken not from vehicles but from experiments using the engine alone. The test condition for 80-km constant speed was created with the engine running at 80-km constant speed.
4) “10/15-mode” referred to the same operating condition as the 10/15-mode cycle test procedure, the legally mandated method for measuring exhaust emission of vehicles.
5) “Actual running-mode” referred to the running mode at average speed of 26.1 km/h.

(Ⅱ) Release into the Water

1) Domestic Waste Incineration Facilities

"Among the domestic waste incineration facilities that are obliged to submit notification under the Water Pollution Control Law", those included in the estimation of dioxin emissions under the category of "domestic waste incineration facilities" were "those that either have waste gas cleansing facilities or wet-type dust-collecting facilities, and that discharge effluent from incineration such as effluent from smoke-cleansing, etc." Since the enforcement of the Law in January 2000, however, "among the domestic waste incineration facilities, those that have no waste gas cleansing facilities but store ashes and discharge effluent into the public waters" have also become subject for estimation.

The amount of dioxins discharged from domestic waste incineration facilities in 2000 was calculated by adding the amounts of dioxins discharged from waste gas cleansing facilities and wet-type dust-collecting facilities, and those from facilities that do not have the aforementioned facilities but have ash-storing facilities. Assuming that the emissions for 1999 and previous years from ash-storing facilities were the same as those for 2000, the amounts of dioxins discharged in 1998 to 1999 were estimated by adding the newly estimated amount for the ash-storing facilities in 2000 to the amount of dioxins in previous estimations (carried out in June 2000).

From the above, the annual amounts of dioxins (WHO-TEF(1998)) emitted from domestic waste incineration facilities were estimated to be 0.044 g-TEQ (1998), 0.035 g-TEQ (1999), and 0.035g-TEQ (2000).

① 1998 and 1999

In FY 1998 and 1999, the Environment Agency measured the concentrations of dioxins in effluents discharged from facilities that had either waste gas cleansing facilities or wet-type dust-collecting facilities, and that discharged effluent from incineration such as from smoke-cleansing (29 facilities in FY 1998 and 28 facilities in FY 1999)—from among the domestic waste incineration facilities that were obliged to submit notification under the Water Pollution Control Law. The Agency calculated the dioxin emission per ton of waste from the results of measurements taken at the above 57 facilities over two years, as well as from the daily amounts of effluent discharged and the daily amounts of waste incinerated. After calculating the average values of per-unit emission by facility type (classified by types of furnaces, treatments, and filters), the average values were multiplied by the annual amounts of waste incinerated at each facility type (103 facilities in 1998 and 101 facilities in 1999), giving an estimated annual amount of 0.037 g-TEQ of dioxins (WHO-TEF(1998)) emitted in 1998 and 0.028 g-TEQ in 1999.

The estimated amount of 0.007g-TEQ, which was emitted from domestic waste incineration

facilities that have ash-storage function only (46 facilities) in 2000, was added to the above-mentioned estimated annual amounts of dioxin emission.

② 2000

Of the domestic waste incineration facilities that discharge effluents into public waters (161 facilities), dioxin emissions from each type of facilities, including waste gas cleansing facilities and wet-type dust-collecting facilities (115 facilities) and facilities for ash storage only (46 facilities), were estimated.

Since January 15, 2000, the Law stipulates the mandatory measurement of the concentration of dioxins in effluent more than once a year. Based on the results of voluntary measurement by business operators, including the results of the inspection of facilities conducted by local governments, the annual amount of dioxin emissions was calculated for each facility to estimate the amount of dioxin emission for 2000. Facilities that had been decommissioned or newly established, or the operational status of which had not been verified in the period after the enactment of the Law to March 31, 2001, were considered to have operated for only six months in that year.

Annual amount of dioxin emission (g-TEQ/year)= measured value of dioxin concentration in effluent (pg-TEQ/l) $\times 10^{3} \times$ amount of effluent discharged per day (t/day) $\times$ number of operating days per month (day/month) $\times$ number of operating months per year (month) $\times 10^{-12}$

In this calculation, for facilities of which the data of dioxin concentration in effluent and daily amount of effluent discharged were unknown, the average annual amount of dioxin emissions (0.00025g-TEQ/year for waste gas cleansing facilities, etc. and 0.00015g-TEQ/year for ash-storage only facilities), calculated based on data gathered from facilities with verified data (79 facilities for waste gas cleansing facilities, etc. and 32 ash-storage only facilities) was used.

As a result, dioxins emitted from waste gas cleansing facilities, etc. and from ash-storage only facilities were estimated to be 0.028g-TEQ, and 0.007g-TEQ, respectively.

2) Industrial Waste Incineration Facilities

"Among the domestic waste incineration facilities that are obliged to submit notification under the Water Pollution Control Law", those included in the estimation of dioxin emissions under the category of "industrial waste incineration facilities" were "those that either have waste gas cleansing facilities or wet-type dust-collecting facilities, and that discharge effluent from incineration such as from smoke-cleansing, etc." Since the enforcement of the Law in January 2000, however, the following facilities, which were not included in previous estimations, were

added in the category under "industrial waste incineration facilities" for dioxin emission estimation: 1) "among the industrial waste incineration facilities that either have waste gas cleansing facilities or wet-type dust-collecting facilities and that discharge effluent into public waters, those that are not regulated by the Water Pollution Control Law (including small waste incinerators, which are not regulated by the Waste Disposal and Public Cleansing Law), such as incineration facilities used by business operators to burn industrial waste on their own, incineration facilities for wood chips, etc., and 2) "among the industrial waste incineration facilities, those that do not have waste gas cleansing facilities but have ash-storage facilities, and that discharge effluent into public waters."

The amount of dioxins emitted from industrial waste incineration facilities in 2000 was derived by estimating the dioxin emissions of each type of facility, including facilities that either had waste gas cleansing facilities or wet-type dust-collecting facilities, and facilities that did not have the above-mentioned facilities but ash-storage facilities. The 1998 and 1999 dioxin emissions were calculated, assuming that the same number of facilities that had waste gas cleansing facilities in 2000, including those not regulated by the Water Pollution Control Law, existed in 1998 and 1999, and assuming that the facilities that had ash-storage facilities had the same amount of emission in 1998 and 1999 as in 2000. Using the value obtained in the previous estimation (June 2000) as the base value, the total amount of dioxin emissions was calculated for the increased number of industrial waste incineration facilities, including those not regulated by the Water Pollution Control Law. The emission from ash-storing facilities was also added to this total.

As a result, the annual amount of dioxins (WHO-TEF(1998)) emitted from industrial waste incineration facilities were estimated to be 5.27 g-TEQ (1998), 5.29 g-TEQ (1999), and 2.47 g-TEQ (2000).

① 1998 and 1999

In FY 1998 and 1999, the Environment Agency measured the concentrations of dioxins in effluents discharged from facilities that had either waste gas cleansing facilities or wet-type dust-collecting facilities, and that discharged effluent from incineration such as from smoke-cleansing (7 facilities in FY 1998 and 11 facilities in FY 1999)—from among the domestic waste incineration facilities that were obliged to submit notification under the Water Pollution Control Law. The Agency calculated the dioxin emission per ton of waste from the results of measurements taken at the above 18 facilities over two years, as well as from the daily amounts of effluent discharged and the daily amounts of waste incinerated. After calculating the average values of per-unit emission by facility type (classified by furnace type), the average values were multiplied by the annual amounts of waste incinerated at each facility type (42 facilities in 1998 and 41 facilities in 1999). Adding the emission amount of one facility where an accident had occurred to this value, estimated annual amounts of dioxin

(WHO-TEF(1998)) emissions were estimated to be 0.51 g-TEQ (1998) and 0.50 g-TEQ (1999).

With regard to incineration facilities for industrial waste that were not required to submit notification under the Water Pollution Control Law, including incineration facilities used by operators to burn industrial waste on their own, incineration facilities for wood chips, etc., the amounts of dioxins emitted in 1998 and 1999 were calculated by assuming that the same number of facilities existed in 1998 and 1999 as in 2000. Multiplying the number of facilities in 2000 (388 facilities) by the average amounts of dioxin emissions per facility for 1998 and 1999, respectively, the annual amounts of dioxins (WHO-TEF(1998)) emitted were estimated to be 4.71 g-TEQ (1998) and 4.73 g-TEQ (1999).

Furthermore, an estimated amount of 0.25g-TEQ of dioxins emitted from incineration facilities for industrial waste that had ash-storage facilities only and that discharged effluent (21 facilities) was added to the 2000 estimation.

An estimated amount of 0.31g-TEQ of dioxins emitted from facilities (72 facilities) that were not classified under any category in 2000 was added to the amount for industrial waste incineration facilities.

② 2000

Of the domestic waste incineration facilities that discharge effluents into public waters (409 facilities), dioxin emissions from each type of facilities, including waste gas cleansing facilities and wet-type dust-collecting facilities (388 facilities) and facilities for ash storage only (21 facilities), were estimated.

Since January 15, 2000, the Law stipulates the mandatory measurement of the concentration of dioxins in effluent more than once a year. Based on the results of voluntary measurements by business operators, including the results of the inspection of facilities conducted by local governments, the annual amount of dioxin emissions was calculated for each facility to estimate the amount of dioxin emission for 2000. Facilities that had been decommissioned or newly established, or the operational status of which had not been verified in the period after the enactment of the Law to March 31, 2001, were considered to have operated for only six months in that year.

Annual amount of dioxin emission (g-TEQ/year)= measured value of dioxin concentration in effluent (pg-TEQ/l) $\times 10^{3} \times$ amount of effluent discharged per day (t/day) $\times$ number of operating days per month (day/month) $\times$ number of operating months per year (month) $\times 10^{-12}$

In this calculation, for facilities in which the data of dioxin concentration in effluent and daily amount of effluent discharged were unknown, the average annual amount of dioxin emissions (0.0049g-TEQ/year for waste gas cleansing facilities, etc. and 0.0091g-TEQ/year for ash-storage only facilities), calculated based on data gathered from facilities with verified data (287 facilities for waste gas cleansing facilities, etc. and 16 ash-storage only facilities) was used. For the facilities that do not belong to any category, the average emission of 0.0040g-TEQ calculated based on data of industrial waste incineration facilities that had all necessary data (457 facilities).

As a result, dioxins emitted from waste gas cleansing facilities, etc., ash-storage only facilities and facilities that belong to no category were estimated to be 1.91g-TEQ, 0.25g-TEQ, and 0.31g-TEQ, respectively.

3) Bleaching Facilities for Pulp Making

The total annual amount of dioxins emitted in 2000 was estimated to be 0.73 g-TEQ, derived from adding together the annual amounts of dioxins emitted from 38 facilities using 53 sets of data (0.00045–3.6 pg-TEQ/l), including 41 sets of data (0.00045–3.6 pg-TEQ/l) contributed by business operators through voluntary measurements at 38 facilities and 12 sets of data (0.0018–2 pg-TEQ/l) contributed by local governments through measurements taken at the inspection of 11 facilities.

The dioxin emission per ton of bleached craft pulp produced was 83.7 ng-TEQ/t, calculated by dividing the total annual amount of dioxin emissions by the annual amount of 8,719,705 tons of bleached craft pulp produced in 2000.

4) PVC Monomer Manufacturing Facilities

The total annual amount of dioxins emitted in 2000 was estimated to be 0.20 g-TEQ, derived from adding together the annual amounts of dioxins emitted from 9 facilities using 9 sets of data (0.076–3.8pg-TEQ/l) contributed by business operators through voluntary measurements.

The dioxin emission per ton of production was 67.6 ng-TEQ/t, calculated by dividing the total annual amount of dioxin emissions by the annual amount of 3,020,580 tons of production in 2000.

Because the values of daily amount of effluent and annual amount of production used last year for estimating the total annual dioxin emissions for 1997–1999 were inaccurate, the total annual amounts were re-estimated to be 0.54 g-TEQ for 1997, 0.53 g-TEQ for 1998, and 0.55 g-TEQ for 1999.

5) Aluminum Alloy Manufacturing (Rolling, etc.)

The total annual amount of dioxins emitted in 2000 was estimated to be 0.054 g-TEQ, derived from adding together the annual amounts of dioxins emitted from 16 business sites using 24 sets of data (0.00017–17 pg-TEQ/l), including 21 sets of data (0.00017–17 pg-TEQ/l) contributed by business operators through voluntary measurements at 16 business sites and 3 sets of data (0.075–1.4 pg-TEQ/l) contributed by local governments through measurements taken at the inspection of 3 facilities.

The dioxin emission per ton of melting was 27.8 ng-TEQ/t, calculated by dividing the total annual amount of dioxin emissions by the annual amount of 1,959,817 tons of melting in 2000.

Since last year's estimation of the total annual amounts of dioxin emissions for 1997–1999 only included the emissions from 11 business sites, the total annual amounts were re-estimated adding the emissions from five new business sites measured since 2000. Thus, the total annual amounts were estimated to be 0.338 g-TEQ for 1997, 0.066 g-TEQ for 1998, and 0.091 g-TEQ for 1999.

6) Aluminum Alloy Manufacturing (Automobiles and Automobile Parts Manufacturing)
The total annual amount of dioxins emitted in 2000 was estimated to be 0.0015 g-TEQ, derived from adding together the annual amounts of dioxins emitted from 9 business sites using 10 sets of data (0.0004–1.4 pg-TEQ/l), including 9 sets of data (0.0004–1.4 pg-TEQ/l) contributed by business operators through voluntary measurements at 9 business sites and 1 set of data (0.084 pg-TEQ/l) contributed by the local government through measurement taken at the inspection of 1 facility.

7) Caprolactam Manufacturing (Using Nitrosyl Chloride) Facilities
The total annual amounts of dioxins emitted were estimated to be 2.50 g-TEQ in 1997, 2.52 g-TEQ in 1998, 2.53 g-TEQ in 1999, and 1.80g-TEQ in 2000. These estimates were derived from adding together the annual amounts of dioxins emitted from each of the 2 business sites from 1997 to 2000 using 13 sets of data (2.8–170 pg-TEQ/l), including 9 sets of data (2.8–150 pg-TEQ/l) contributed by business operators through voluntary measurements at 2 business sites and 4 sets of data (8.3–170 pg-TEQ/l) contributed by local governments through measurements taken at the inspection of 2 facilities.

8) Chlorobenzene Manufacturing Facilities
The total annual amounts of dioxins emitted were estimated to be 0.011 g-TEQ in 1997, 0.011 g-TEQ in 1998, 0.011 g-TEQ in 1999, and 0.012 g-TEQ in 2000. These estimates were derived from adding together the annual amounts of dioxins emitted from each of the 4 business sites from 1997 to 2000 using 12 sets of data (0.00195–9.5 pg-TEQ/l), including 8 sets of data (0.00195–9.5 pg-TEQ/l) obtained from the results of measurements conducted by the Ministry of Economy, Trade and Industry and the Ministry of the Environment at 4 facilities and 4 sets of data (0.044–6.7 pg-TEQ/l) contributed by business operators through voluntary measurements at

4 business sites.

The dioxin emission per ton of production was 141.1 ng-TEQ/t, calculated by dividing the total annual amount of dioxin emission for 2000 by the annual amount of 82,180 tons of production in 2000.

9) Potassium Sulphate Manufacturing Facilities

The total annual amounts of dioxins emitted were estimated to be 0.078 g-TEQ in 1997, 0.074 g-TEQ in 1998, 0.076 g-TEQ in 1999, and 0.081 g-TEQ in 2000. These estimates were derived from adding together the annual amounts of dioxins emitted from each of the 3 business sites from 1997 to 2000 using 10 sets of data (0.0162–43 pg-TEQ/l), including 7 sets of data (0.0162–38.3 pg-TEQ/l) obtained from the results of measurements conducted by the Ministry of Economy, Trade and Industry and the Ministry of the Environment at 3 facilities and 3 sets of data (1.0–43 pg-TEQ/l) contributed by business operators through voluntary measurements at 3 business sites.

The dioxin emission per ton of production was 2,681.7 ng-TEQ/t, calculated by dividing the total annual amount of dioxin emission for 2000 by the annual amount of 30,173 tons of production in 2000.

10) Acetylene Manufacturing (Dry Process) Facilities

The total annual amounts of dioxins emitted were estimated to be 1.80 g-TEQ in 1997, 1.61 g-TEQ in 1998, 1.63 g-TEQ in 1999, and 1.76 g-TEQ in 2000. These estimates were derived from adding together the annual amounts of dioxins emitted from each of the 2 business sites from 1997 to 2000 using 2 sets of data (0.51–60 pg-TEQ/l) contributed by business operators through voluntary measurements at 2 business sites.

11) Short Alumina Fiber Manufacturing Facilities

The total annual amounts of dioxins emitted were estimated to be 0.074 g-TEQ in 1997, 0.087 g-TEQ in 1998, 0.082 g-TEQ in 1999, and 0.096 g-TEQ in 2000. These estimates were derived from adding together the annual amounts of dioxins emitted from each of the 3 business sites from 1997 to 2000 using 5 sets of data (4.24–60 pg-TEQ/l), including 3 sets of data (4.24–60 pg-TEQ/l) contributed by business operators through voluntary measurements at 3 business sites and 2 sets of data (4.48–9.67 pg-TEQ/l) obtained from the results of measurement conducted by the Ministry of Economy, Trade and Industry and the Ministry of the Environment at one facility.

12) Terminal Sewage Treatment Facilities

In FY 1996, the Environment Agency conducted a survey of the concentration of dioxins in effluents discharged from 7 terminal sewage treatment facilities. Since the dioxin

concentrations were all below the lower end of the fixed level, estimation of dioxin emissions was not carried out. However, after the Law was enacted in January 2000, business operators detected dioxins in their voluntary measurements. Thus, the estimation of the dioxin emission was carried out for 224 specified facilities.

Since January 15, 2000, the Law stipulates the mandatory measurement of the concentration of dioxins in effluent more than once a year. Based on the results of voluntary measurement by business operators, including the results of inspection of facilities conducted by local governments, the annual amount of dioxin emissions was calculated for each facility to estimate the amount of dioxin emission for 2000. In the period following the enactment of the Law to March 31, 2001, facilities that had been decommissioned or newly established, or the operational status of which had not been verified (operation suspected), were considered to have operated for only six months in that year.

Annual amount of dioxin emissions (g-TEQ/year) = measured value of dioxin concentration in effluent (pg-TEQ/l) $\times 10^{3} \times$ amount of effluent discharged per day (t/day) $\times$ number of operating days per month (day/month) $\times$ number of operating months per year (month) $\times 10^{-12}$

In this calculation, with regard to facilities in which the data of dioxin concentration in effluent and daily amount of effluent discharged were unknown, estimation was made using the average annual amount of dioxin emissions (0.0045 g-TEQ /year), calculated based on data gathered from facilities with verified data (199 facilities).

From these results, the annual amount of dioxins (WHO-TEF(1998)) emitted in 2000 was estimated to be 1.09 g-TEQ. The annual amounts of dioxins emitted in the years 1997–1999 were assumed to be the same as the amount in 2000.

13) Joint Wastewater Treatment Facilities

Since the concentration of dioxins in effluent discharged from joint sewage treatment facilities that treat effluents from other factories and business sites had not been measured before, no estimate of the dioxin emission had been made. However, with the enactment of the Law in January 2000, the estimation of dioxin emission was carried out for 30 specified facilities.

Since January 15, 2000, the Law stipulates the mandatory measurement of the concentration of dioxins in effluent more than once a year. Based on the results of voluntary measurements by business operators, including results of the inspection of facilities conducted by local governments, the annual amount of dioxin emissions was calculated for each facility to estimate the amount of dioxin emission for 2000. In the period following the enactment of the Law to March 31, 2001, facilities that had been decommissioned or newly established, or the

operational status of which had not been verified (operation suspected), were considered to have operated for only six months in that year.

Annual amount of dioxin emissions （g-TEQ/year） = measured value of dioxin concentration in effluent （pg-TEQ/l） $\times 10^{3} \times$ amount of effluent discharged per day (t/day) $\times$ number of operating days per month (day/month) $\times$ number of operating months per year (month) $\times 10^{-12}$

In this calculation, with regard to facilities of which the data of dioxin concentration in effluent and daily amount of effluent discharged were unknown, estimation was made using the average annual amount of dioxin emissions (0.0038 g-TEQ /year), calculated based on data gathered from facilities with verified data (20 facilities).

From these results, the annual amount of dioxins (WHO-TEF(1998)) emitted in 2000 was estimated to be 0.126 g-TEQ. The annual amounts of dioxins emitted in the years 1997–1999 were assumed same as the amount in 2000.

14) Final Disposal Sites

① 1997, 1998, and 1999

In the “Environmental Conservation Survey of Final Disposal Sites” conducted by the Environment Agency in FY 1998, dioxins contained in water from treatment as well as from water seeping from 21 of the final disposal sites nationwide were measured. According to survey results and data of the National Institute for Environmental Studies and the Ministry of Health and Welfare, the average concentration of dioxins in water seeping from 94 facilities (21 facilities for the measurement of coplanar PCBs) was 5.7 pg-TEQ/l (0–306 pg-TEQ/l) and the average concentration of dioxins in water from treatment from 24 facilities (15 facilities for the measurement of coplanar PCBs) was 0.18 pg-TEQ/l (0–1.1 pg-TEQ/l).

The annual amount of dioxin emissions was estimated to be 0.093 g-TEQ, derived from multiplying the average values of dioxin concentration by the total amount discharged from final disposal sites—which was calculated from the total area of final disposal sites nationwide and the average annual rainfall.

② 2000

The annual amount of dioxins contained in effluents was estimated to be 0.056 g-TEQ, derived from multiplying the average value of dioxin concentration (WHO-TEF(1998)) in effluents measured between January 15, 2000 and January 14, 2001 by the areas of landfill in final disposal sites, the amount of rainfall, and the rate of rainwater percolating into the soil.
The above method was used to calculate the annual amount of dioxin emissions from each prefecture.

The annual amount of dioxins emitted from final disposal sites for domestic waste was calculated by adding together the annual amounts of dioxins emitted from each of the prefectures estimated using the above calculation method. The annual amount of dioxins emitted from final disposal sites for industrial waste was estimated using a national average value.

【 Reference 】

a) Toxic Equivalency Factors of PCDD/PCDF

Isomer		WHO-TEF(1998)	I-TEF(1988)
P C D D	2,3,7,8-TCDD	1	1
	1,2,3,7,8-PCDD	1	0.5
	1,2,3,4,7,8-HCDD	0.1	0.1
	1,2,3,6,7,8-HCDD	0.1	0.1
	1,2,3,7,8,9-HCDD	0.1	0.1
	1,2,3,4,6,7,8-HCDD	0.01	0.01
	1,2,3,4,6,7,8,9-OCDD	0.0001	0.001
	Others	0	0
P C D F	2,3,7,8-TCDF	0.1	0.1
	1,2,3,7,8-PCDF	0.05	0.05
	2,3,4,7,8-PCDF	0.5	0.5
	1,2,3,4,7,8-HCDF	0.1	0.1
	1,2,3,6,7,8-HCDF	0.1	0.1
	1,2,3,7,8,9-HCDF	0.1	0.1
	2,3,4,6,7,8-HCDF	0.1	0.1
	1,2,3,4,6,7,8-HCDF	0.01	0.01
	1,2,3,4,7,8,9-HCDF	0.01	0.01
	1,2,3,4,6,7,8,9-OCDF	0.0001	0.001
	Others	0	0

b) Toxic Equivalency Factors of Coplanar PCBs

Isomer		WHO-TEF(1998)
Non-ortho	3,4,4',5-TCB	0.0001
	3,3',4,4'-TCB	0.0001
	3,3',4,4',5-PCB	0.1
	3,3',4,4',5,5'-HCB	0.01
Mono-ortho	2',3,4,4',5-PCB	0.0001
	2,3',4,4',5-PCB	0.0001
	2,3,3',4,4'-PCB	0.0001
	2,3,4,4',5-PCB	0.0005
	2,3',4,4',5,5'-HCB	0.00001
	2,3,3',4,4',5-HCB	0.0005
	2,3,3',4,4',5'-HCB	0.0005
	2,3,3',4,4',5,5'-HCB	0.0001