Findings of the Fiscal 2000 Survey on Brominated Dioxins

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The Ministry of the Environment has compiled the results of the pilot survey on brominated dioxins conducted in fiscal 2000.

This was the first cross-sectional survey on various environmental media of brominated dioxins, and its findings largely helped to elucidate the existence of these dioxins.

1. Overview of survey

In fiscal 2000, the Ministry of the Environment conducted a pilot survey on the existence of brominated dioxins based on article 2 of the supplementary provisions to the Law Concerning Special Measures against Dioxins, which calls for the promotion of studies and research on brominated dioxins.

Concerning this survey:

(1) Three survey sites were established: areas in the vicinity of waste incineration facilities (region A), other general metropolitan areas (region B), and control regions (region C; agricultural regions).

(2) Nine types of media, including such environmental media as ambient air, settled soot and dust, soil, groundwater, public water, sediment, aquatic life (fish and shellfish), and terrestrial wildlife (birds and mammals), and food samples were collected.

(3) The media were determined for brominated dioxins (classified into monobromopolychlorinated dioxins and polybrominated dioxins).

2. Survey findings

(1) Detection according to region

Brominated dioxins were detected in some of the environmental media taken from areas in the vicinity of waste incineration facilities and general metropolitan areas. None were detected in media collected from control regions.

(2) Detection according to media

Brominated dioxins were detected in ambient air, settled soot and dust, soil, sediment, and aquatic life, but were not found in groundwater, public water, terrestrial wildlife, nor food samples.

Table Detection of brominated dioxins

	Ambient air	Settled soot and dust	Soil	Ground-water	Public water	Sediment	Aquatic life	Terres-trial wildlife	Food samples
Areas in the vicinity of waste incineration facilities	○	○	○△	×	×	○△	×	×	×
General metropolitan areas	○	×	○	×	×	○△	○	×	×
Control regions	×	×	×	×	×	×	×	×	×

Legend ○ Monobromopolychlorinated dioxins detected

△ Polybrominated dioxins detected

× Neither dioxin detected

3. Evaluation of surveyed items and further plans

(1) The presence of brominated dioxins in the general environment was largely confirmed through this survey.

(2) The survey will be continued in order to further elucidate the accumulation of brominated dioxins in the environment.

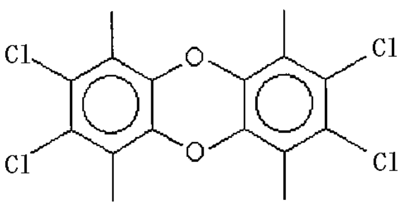
As brominated dioxins exist in the environment at lower concentrations than (chlorinated) dioxins, efforts must be made to enhance determination sensitivity.

(Reference)

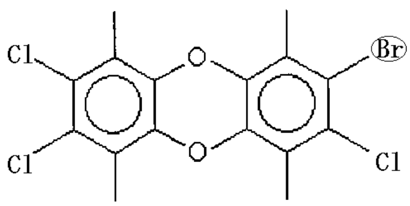
1. “Brominated dioxins” refer to those PCDDs (polychlorinated dibenzo-p-dioxins) and PCDFs (polychlorinated dibenzofurans) in which more than one chlorine atom is substituted by a bromine atom.
2. Those in which only one chlorine atom is substituted by a bromine atom are called “monobromopolychlorinated dioxins”, and those in which all chlorine atoms are substituted by bromine atoms are called “polybrominated dioxins”.

Structural diagram

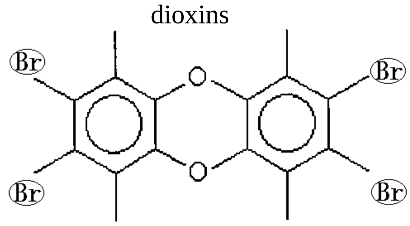
Example of PCDDs



Example of monobromopolychlorinated dioxins



Example of polybrominated dioxins



1 Survey Objectives

Based on Supplementary Provision Article 2 of the Law Concerning Special Measures against Dioxins (1999 law number 105, applied since January 2000), the Ministry of the Environment is working to promote studies and research on the effects of brominated dioxins on human health and the environment.

The objective of this survey was to obtain basic data for promoting studies and research on the effects of brominated dioxins on human health and the ecosystem through a pilot survey conducted in order to grasp the actual conditions of brominated dioxin contamination in the vicinity of regions believed to be producing such dioxins.

2 Outline of Survey

(1) Surveyed media

Surveys were conducted on nine media, consisting of ambient air, settled soot and dust, soil, groundwater, public waters, sediment, aquatic life (fish and shellfish), terrestrial wildlife (birds and mammals), and food samples.

(2) Analyzed compounds

Isomers and congeners of polybrominated dibenzo-p-dioxins (PBDDs) and polybrominated dibenzofurans (PBDFs) shown in Table 1, as well as isomers and congeners of monobromopolychlorinated dibenzo-p-dioxins (MoBPCDDs) and monobromopolychlorinated dibenzofurans (MoBPCDFs) shown in Table 2, were analyzed.

Samples that contained brominated dioxins and food samples were further determined for other dioxins and polybrominated diphenyl ethers (PBDEs). The analyzed items are listed in Tables 3 and 4. Note that only compounds for which internal standards were available were selected for determination in this survey.

Table 1. Polybrominated dibenzo-p-dioxins (PBDDs) and polybrominated dibenzofurans (PBDFs)

Bromine substituted compounds	PBDDs	PBDFs
Tetrabrominated compounds	2,3,7,8-TeBDD	2,3,7,8-TeBDF
Pentabrominated compounds	1,2,3,7,8-PeBDD	1,2,3,7,8-PeBDF 2,3,4,7,8-PeBDF
Hexabrominated compounds	1,2,3,4,7,8-/ 1,2,3,6,7,8-HxBDD 1,2,3,7,8,9-HxBDD	1,2,3,4,7,8-HxBDF

Table 2. Monobromopolychlorinated dibenzo-p-dioxins (MoBPCDDs) and monobromopolychlorinated dibenzofurans (MoBPCDFs)

Substituted compounds	MoBPCDDs	MoBPCDFs
Monobromotrichlorinated compounds	2-MoB-3,7,8-TrCDD	3-MoB-2,7,8-TrCDF
Monobromotetrachlorinated compounds	1-MoB-2,3,7,8-TeCDD	1-MoB-2,3,7,8-TeCDF
Monobromopentachlorinated compounds	2-MoB-3,6,7,8,9-PeCDD	—
Monobromohexachlorinated compounds	1-MoB-2,3,6,7,8,9-HxCDD	—
Monobromoheptachlorinated compounds	1-MoB-2,3,4,6,7,8,9-HpCDD	—

Table 3. Compounds for analysis of dioxins

		No. of chlorines	Compound for analysis	Abbreviation
Dioxins		4	2,3,7,8-tetrachlorodibenzo-p-dioxin	2,3,7,8-TeCDD
			1,3,6,8-tetrachlorodibenzo-p-dioxin	1,3,6,8-TeCDD
			1,3,7,9-tetrachlorodibenzo-p-dioxin	1,3,7,9-TeCDD
			Tetrachlorodibenzo-p-dioxins total	TeCDDs total
		5	1,2,3,7,8-pentachlorodibenzo-p-dioxin	1,2,3,7,8-PeCDD
			Pentachlorodibenzo-p-dioxins total	PeCDDs total
		6	1,2,3,4,7,8-hexachlorodibenzo-p-dioxin	1,2,3,4,7,8-HxCDD
			1,2,3,6,7,8-hexachlorodibenzo-p-dioxin	1,2,3,6,7,8-HxCDD
			1,2,3,7,8,9-hexachlorodibenzo-p-dioxin	1,2,3,7,8,9-HxCDD
			Hexachlorodibenzo-p-dioxins total	HxCDDs total
		7	1,2,3,4,6,7,8-heptachlorodibenzo-p-dioxin	1,2,3,4,6,7,8-HpCDD
			Heptachlorodibenzo-p-dioxins total	HpCDDs total
		8	Octachlorodibenzo-p-dioxin	OCDD
Dibenzofurans		4	2,3,7,8-tetrachlorodibenzofuran	2,3,7,8-TeCDF
			1,2,7,8-tetrachlorodibenzofuran	1,2,7,8-TeCDF
			Tetrachlorodibenzofurans total	TeCDFs total
		5	1,2,3,7,8-pentachlorodibenzofuran	1,2,3,7,8-PeCDF
			2,3,4,7,8-pentachlorodibenzofuran	2,3,4,7,8-PeCDF
			Pentachlorodibenzofurans total	PeCDFs total
		6	1,2,3,4,7,8-hexachlorodibenzofuran	1,2,3,4,7,8-HxCDF
			1,2,3,6,7,8-hexachlorodibenzofuran	1,2,3,6,7,8-HxCDF
			1,2,3,7,8,9-hexachlorodibenzofuran	1,2,3,7,8,9-HxCDF
			2,3,4,6,7,8-hexachlorodibenzofuran	2,3,4,6,7,8-HxCDF
			Hexachlorodibenzofurans total	HxCDFs total
		7	1,2,3,4,6,7,8-heptachlorodibenzofuran	1,2,3,4,6,7,8-HpCDF
			1,2,3,4,7,8,9-heptachlorodibenzofuran	1,2,3,4,7,8,9-HpCDF
			Heptachlorodibenzofurans total	HpCDFs total
		8	Octachlorodibenzofuran	OCDF
Co-planar PCBs	Non-ortho	4	3,4,4',5-tetrachlorobiphenyl	3,4,4',5-TeCB (#81)
			3,3',4,4'-tetrachlorobiphenyl	3,3',4,4'-TeCB (#77)
		5	3,3',4,4',5-pentachlorobiphenyl	3,3',4,4',5-PeCB (#126)
		6	3,3',4,4',5,5'-hexachlorobiphenyl	3,3',4,4',5,5'-HxCB (#169)
	Mono-ortho	5	2',3,4,4',5-pentachlorobiphenyl	2',3,4,4',5-PeCB (#123)
			2,3',4,4',5-pentachlorobiphenyl	2,3',4,4',5-PeCB (#118)
			2,3,3',4,4'-pentachlorobiphenyl	2,3,3',4,4'-PeCB (#105)
			2,3,4,4',5-pentachlorobiphenyl	2,3,4,4',5-PeCB (#114)
		6	2,3',4,4',5,5'-hexachlorobiphenyl	2,3',4,4',5,5'-HxCB (#167)
			2,3,3',4,4',5-hexachlorobiphenyl	2,3,3',4,4',5-HxCB (#156)
			2,3,3',4,4',5'-hexachlorobiphenyl	2,3,3',4,4',5'-HxCB (#157)
		7	2,3,3',4,4',5,5'-heptachlorobiphenyl	2,3,3',4,4',5,5'-HpCB (#189)

Table 4. Compounds for analysis of polybrominated diphenyl ethers (PBDEs)

No. of bromines	Compound for analysis	Abbreviation
Tribrominated compounds	2,4,4’-tribromodiphenyl ether	2,4,4’-TrBDE
Tetrabrominated compounds	2,2',4,4'-tetrabromodiphenyl ether	2,2',4,4'-TeBDE
Pentabrominated compounds	2,2',4,4',6-pentabromodiphenyl ether	2,2',4,4',6-PeBDE
	2,2',4,4',5-pentabromodipheyl ether	2,2',4,4',5-PeBDE
Hexabrominated compounds	2,2',4,4',5,6'-hexabromodiphenyl ether	2,2',4,4',5,6'-HxBDE
	2,2',4,4',5,5'-hexabromodiphenyl ether	2,2',4,4',5,5'-HxBDE
Heptabrominated compounds	2,2',3,4,4',5,6'-heptabromodiphenyl ether	2,2',3,4,4',5,6'-HxBDE
Decabrominated compounds	Decabromodiphenyl ether	DeBDE

(3) Survey samples

Survey spots were selected per survey medium in regions A, B and C established according to the guideline described below. Samples were collected in February and March 2001.

<Establishing guideline>

1) Region A

Waste incineration facilities that burn home appliances and household items containing brominated flame retardants are assumed to be the sources of emission. Areas within 1 km of such emission sources are specified as “regions in the vicinity of incineration facilities”.

2) Region B

Metropolitan regions with a large population

3) Region C

Other regions where environmental pollution caused by brominated dioxins are thought to be minimal

3 Overview of Sampling

1) Ambient air

Region A samples were taken from three locations selected from among such spots as shown in Figure 1, region B samples from three spots that are considered to be representative of the region, and region C samples from one spot. In region A, taking into consideration the wind direction at the spot that is thought to be as near as possible to the area of maximum ground concentration, the three spots included both an upwind and downwind spot (A1, A2 and A3; Figure 1). For regions B and C, random representative spots were selected.

An overview of ambient air samples is summarized in Table 5. Figures 2 to 8 show wind roses, with wind speed of less than 0.4 m/s defined as "calm".

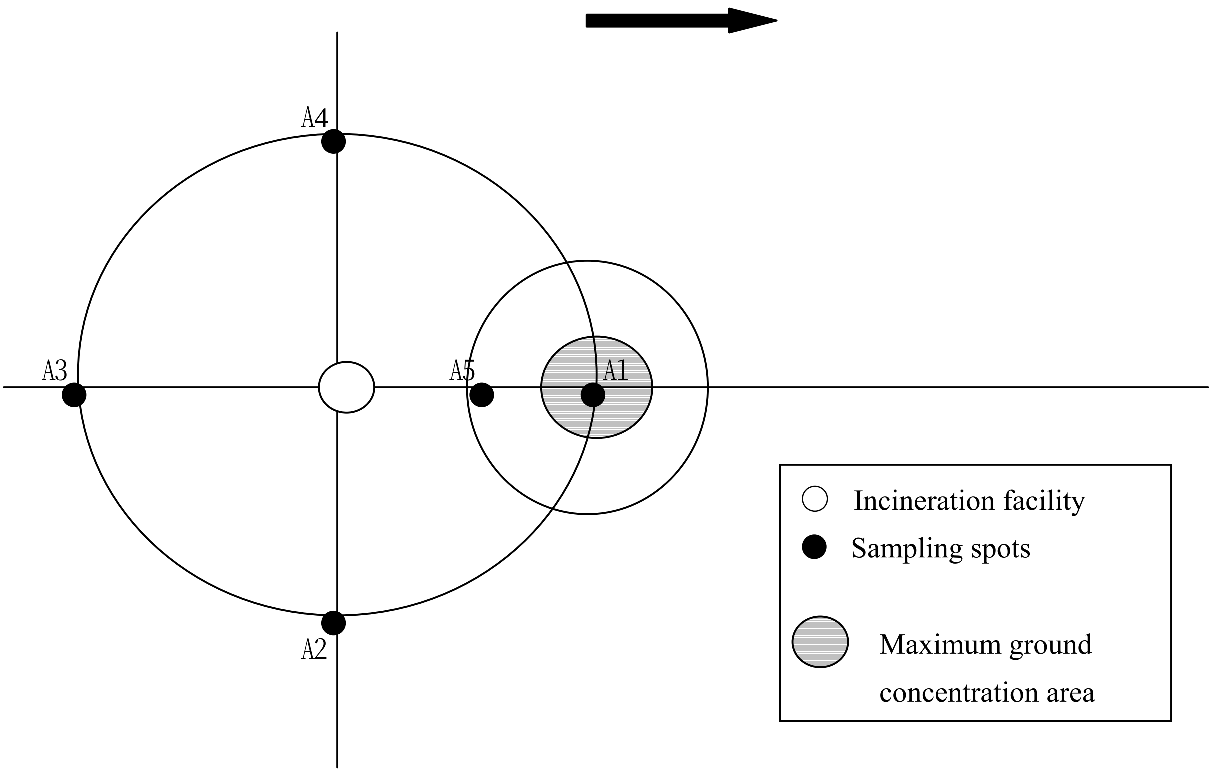


Figure 1. Establishment of region A sampling spots

Table 5. Overview of ambient air samples

Sampling spot		Weather	Suction time (min.)	Average temp. (ºC)	Average atm (hPa)	Suction volume (m^3)	Converted* suction volume (m^3)	Total amount of dust particles (mg)	Total concentration of dust particles (mg/m^3)
Region A	A1	Cloudy	1,440	2.7	1003	1076	1132	64.0	0.057
	A2	Cloudy	1,440	2.9	1004	1076	1133	114	0.10
	A3	Cloudy	1,440	2.1	1003	1072	1130	53.7	0.048
Region B	B1	Clear	1,440	11.6	1014	1070	1102	87.2	0.079
	B2	Clear	1,440	12.5	1011	1070	1096	84.6	0.077
	B3	Clear	1,440	11.9	1010	1065	1092	85.6	0.078
Region C	C1	Cloudy	1,440	-2.0	906	1076	1040	24.4	0.023

* Suction volume at 20 ºC, 101.3 hPa

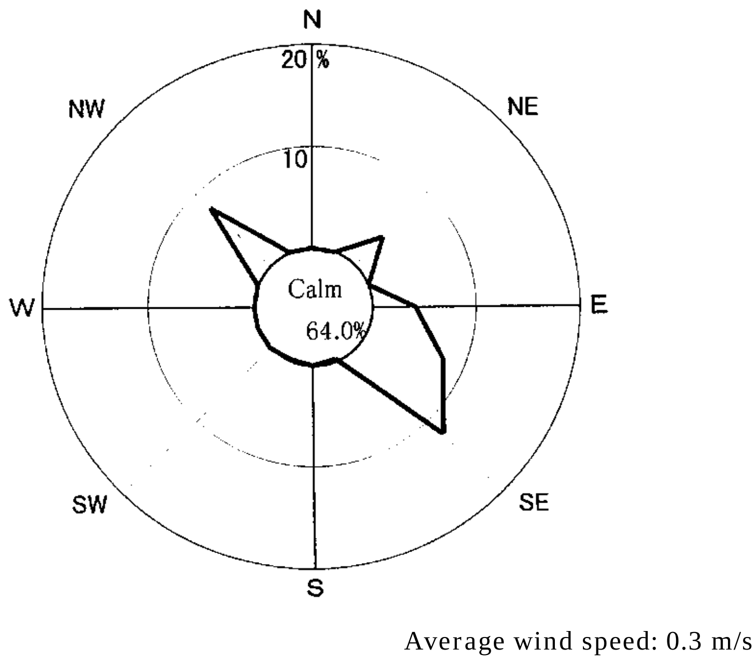


Figure 2. Wind rose of region A, spot A1

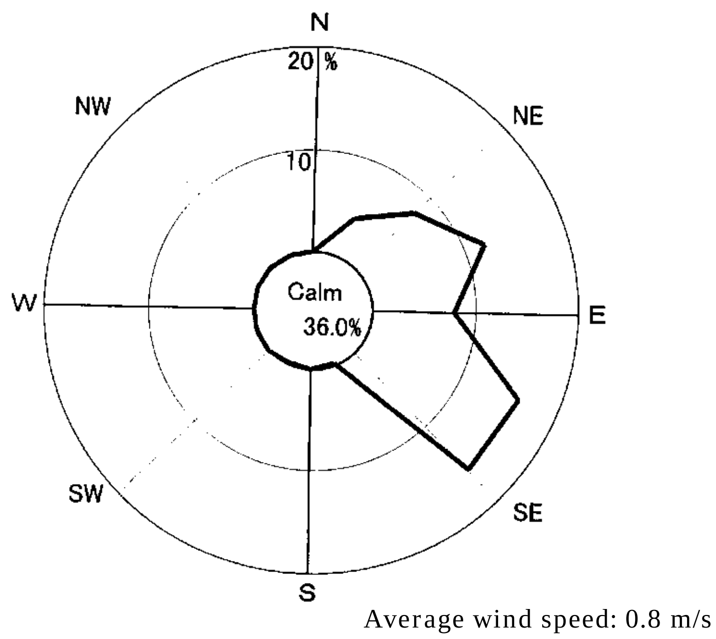


Figure 3. Wind rose of region A, spot A2

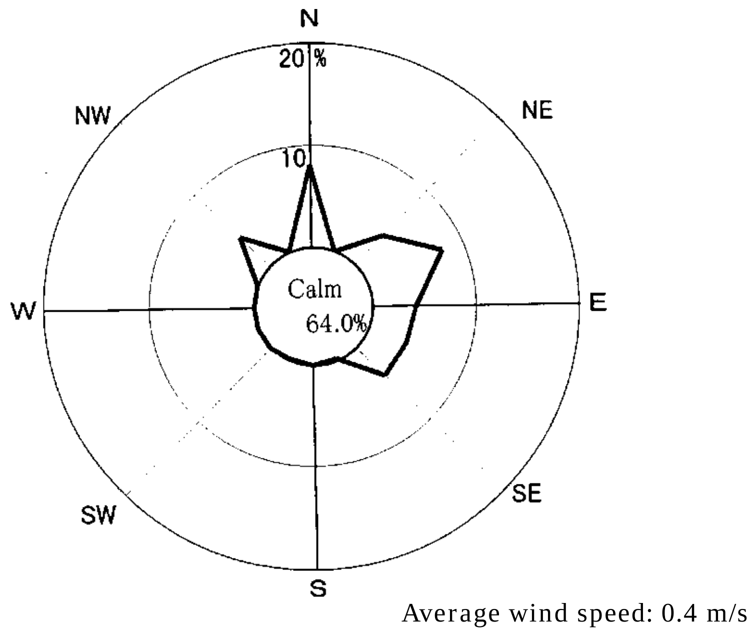


Figure 4. Wind rose of region A, spot A3

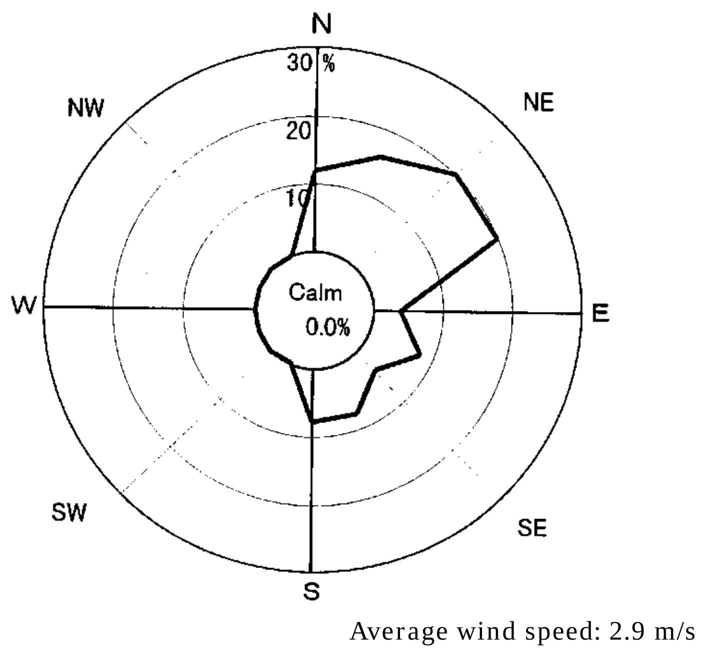
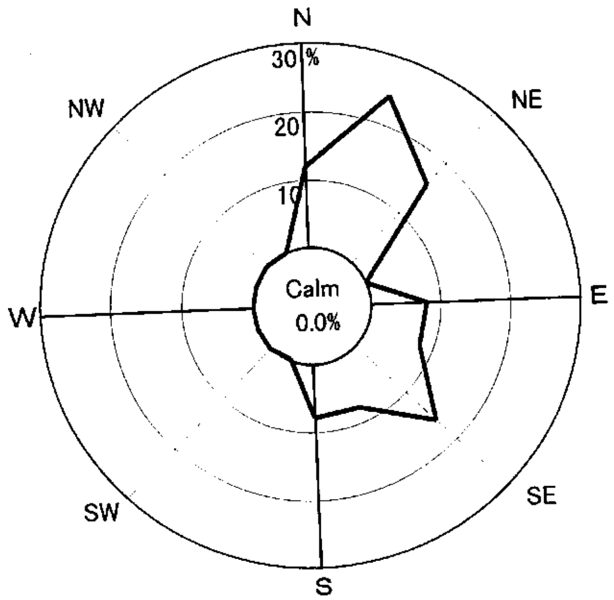
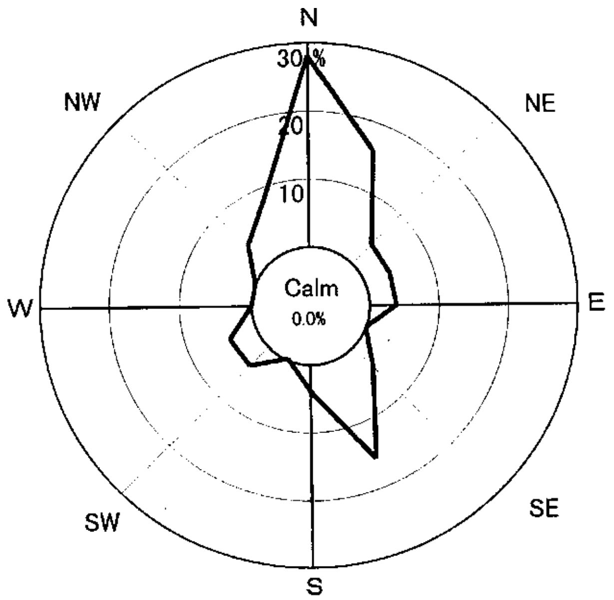


Figure 5. Wind rose of region B, spot B1



Average wind speed: 2.2 m/s

Figure 6. Wind rose of region B, spot B2



Average wind speed: 1.7 m/s

Figure 7. Wind rose of region B, spot B3

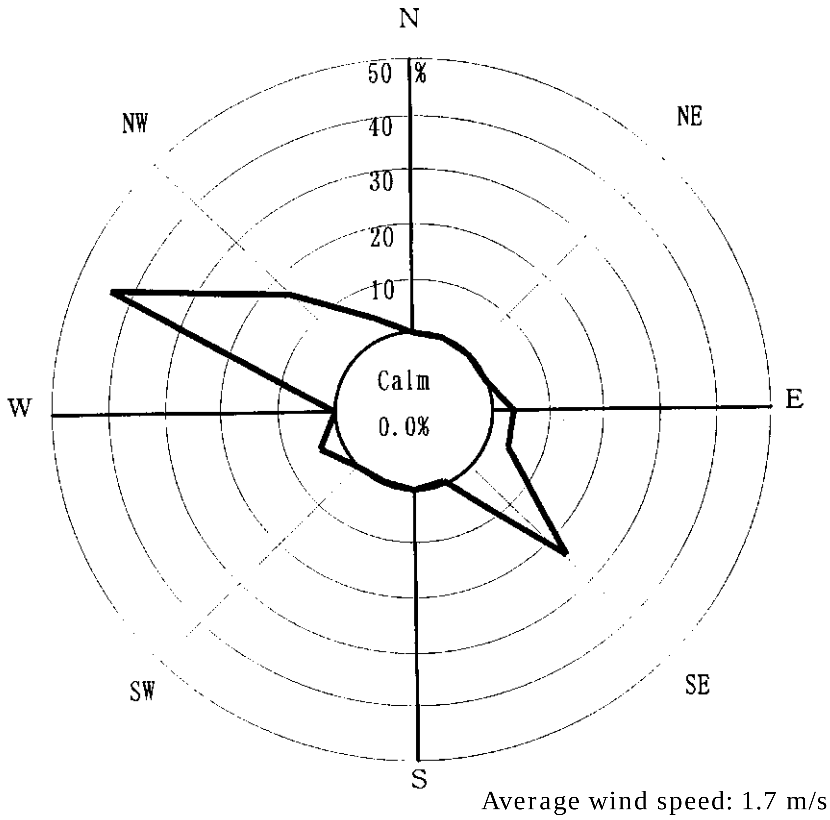


Figure 8. Wind rose of region C, spot C1

2) Settled soot and dust

Samples were collected at the same spots as ambient air samples (three spots each in regions A and B and one spot in region C). Sampling period was one month. Table 6 shows an overview of the settled soot and dust samples.

Table 6. Overview of settled soot and dust samples

Sampled spots		Amount of settled soot and dust (mg)	Concentration of settled soot and dust (t/km^2/30 days)
Region A	A1	1137	7
	A2	1970	12
	A3	1203	7
Region B	B1	791	5
	B2	612	4
	B3	479	3
Region C	C1	461	3

3) Soil

Surface soil was sampled from five spots in region A (Figure 1), three spots in region B, and one spot in region C, near the spots where ambient air samples were taken. At each spot, five surface soil samples were collected, an equal amount of each mixed together and determined. Table 7 shows an overview of the findings.

Table 7. Overview of soil samples

Sampled spots		Water content (%)	Ignition loss (%)	Soil quality	Soil color	Covering objects, etc.
Region A	A1	10.4	20.9	Silt-like loam	Dark brown	Dead leaves
	A2	10.6	20.2	Loam	Dark brown	None
	A3	11.2	36.6	Loam	Dark brown	Dead leaves
	A4	8.6	20.8	Loam	Dark brown	None
	A5	5.4	10.1	Loam	Dark brown	None
Region B	B4	4.9	12.8	Loam	Blackish brown	Grass
	B5	6.9	16.1	Loam	Grayish brown	Grass
	B6	4.8	12.8	Silt-like loam	Blackish brown	Grass
Region C	C1	5.5	23.3	Planting loam	Dark brown	Snow, dead leaves

4) Groundwater

Two spots each were selected in regions A and B for groundwater sampling. A spot was also selected in region C. Table 8 shows an overview of the samplings.

5) Public water and sediment

Water and sediment samples were taken from two public water spots (of the same river) in region A, a spot each in a river and the sea in region B, and a spot in a river in region C. Tables 9 and 10 show an overview of the samplings.

6) Aquatic life

In order to survey the pollution levels in public waters, several aquatic life samples were collected and analyzed. Table 11 shows the species and bodies of waters sampled.

7) Terrestrial wildlife (birds and mammals)

In order to survey contamination levels in animals habitating in the vicinity of incineration facilities, several terrestrial wildlife (birds and mammals) were sampled from each of the survey regions. Table 12 shows the species of animals sampled.

8) Food samples

In order to survey contamination levels in people's meals, residents were selected in regions A and B and their meals sampled (three meals were considered one sample) twice by a method whereby the same food of the same amount as eaten are used as samples. One person was selected in region C. Food samples are given in detail in Table 13.

Table 8. Overview of groundwater samples

Sampled spots		Weather	Temp. (ºC)	Water temp. (ºC)	pH	SS (mg/L)	Electric conductivity (mS/m)	Odor	Appearance
Region A	A2	Cloudy	2.5	10.0	7.1	< 1	8.5	No odor	No color
	A6	Clear	19.1	15.1	6.6	12	75	Moderate soil odor	Light grayish yellow
Region B	B7	Clear	3.9	13.7	8.3	< 1	70	Moderate hydrogen sulfide odor	Light yellow
	B8	Clear	3.5	13.5	6.7	< 1	51	No odor	No color
Region C	C2	Cloudy	9.5	10.3	6.8	< 1	20	No odor	No color

Table 9. Overview of water samples

Sampled spots		Weather (previous day)	Temp. (ºC)	Water temp. (ºC)	pH	SS (mg/L)	Transpa-rency	Odor	Appearance
Region A	A7 (river)	Cloudy (Cloudy)	2.5	10.0	7.1	12	28	Weak sewage smell	Grayish green
	A8 (river)	Cloudy (Cloudy)	2.5	10.2	7.1	16	37	Weak sewage smell	Grayish green
Region B	B9 (sea)	Cloudy (Clear)	14.8	11.2	8.3	12	> 50	No odor	Light brown
	B10 (river)	Clear (Clear)	6.0	7.2	7.2	4	28	No odor	Light yellowish green
Region C	C3 (river)	Cloudy (Clear)	4.6	4.3	7.3	< 1	> 50	No odor	No color

Table 10. Overview of sediment samples

Sampled spots		Mud temp. (ºC)	Water content (%)	Ignition loss (%)	Mud quality	Odor	Outer appearance	Tramp material
Region A	A7 (river)	9.4	55.8	8.9	Sandy clay	Moderate rotting smell	Dark gray	None
	A8 (river)	10.8	51.6	18.9	Sandy clay	Moderate rotting smell	Black	None
Region B	B9 (sea)	12.2	71.3	21.3	Mud	Moderate rotting smell, weak hydrogen sulfide odor	Dark brownish olive	Shells
	B10 (river)	6.7	59.8	19.8	Mud	Moderate rotting smell	Brown	Fallen leaves
Region C	C3 (river)	4.6	20.5	3.5	Sandy mud	No odor	Brown	Fallen leaves

Table 11. Overview of aquatic life samples

Sampled spots		Species	No.	Weight (g)	Length of body/shell (cm)
Region A	A9 (river)	Carp *(Cyprinus carpio)*	3	1946–2791	35.6–46.5
	A10 (river)	Carp *(Cyprinus carpio)*	3	2416–2727	42.7–45.2
Region B	B9 (sea)	Sea bass *(Lateolabrax japonicus)*	3	576–1039	33.2–44.4
		Mullet *(Mugil cephalus)*	3	888–2120	40.1–54.0
		Blue mussel *(Mytilus edulis)*	45	1.91–4.79	1.4–2.1
	B11 (river)	Carp *(Cyprinus carpio)*	4	2028–3041	43.9–50.0
		Crucian carp *(Carassius auratus)*	4	598–716	27.5–28.9
		Japanese barbel *(Hemibarbus barbus)*	1	1330	45.2
Region C	C4 (river)	Japanese dace *(Tribolodon hakonensis)*	48	13.8–32.5	8.5–12.7
		Pale chub *(Zacco platypus)*	10	5.77–28.89	6.7–11.6
		River crab *(Geothelphusa dehaani)*	80	1.48–4.48	1.4–2.3

Table 12. Overview of terrestrial wildlife samples

	Species	No.	Weight (g)	Length (cm)	Wingspan (cm)	Tail length (cm)
Region A	Crow	1	846	48.5	34.4	19.6
Region B	Pigeon	2	276, 323	26.2, 30.5	22.6, 22.1	11.5, 14.2
Region C	Japanese deer	1	unknown	unknown	—	—
	Boar	1	unknown	unknown	—	—

Table 13. Food sample (Region A, male, age 45 years, weight 75 kg)

Day 1 (2305 g)	Day 2 (2668 g)	Day 3 (2543 g)
Steamed rice (rice) Miso soup (Chinese cabbage, seaweed) Broiled fish (salmon) Green tea	Steamed rice (rice) Omelet (egg) Miso soup (*komatsuna* leaf, seaweed) Grated radish (radish) Green tea	Steamed rice (rice) Miso soup (spinach, seaweed) Fried dried tofu sandwich (dried tofu, ham, cheese) Dried radish strips (radish, deep-fried tofu, *shiitake* mushroom)
Steamed rice (rice) Miso soup (deep-fried tofu, leek) Stir-fried vegetables (egg, *komatsuna* leaf, *nira* leek) Roasted vegetable (bamboo shoot, *konnyaku*, dried bonito)	Curry and rice (rice, pork, potato, carrot, onion, curry roux) *Udo* plant mixed with mayonnaise (*udo* plant, cucumber, seaweed, mayonnaise)	Steamed rice (rice) Miso soup (taro, carrot, radish, burdock, fried *fu* bread) Butterbur with vinegar miso (butterbur) Stir-fried pork and vegetables with miso (pork, cabbage, green pepper, sesame, garlic) *Kombu* kelp cooked with pickled plums (*kombu* kelp, pickled plum)
Fried noodles (noodle, cabbage, pork, carrot, onion) Green tea	Steamed rice (rice) Miso soup (radish, deep-fried tofu) Spinach dressed with sesame (spinach, sesame) Dried radish strips (radish, deep-fried tofu, *shiitake* mushrooms) Stir-fried chicken and vegetables (chicken, *konnyaku*, carrot, *shiitake* mushroom, lotus root, bamboo shoot)	Steamed rice (rice) Miso soup (leek, seaweed, tofu) *Gyoza* dumplings (pork, *nira* leek, cabbage, carrot, *gyoza* wrapper) *Komatsuna* leaf stir-fried with *kounago* fish (*komatsuna* leaf, deep-fried tofu, *kounago* fish)

Table 14. Food sample (Region A, female, age 50 years, weight 67 kg)

Day 1 (1973 g)	Day 2 (2051 g)	Day 3 (2543 g)
Steamed rice (rice) *Natto* fermented soybeans (soybean) Miso soup (leek, carrot, *shimeji* mushroom, potato, egg) Salad (celery, red onion, french dressing)	Steamed rice (rice) Raw egg (chicken egg) Baked seaweed Boiled bean sprout (bean sprout, carrot, sesame, sesame seed oil, chicken broth)	Meat with rice (rice, ground beef and pork, tomato, onion, mushroom, carrot, sausage, garlic, olive oil, soup cube, spices) Navel orange Broccoli Sake-steeped scallops (scallop, sake)
Cheese toast (raisin bread, cheese) Low-fat milk Navel orange Crown daisy dressed with sesame (crown daisy, sesame)	Toasted sandwich (bread, roast ham, cheese) Sauteed broccoli (broccoli, butter) Vegetable juice	Steamed rice (rice) Tuna steeped in soy sauce (tuna) Mushroom soup (*maitake* mushroom, carrot, onion, egg, sesame seed oil, garlic, chicken broth) Kimchi (Chinese cabbage)
Spaghetti with meat sauce (spaghetti, ground beef and pork, tomato, onion, mushroom, carrot, sausage, garlic, olive oil, soup cube, spices) Adlay tea	Miso-baked pork (pork, egg, sesame seed oil, miso) Stir-fried vegetables (cabbage, carrot, bean sprout, garlic) Mushroom soup (*maitake* mushroom, carrot, onion, egg, sesame seed oil, garlic, chicken broth)	Toast (bread) Assorted deep-fried food (oyster, pumpkin, *shiitake* mushroom, sweet potato) Broccoli salad (broccoli, mayonnaise) Adlay tea
Sesame rice crackers Adlay tea Green tea	Low-fat milk Strawberries Adlay tea	Adlay tea Banana Yogurt Rice cracker Green tea

Table 15. Food sample (Region B, male, age 53 years, weight 87 kg)

Day 1 (1634 g)	Day 2 (1963 g)	Day 3 (2122 g)
Toast (bread, blueberry jam) Apple Strawberry Tea with milk (tea, milk) Health food (soybean, azuki bean, *kombu* kelp, wheat germ)	Toast (bread, blueberry jam) *Hassaku* fruit Tea with milk (tea, milk)	Toast (bread, marmalade) Apple Banana Croquette Cabbage Tea with milk (tea, milk)
Fried noodles (noodle, pork, cabbage, seaweed) Milk	Steamed rice (rice) Broiled fish (salmon) *Shumai* dumplings Broccoli *Kombu* kelp	Steamed rice (rice) Pork cutlet (pork) Croquette Cabbage Spinach Green tea
Steamed rice (rice) Miso soup (seaweed) Tempura (shrimp, pumpkin, lotus root, onion, peas) Salad (cucumber, scallop, onion) Green tea	Riceballs (rice) *Inari*-sushi (rice, deep-fried tofu) Meatballs (pork) Vienna sausage Egg Croquette	Steamed rice (rice) Steak (beef, spinach, potato, carrot) Miso soup (radish) Green tea
Chocolate Apple juice	Banana Ice cream Milk	Sponge cake Juice

Table 16. Food sample (Region B, male, age 59 years, weight 78 kg)

Day 1 (2411 g)	Day 2 (2214 g)	Day 3 (2471 g)
Toast (bread) Salad (wiener, macaroni, lettuce, tomato) Fried eggs (chicken egg) Milk Coffee Apple	Toast (bread, cheese, strawberry jam) Lettuce Milk	Toast (bread, strawberry jam) Scrambled egg (chicken egg) Tomato Milk
Steamed rice (rice) Miso soup (*shijimi* clam) *Nira* leeks and egg (*nira* leek, chicken egg) Salad (cabbage, tomato) *Shumai* dumpling	Steamed rice (rice) Broiled fish (salmon) Omelet (chicken egg) Broccoli Cooked beans Green tea	Steamed rice (rice) Eel *Tsukudani* delicacies (leaf chili peppers) Green tea
Steamed rice (rice) Miso soup (deep-fried tofu, radish) Green peppers stuffed with meat (green pepper, pork, onion) Lettuce Boiled *ganmodoki* tofu (*ganmodoki* tofu) Miso soup (radish, deep-fried tofu) Green tea	Steamed rice (rice) Fried shrimp (shrimp) Seafood in sweetened vinegar (octopus, *mozuku* seaweed) Salad (tomato, cabbage, cucumber, broccoli) *Nimono* cooking (tuna) Miso soup (seaweed, onion) Green tea	Steamed rice (rice) Fish (tuna fish) Miso soup (tofu, leek) Vegetables (lettuce, pumpkin, echalotte) Fish in sweetened vinegar (shad) Green tea
Donuts Japanese sake Orange	Japanese sake Coffee Navel orange	Japanese sake Coffee

Table 17. Food sample (Region C, female, age 53 years, weight 58 kg)

Day 1 (2543 g)	Day 2 (1807 g)	Day 3 (2016 g)
Steamed rice (rice) *Natto* fermented soybeans Broiled fish (mackerel) Five-ingredient *kimpira* cooking (burdock, carrot, *konnyaku*, *chikuwa* fish paste cake, fried fish cake) Cooked butterbur (butterbur) Green tea	Steamed rice (rice) Scrambled eggs (chicken egg) *Mentaiko* fish eggs Cooked butterbur (butterbur)	Steamed rice (rice) *Natto* fermented soybeans Fish（*mehikari* fish） Pickles (cucumber)
Steamed rice (rice) Broiled chicken (chicken, leek, bamboo shoot) Soy sauce marinated sashimi (tuna, yellowtail) Five-ingredient *kimpira* cooking (burdock, carrot, *konnyaku*, *chikuwa* fish paste cake, fried fish cake) Boiled vegetable (*komatsuna* leaf)	Steamed rice (rice) Roast beef (beef) Fish(*mehikari* fish, sardine） Spinach with dressing (spinach, *shiitake* mushroom, dried young sardines) *Mentaiko* fish eggs Cooked butterbur (butterbur)	Steamed rice (rice, shrimp) Fried chicken (chicken) Cooked vegetables (taro, carrot, bamboo shoot, *shiitake* mushroom, *shimeji* mushroom, *chikuwa* fish paste cake, *konnyaku*) Salad (broccoli) Strawberry Tea
Simmered *udon* noodles (*udon* noodle, chicken egg, pork, *komatsuna* leaf, leek, potato, radish, *shiitake* mushroom, *nameko* mushroom, deep-fried tofu) Pancake (flour, butter) *Hassaku* fruit Pickles (cucumber) Green tea	Rice gruel (rice, *nira* leek, chicken egg, chicken) Pickles (cucumber) Salad (chicken, cucumber, tomato)	*Udon* noodles (*udon* noodle, deep-fried tofu, Chinese spinach, mushroom, pork) Tempura (eggplant, celery, fried mixture) Miso-pickled cucumber and scallion Apple Cooked vegetables (taro, carrot, bamboo shoot, *shiitake* mushroom, *shimeji* mushroom, *chikuwa* fish paste cake, *konnyaku*) Oolong tea
Green tea	Coffee Rice cracker Pomegranate wine Green tea	*Amazake* rice wine Steamed bread

4 Analytical Methods

1) Analytical method for brominated dioxins

[Pre-treatment of samples**]**

[Ambient air and settled soot and dust]

After air-drying the sampled filter paper and polyurethane foam, they were Soxhlet-extracted for 16 hours with toluene and acetone, respectively. The filter paper and polyurethane foam extracts were mixed together, concentrated using a reduced pressure condenser at below 40 ºC, and solvent-exchanged into toluene. This was then measured into a 100 mL graduated flask as pre-treated solution. The following procedures were performed after the pre-treated solution was batched off, solvent-exchanged into roughly 100 mL of hexane, and the internal standard added.

All procedures were performed in a shaded laboratory, using amber-colored or aluminum foil-wrapped glassware.

[Soil and sediment]

After sifting the air-dried sample at 2 mm, 10 g were placed in a cylindrical filter paper, 20 g of copper powder and internal standard added to it, and Soxhlet-extracted for 16 hours with toluene. The extract was then passed through a funnel filled with 20 g anhydrous sodium sulfate and dehydrated, then solvent-exchanged into roughly 100 mL of hexane to produce the pre-treated solution.

All procedures were performed in a shaded laboratory, with amber-colored or aluminum foil-wrapped glassware.

[Groundwater and public water]

20 L of specimen were filtered through a fiberglass filter, and separated into filtered water and residual material (suspended matter). 150 mL of dichloromethane was added to 1 L of filtered water and the solution shook for 10 minutes. After it was left standing, the dichloromethane layer was removed, another 150 mL of dichloromethane added to the water layer, and the procedure repeated. After returning the dichloromethane extract, the solution was dehydrated by passing it through a funnel filled with 20 g anhydrous sodium sulfate. The residual material was then air-dried, and Soxhlet-extracted for 16 hours with toluene. The toluene extract was in turn dehydrated by passing it through a funnel filled with 20 g anhydrous sodium sulfate. The extracts from the filtered water and residual material were mixed together and concentrated at a temperature below 40 ºC using a reduced pressure condenser. The concentration was solvent-exchanged into roughly 100 mL of hexane and an internal standard added to produce the pre-treated solution.

All procedures were performed in a shaded laboratory, with amber-colored or aluminum-foil wrapped glassware.

[Aquatic life, terrestrial wildlife, and food samples]

100 g of uniformly-prepared specimen were placed in a 500 mL oblong flask (food samples were divided into five oblong flasks, weighing 500 g). Internal standards and 200 mL of a 2 mol/L potassium hydroxide solution were added and the solution shook for three hours at room temperature. This was then transferred to a 1 L separating funnel, 150 mL of methanol and 100 mL of hexane added, and shook for 10 minutes. After it was left standing, the hexane layer was removed, another 100 mL of hexane added to the water layer, and the procedure repeated twice. The hexane extract was then returned, 200 mL of a 2% sodium chloride solution was added, and the solution rocked gently in a circular motion. After it was left standing, the water layer was disposed, another 100 mL of a 2% sodium chloride solution added to the hexane layer, and the procedure repeated twice. The hexane layer was then passed through a funnel filled with 20 g anhydrous sodium sulfate and dehydrated, and concentrated to approximately 100 mL using a reduced pressure condenser at below 40°C to produce the pre-treated solution.

All procedures were performed in a shaded laboratory, with amber-colored or aluminum foil-wrapped glassware.

[Preparation of sample solutions**]**

The pre-treated solutions were transferred to a 300 mL separating funnel, 10 mL of concentrated sulfuric acid added, and gently mixed together. After it was left standing, the sulfuric acid layer was disposed. This procedure was repeated until the sulfuric acid layer became colorless. Then, 20 mL of purified water was added to the hexane layer and gently shook. After it was left standing, the water layer was disposed, and the hexane layer washed with purified water two more times. Next, 10 mL of a 5% sodium bicarbonate solution was added to the hexane layer and gently shook. After it was left standing, the water layer was disposed, and the hexane layer was passed through a funnel filled with 10 g anhydrous sodium sulfate and dehydrated. It was then concentrated to approximately 5 mL in a reduced pressure condenser at temperatures below 40°C.

Soil and sediment samples were further treated with reduced copper. 5 g reduced copper were added to the hexane solution treated with sulfuric acid and shook for 10 minutes. After 10 minutes, the reduced copper was separated and eliminated, and the solution concentrated to approximately 5 mL using a reduced pressure condenser at temperatures below 40°C.

The concentrated hexane solution was transferred to a silica gel column (2 g) with 200 mL of hexane. This eluate was placed in a 300 mL oblong flask and concentrated to approximately 5 mL in a reduced pressure condenser at below 40°C. It was then transferred to a Florisil column (5 g, containing 1% water), and after washing with 150 mL of hexane, 200 mL of a 60 V/V% dichloromethane-hexane solution was poured in to elute the target substance. The eluate was transferred to a 300 mL oblong flask, and concentrated to approximately 5 mL in a reduced pressure condenser at below 40°C. The concentrated hexane solution was next transferred to an activated carbon dispersed silica gel column (0.5 g), and after washing with 100 mL 5 V/V% dichloromethane-hexane solution, 250 mL toluene was poured in to elute the target substance. The eluate was placed in a 300 mL oblong flask and concentrated to approximately 5 mL using a reduced pressure condenser at below 40°C.

The concentrated solution produced was transferred to a 10 mL condensing test tube with a small amount of hexane, and the solvent eliminated under a nitrogen air current. 50 µL (20 µL for public water and groundwater samples) of decane was added to the residual material and dissolved to produce the sample solution.

All procedures were performed in a shaded laboratory, with amber-colored or aluminum foil-wrapped glassware.

Syringe spikes were not used in this survey, as only a few types of standard products are available.

[Preparation of blank sample solutions**]**

The solution created after performing the same procedures as [Pre-treatment of samples] and [Preparation of sample solutions] but without adding any samples, was used as the empty sample solution.

[Preparation of reference solution**]**

A standard stock solution of brominated dioxins and ^{13}C tagged brominated dioxins were diluted with decane to produce 100 to 0.1 ng/mL (internal standard 10 ng/mL) of standard mixed solution for quantification. ^{13}C tagged brominated dioxins were also diluted with decane to create 10 ng/mL of clean-up spike solution.

[Gas chromatograph – high-resolution mass spectrometer operating conditions**]**

Determination of PBDDs and PBDFs

Model:	Autospec ULTIMA [micromass Ltd.]
Column:	Fused Silica TC-1 [GL Science K.K.]
	Length 30 m, inside diameter 0.25 mm, film thickness 0.25 µm
Injection style:	Splitless
Temperature:	Sample inlet 260 ºC
	Column 160 ºC (retained 1 min.) → raised 15 ºC/min. →
	300 ºC (retained 20 min.)

Determination of MoBPCDD and MoBPCDF and confirmation of TeBDD, TeBDF

Model:	Autospec ULTIMA [micromass Ltd.]
Column:	Fused Silica DB-5MS [J&W Scientific]
	Length 30 m, inside diameter 0.25 mm, film thickness 0.25 µm
Injection style:	Splitless
Temperature:	Sample inlet 260 ºC
	Column 160 ºC (retained 1 min.) → raised 5 ºC/min. →
	250 ºC (retained 1 min.) → raised 15 ºC/min. →
	300 ºC (retained 31.8 min.)

Ion source temperature:	260 ºC
Ionization method:	EI

Ionization current:	500 µA	
Ionization voltage:	30 eV	
Resolution:	10,000*	
Established mass:	TeBDF	m/z 483.6955, 485.6934
	[$^{13}C_{12}$]TeBDF	m/z 495.7357, 497.7337
	TeBDD	m/z 499.6904, 501.6883
	[$^{13}C_{12}$]TeBDD	m/z 511.7306, 513.7286
	PentaBDF	m/z 561.6060, 563.6039
	[$^{13}C_{12}$]PeBDF	m/z 573.6462, 575.6442
	PeBDD	m/z 577.6009, 579.5988
	[$^{13}C_{12}$]PeBDD	m/z 589.6412, 591.6391
	HxBDF	m/z 639.5165, 641.5144
	HxBDD	m/z 655.5114, 657.5094
	[$^{13}C_{6}$]HxBDD	m/z 663.5295, 665.5274
	MoB-TrCDF	m/z 349.8491, 351.8461
	MoB-TrCDD	m/z 365.8440, 367.8410
	MoB-TeCDF	m/z 383.9761, 385.8092
	MoB-TeCDD	m/z 399.8041, 401.8021
	[$^{13}C_{12}$]MoB-TeCDD	m/z 411.8444, 413.8423
	MoB-PeCDD	m/z 433.7651, 435.7631
	MoB-HxCDD	m/z 467.7262, 469.7241
	MoB-HpCDD	m/z 503.6851, 505.6822

Under these conditions, 1,2,3,4,7,8-HxBDD and 1,2,3,6,7,8-HxBDD cannot be separated by GC, so the analysis values are indicated with total values.

*: in order to prioritize detection sensitivity, resolution was set at 10,000 instead of 12,000.

[Quantitative analysis**]**

1 µm standard mixed solution for quantification was poured into a gas chromatograph – high-resolution mass spectrometer, and an SIM conducted per established mass for each bromine number. The peak area ratios (A) compared to the internal standards of each brominated compound was determined from the resulting SIM chart. Similarly, peak area ratios (B) were determined for sample solutions and their quantitative values calculated.

[Calculation**]**

$$\text{Concentration (pg/g)} = \frac{Q\ (\text{pg}) \times \dfrac{\text{Sample solution peak area ratio (B)}}{\text{Standard solution peak area ratio (A)}}}{\text{Sample volume (g)}}$$

Q: Internal standard loading

[Detection limits**]**

Table 18 shows the detection limits of brominated dioxins.

Table 18. Detection limits of brominated dioxins

	Ambient air	Settled soot and dust	Soil, Sediment	Groundwater, Public water	Aquatic life, Terrestrial wildlife	Food
MoB-TrCDD MoB-TeCDD	0.02 pg/m^3	20 pg/m^2/day	1 pg/g	0.1 pg/L	0.05 pg/g	0.01 pg/g
MoB-PeCDD	0.04 pg/m^3	40 pg/m^2/day	2 pg/g	0.2 pg/L	0.1 pg/g	0.02 pg/g
MoB-HxCDD	0.08 pg/m^3	80 pg/m^2/day	4 pg/g	0.4 pg/L	0.2 pg/g	0.04 pg/g
MoB-HpCDD	0.2 pg/m^3	200 pg/m^2/day	10 pg/g	1 pg/L	0.5 pg/g	0.1 pg/g
MoB-TrCDF MoB-TeCDF	0.02 pg/m^3	20 pg/m^2/day	1 pg/g	0.1 pg/L	0.05 pg/g	0.01 pg/g
2,3,7,8-TeBDD	0.02 pg/m^3	20 pg/m^2/day	1 pg/g	0.1 pg/L	0.05 pg/g	0.01 pg/g
1,2,3,7,8-PeBDD	0.04 pg/m^3	40 pg/m^2/day	2 pg/g	0.2 pg/L	0.1 pg/g	0.02 pg/g
1,2,3,4,7,8-/ 1,2,3,6,7,8-HxBDD 1,2,3,7,8,9-HxBDD	0.2 pg/m^3	200 pg/m^2/day	10 pg/g	1 pg/L	0.5 pg/g	0.1 pg/g
2,3,7,8-TeBDF	0.02 pg/m^3	20 pg/m^2/day	1 pg/g	0.1 pg/L	0.05 pg/g	0.01 pg/g
1,2,3,7,8-PeBDF 2,3,4,7,8-PeBDF	0.04 pg/m^3	40 pg/m^2/day	2 pg/g	0.2 pg/L	0.1 pg/g	0.02 pg/g
1,2,3,4,7,8-HxBDF	0.4 pg/m^3	200 pg/m^2/day	10 pg/g	1 pg/L	0.5 pg/g	0.1 pg/g

[Reagents**]**

Hexane:	For dioxin analysis [Wako Pure Chemicals Industries, Ltd.]
Dichloromethane:	For dioxin analysis [Wako Pure Chemicals Industries, Ltd.]
Toluene:	For dioxin analysis [Wako Pure Chemicals Industries, Ltd.]
Acetone:	For dioxin analysis [Wako Pure Chemicals Industries, Ltd.]
Methanol:	For dioxin analysis [Wako Pure Chemicals Industries, Ltd.]
Decane:	Reagent chemical [Tokyo Kasei Kogyo Co. Ltd.]
Sulfuric acid:	Reagent chemical [Kanto Kagaku]
Potassium hydroxide:	Reagent chemical [Kanto Kagaku]
Purified water:	Pre-washed with hexane
5 W/V% sodium bicarbonate solution	
Anhydrous sodium sulfate:	For PCB analysis [Kanto Kagaku]
Copper powder:	Reagent Grade 1 [Kanto Kagaku], Pre-washed with hexane
Reduced copper (granular):	For analysis of elements [Wako Pure Chemicals Industries, Ltd.]
Silica gel:	Wako-gel S-1 [Wake Pure Chemicals Industries, Ltd.]
Florisil containing 1% water:	Purified water added to Florisil (for testing agricultural residual chemicals) [Wako Pure Chemicals Industries, Ltd.], shook, and prepared.

Activated carbon-dispersed silica gel: For dioxin analysis [Kanto Kagaku]

[Standard products**]**

The following are all products of Cambridge Isotope Laboratories (USA).

2,3,7,8-TeBDD	(5±0.5 µg/mL nonane solution)
[$^{13}C_{12}$] 2,3,7,8-TeBDD*	(5±0.5 µg/mL nonane solution)
1,2,3,7,8-PeBDD	(5±0.5 µg/mL nonane solution)
[$^{13}C_{12}$] 1,2,3,7,8-PeBDD*	(5±0.5 µg/mL nonane solution)
1,2,3,4,7,8-HxBDD	(5±0.5 µg/mL nonane solution)
1,2,3,6,7,8-HxBDD	(5±0.5 µg/mL nonane solution)
1,2,3,7,8,9-HxBDD	(5±0.5 µg/mL nonane solution)
[$^{13}C_{12}$] 1,2,3,6,7,8-HxBDD*	(5±0.5 µg/mL nonane solution)
2,3,7,8-TeBDF	(5±0.5 µg/mL nonane solution)
[$^{13}C_{12}$] 2,3,7,8-TeBDF*	(5±0.5 µg/mL nonane solution)
1,2,3,7,8-PeBDF	(5±0.5 µg/mL nonane solution)
2,3,4,7,8-PeBDF	(5±0.5 µg/mL nonane solution)
[$^{13}C_{12}$] 1,2,3,7,8-PeBDF*	(5±0.5 µg/mL nonane solution)
1,2,3,4,7,8-HxBDF	(5±0.5 µg/mL nonane solution)
3-MoB-2,7,8-TrCDF	(50±5 µg/mL nonane solution)
2-MoB-3,7,8-TrCDD	(50±5 µg/mL nonane solution)
1-MoB-2,3,7,8-TeCDF	(50±5 µg/mL nonane solution)
1-MoB-2,3,7,8-TeCDD	(50±5 µg/mL nonane solution)

[$^{13}C_{12}$] 1-MoB-2,3,7,8-TeCDD* (50±5 μg/mL nonane solution)
2-MoB-3,6,7,8,9-PeCDD (50±5 μg/mL nonane solution)
1-MoB-2,3,6,7,8,9-HxCDD (50±5 μg/mL nonane solution)
1-MoB-2,3,4,6,7,8,9-HpCDD (50±5 μg/mL nonane solution)
*: for clean-up spikes

[Apparatus]

Glassware: separation filter, tall beaker, oblong flask, chromatography column, condenser test tubes, etc.
(Amber-colored or aluminum foil-wrapped glassware was used.)
Soxhlet extractor
Rotary evaporator
Water bath
Shaker
Gas chromatograph mass spectrometer: High-resolution mass spectrometer with multiple ion detector

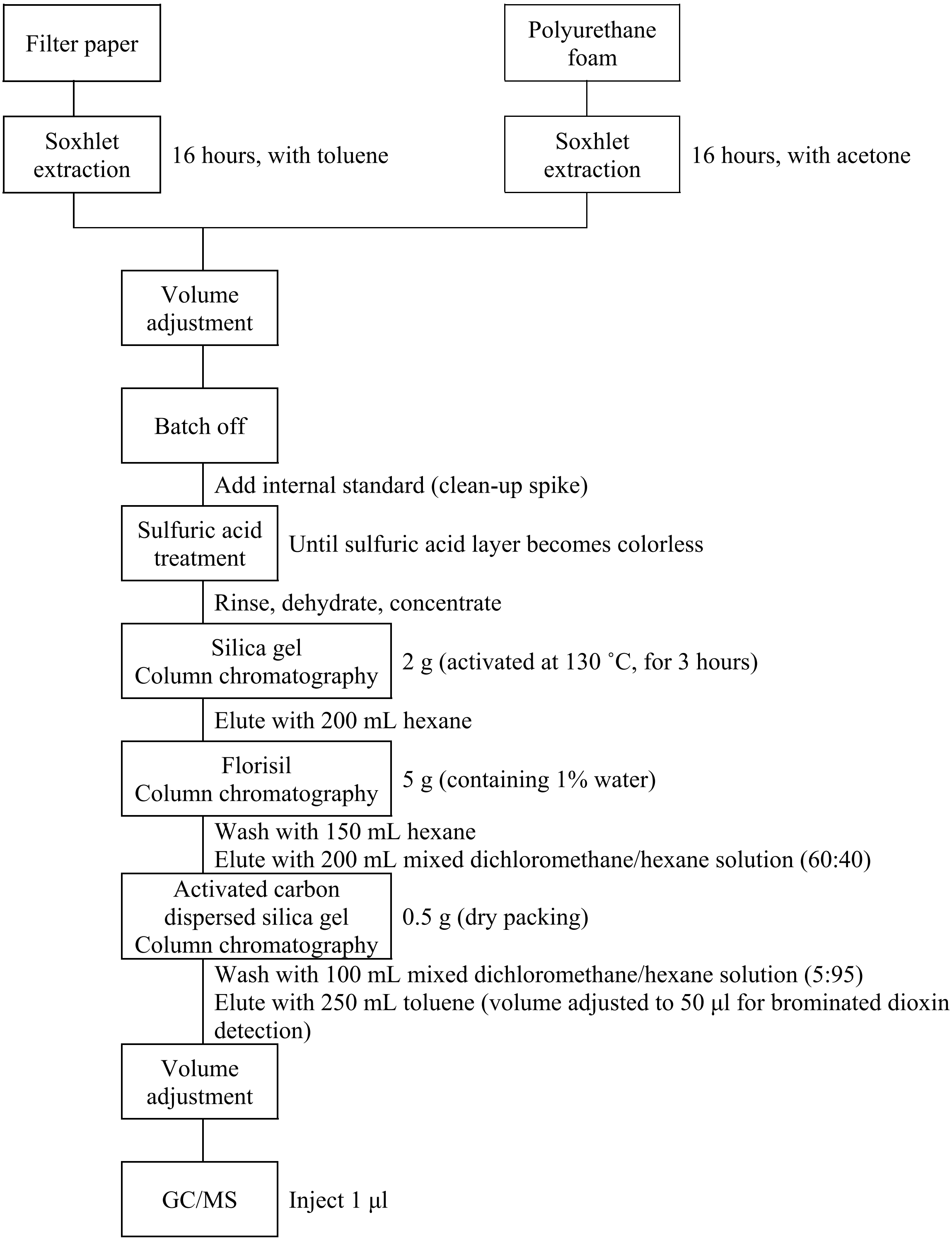


Figure 9. Flowchart of analytical method for determining brominated dioxins in ambient air and settled soot and dust

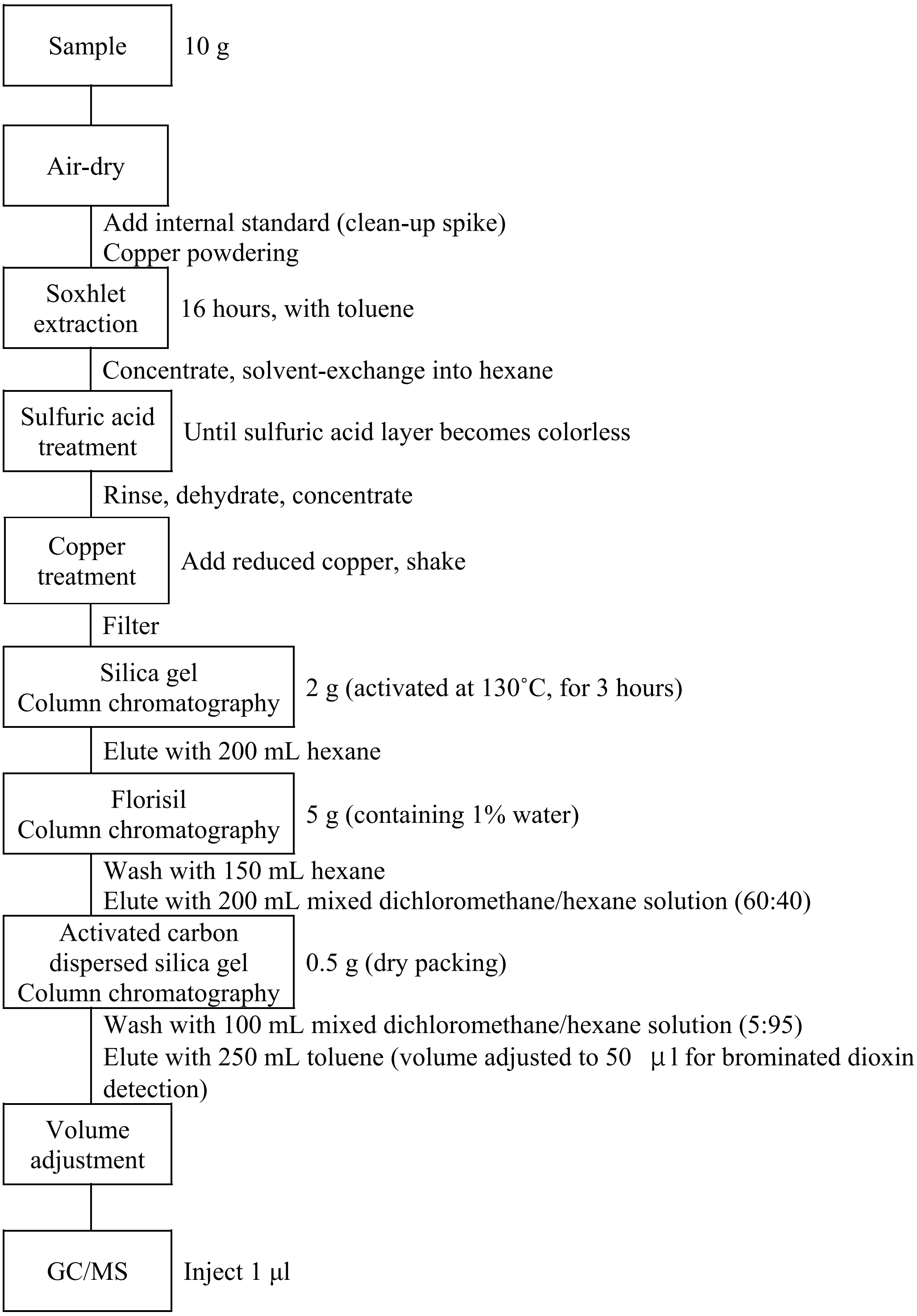


Figure 10. Flowchart of analytical method for determining brominated dioxins in soil and sediment

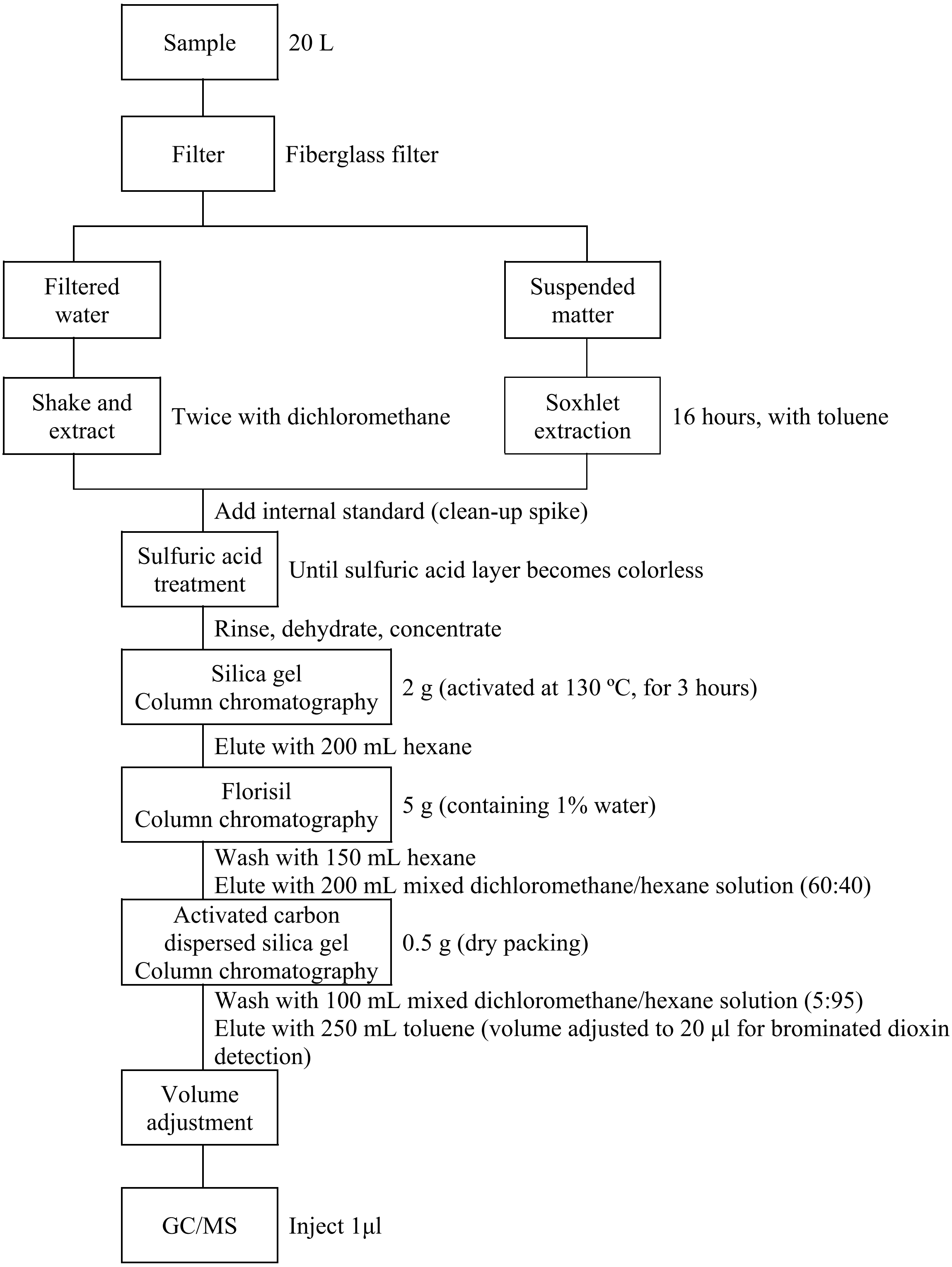


Figure 11. Flowchart of analytical method for determining brominated dioxins in groundwater and public water

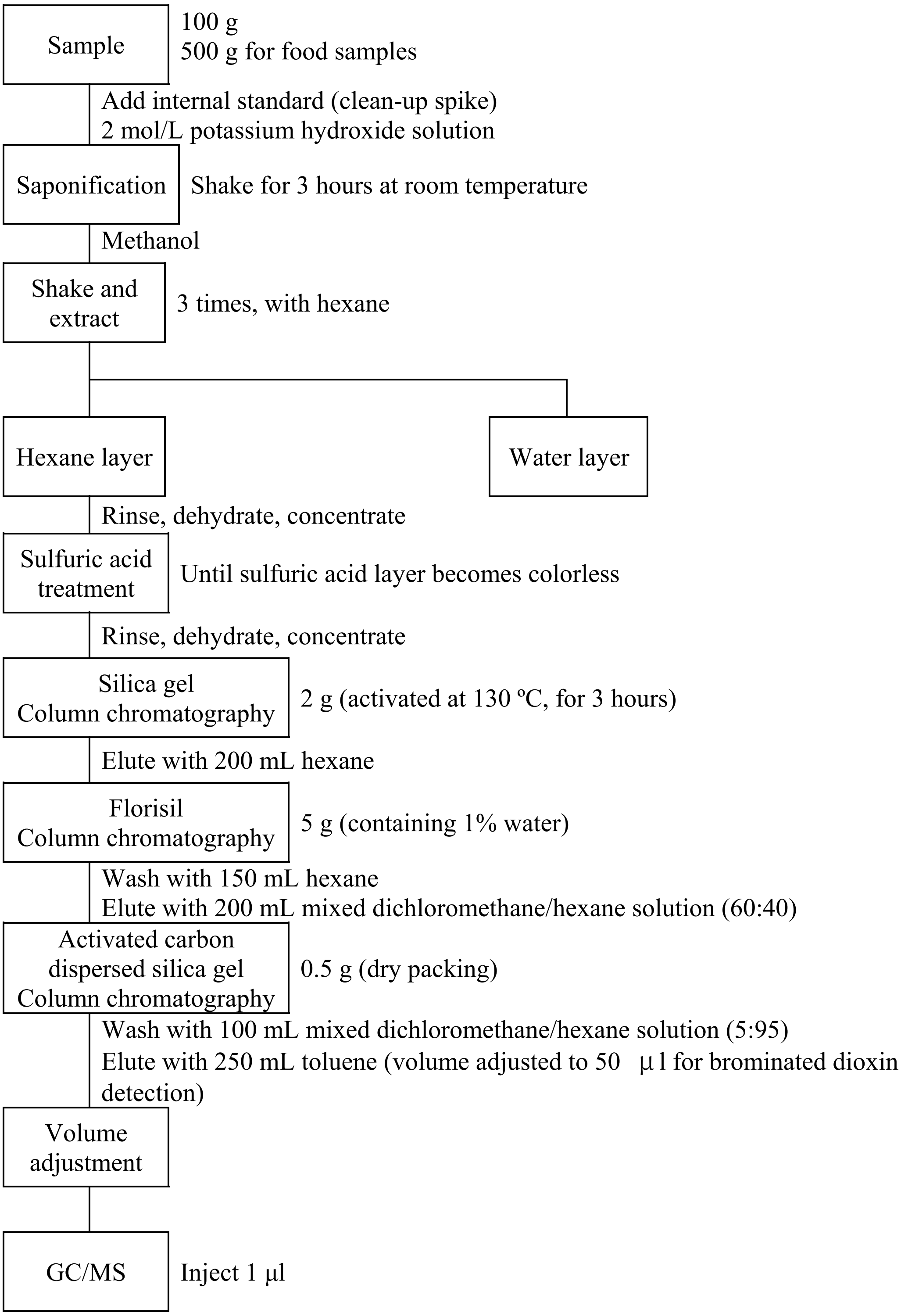


Figure 12. Flowchart of analytical method for determining brominated dioxins in aquatic life, terrestrial wildlife, and food samples

2） Analytical method for (chlorinated) dioxins

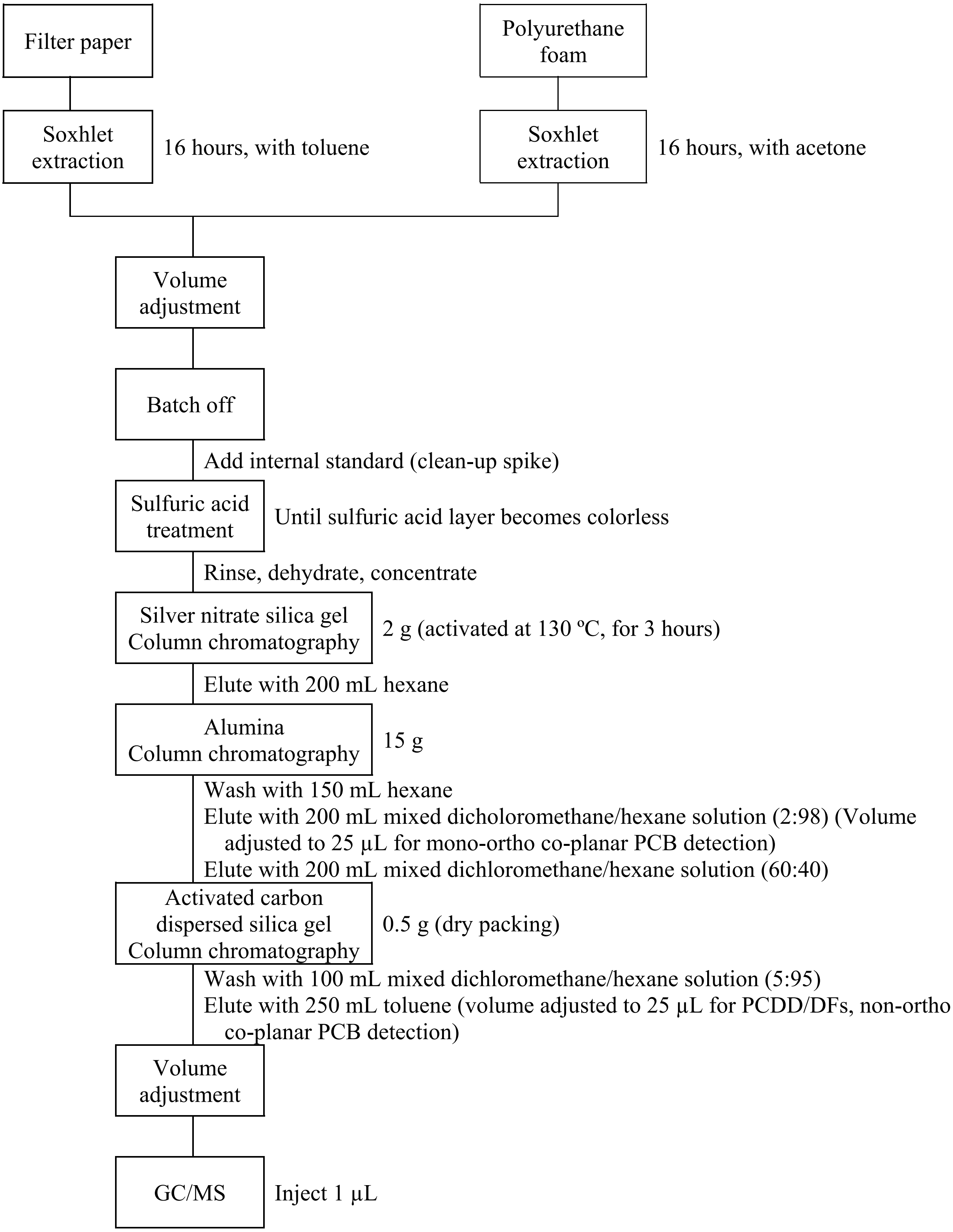


Figure 13. Flowchart of analytical method for determining (chlorinated) dioxins in ambient air and settled soot and dust

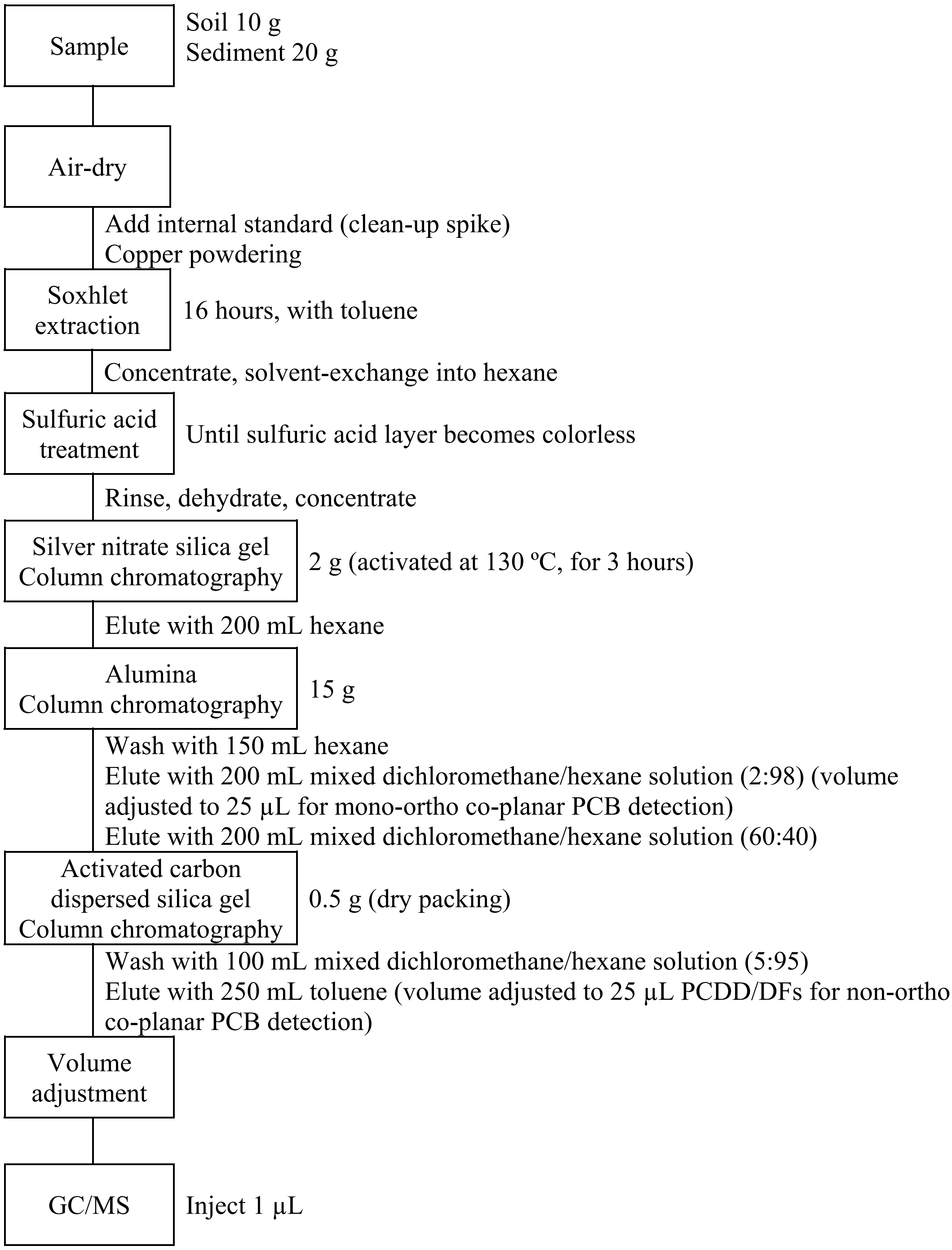


Figure 14. Flowchart of analytical method for determining (chlorinated) dioxins in soil and sediment

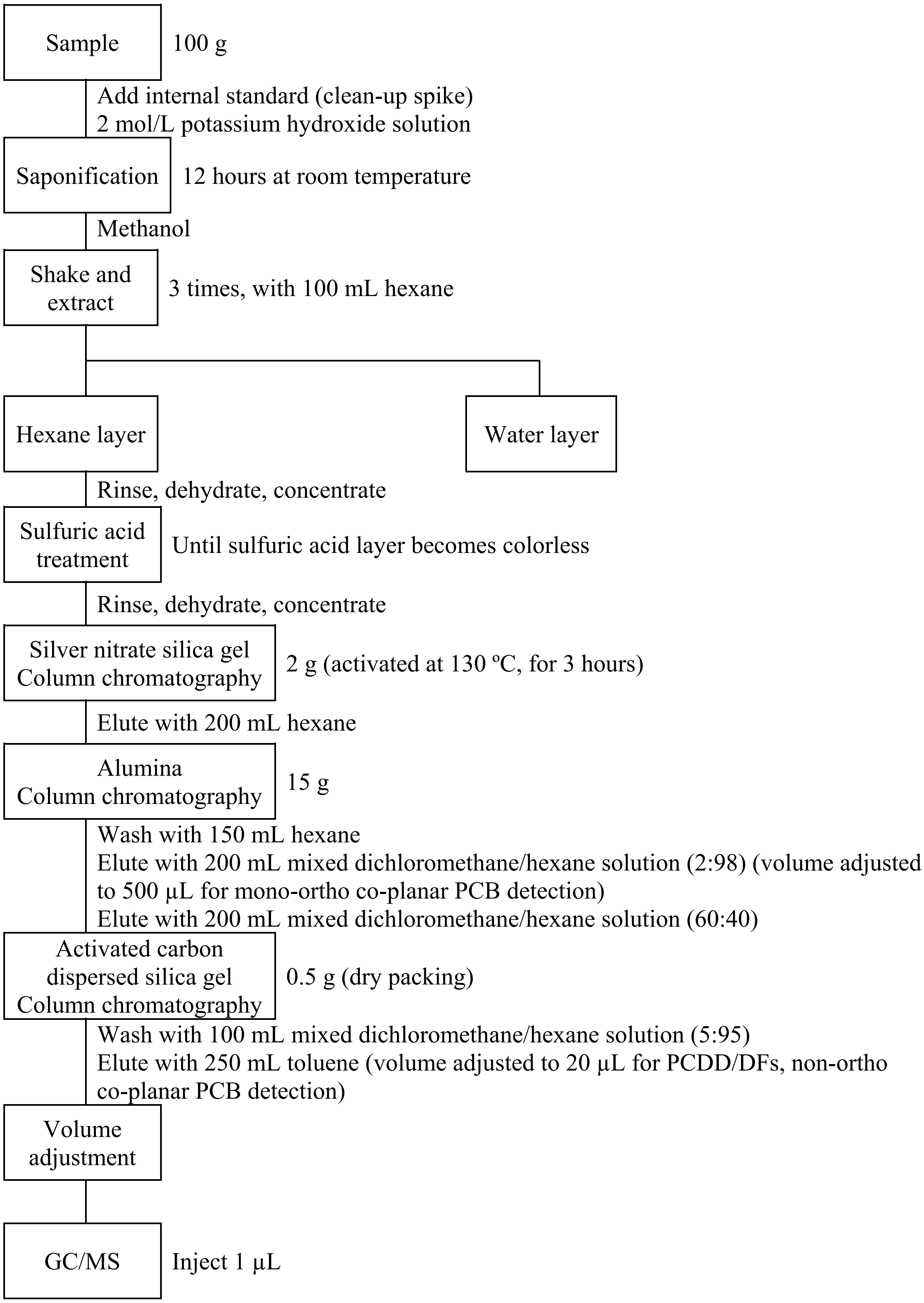


Figure 15. Flowchart of analytical method for determining (chlorinated) dioxins in food samples

[Gas chromatograph – high-resolution mass spectrometer operating conditions**]**

[Ambient air, settled soot and dust, soil, sediment]

Column: (a) Fused Silica SP-2331 [SIGMA-ALDRICH]
Length 60 m, inner diameter 0.32 mm, film thickness 0.2 μm
(b) Fused Silica DB-17 [J&W SCIENTIFIC]
Length 60 m, inner diameter 0.32 mm, film thickness 0.25 μm
(c) Fused Silica DB-5MS [J&W SCIENTIFIC]
Length 60 m, inner diameter 0.25 mm, film thickness 0.25 μm

Injection style: Splitless

Temperature: Sample inlet 260 ºC

Column

(a) 150 ºC (retained 1 min.)→ raised 15 ºC/min. →
200 ºC (retained 5 min.) → raised 2 ºC/min. →
250 ºC (retained 30 min.)

(b) 150 ºC (retained 1 min.)→ raised 10 ºC/min. → 210 ºC
→ raised 30 ºC/min. → 270 ºC (retained 34 min.)

(c) 150 ºC (retained 1 min.)→ raised 15 ºC/min.
→ 200 ºC (retained 5 min.) → raised 2 ºC/min.
→ 250 ºC (retained 10 min.) → raised 20 ºC/min.
→ 270 ºC (retained 10 min.)

[Groundwater, public water, aquatic life, terrestrial wildlife, food samples]

Column: (a) Fused Silica SP-2331 [SIGMA-ALDRICH]
Length 60 m, inner diameter 0.32 mm, film thickness 0.2 μm
(b) Fused Silica DB-17 [J&W SCIENTIFIC]
Length 60 m, inner diameter 0.32 mm, film thickness 0.25 μm
(c) Fused Silica HT8 [SGE]
Length 50 m, inner diameter 0.22 mm, film thickness 0.25 μm

Injection style: Splitless

Temperature: Sample inlet 260 ºC

Column

(a) 150 ºC (retained 1 min.)→ raised 15 ºC/min.
→ 200 ºC (retained 5 min.)→ raised 2 ºC/min.
→ 250 ºC (retained 30 min.)

(b) 150 ºC (retained 1 min.)→ raised 10 ºC/min. → 180 ºC
→ raised 5 ºC/min. → 210 ºC (retained 5 min.)
→ raised 30 ºC/min. → 270 ºC (retained 33 min.)

(c) 160 ºC (retained 1 min.)→ raised 15 ºC/min.
→ 220 ºC (retained 5 min.)→ raised 2 ºC/min.

→ 270 ºC (retained 5 min.)

Model:		Autospec ULTIMA [Micromass Ltd.]	
Ion source temperature:		260 ºC	
Ionization method:		EI	
Ionization voltage:		30 eV	
Ionization current:		500 μA	
Resolution:		10,000	
Established mass:		TeCDF	m/z 303.9016, 305.8987
		[$^{13}C_{12}$]TeCDF	m/z 315.9419, 317.9389
		TeCDD	m/z 319.8965, 321.8936
		[$^{13}C_{12}$]TeCDD	m/z 331.9368, 333.9338
		PeCDF	m/z 339.8597, 341.8568
		[$^{13}C_{12}$]PeCDF	m/z 351.9000, 353.8970
		PeCDD	m/z 355.8546, 357.8517
		[$^{13}C_{12}$]PeCDD	m/z 367.8949, 369.8919
		HxCDF	m/z 373.8207, 375.8178
		[$^{13}C_{12}$]HxCDF	m/z 385.8610, 387.8580
		HxCDD	m/z 389.8156, 391.8127
		[$^{13}C_{12}$]HxCDD	m/z 401.8559, 403.8530
	*	HpCDF	m/z 407.7818, 409.7788
	*	[$^{13}C_{12}$]HpCDF	m/z 419.8220, 421.8190
	*	HpCDD	m/z 423.7767, 425.7737
	*	[$^{13}C_{12}$]HpCDD	m/z 435.8169, 437.8140
	*	OCDF	m/z 441.7428, 443.7398
	*	[$^{13}C_{12}$]OCDF	m/z 453.7830, 455.7801
	*	OCDD	m/z 457.7377, 459.7348
	*	[$^{13}C_{12}$]OCDD	m/z 469.7779, 471.7750
	**	TeCB	m/z 289.9224, 291.9194
	**	[$^{13}C_{12}$]TeCB	m/z 301.9626, 303.9597
	**	PeCB	m/z 325.8804, 327.8775
	**	[$^{13}C_{12}$]PeCB	m/z 337.9207, 339.9178
	**	HxCB	m/z 359.8415, 361.8385
	**	[$^{13}C_{12}$]HxCB	m/z 371.8817, 373.8788
	**	HpCB	m/z 393.8025, 395.7995
	**	[$^{13}C_{12}$]HpCB	m/z 405.8428, 407.8398

* A DB-17 column was used.

** A DB-17 column was used to determine non-ortho co-planar PCBs, and DB-5MS or HT8 columns for mono-ortho co-planar PCBs.

[Detection and quantification limits**]**

Table 19 shows detection and quantification limits of (chlorinated) dioxins.

Table 19. Quantification and detection limits of (chlorinated) dioxins

Analyzed compound	Ambient air		Settled soot and dust		Soil		Sediment		Food samples
	Quantification limit	Detection limit	Quantification limit	Detection limit	Quantification limit	Detection limit	Quantification limit	Detection limit	Detection limit
TeCDD	0.005 pg/m^3	0.001 pg/m^3	5 $pg/m^2/d$	2 $pg/m^2/d$	0.25 pg/g	0.08 pg/g	0.12 pg/g	0.04 pg/g	0.003 pg/g
PeCDD	0.005 pg/m^3	0.001 pg/m^3	5 $pg/m^2/d$	2 $pg/m^2/d$	0.25 pg/g	0.08 pg/g	0.12 pg/g	0.04 pg/g	0.005 pg/g
HxCDD	0.010 pg/m^3	0.003 pg/m^3	10 $pg/m^2/d$	3 $pg/m^2/d$	0.5 pg/g	0.2 pg/g	0.24 pg/g	0.07 pg/g	0.006 pg/g
HpCDD	0.010 pg/m^3	0.003 pg/m^3	10 $pg/m^2/d$	3 $pg/m^2/d$	0.5 pg/g	0.2 pg/g	0.24 pg/g	0.07 pg/g	0.006 pg/g
OCDD	0.018 pg/m^3	0.005 pg/m^3	20 $pg/m^2/d$	6 $pg/m^2/d$	1.0 pg/g	0.3 pg/g	0.5 pg/g	0.1 pg/g	0.01 pg/g
TeCDF	0.005 pg/m^3	0.001 pg/m^3	5 $pg/m^2/d$	2 $pg/m^2/d$	0.25 pg/g	0.08 pg/g	0.12 pg/g	0.04 pg/g	0.003 pg/g
PeCDF	0.005 pg/m^3	0.001 pg/m^3	5 $pg/m^2/d$	2 $pg/m^2/d$	0.25 pg/g	0.08 pg/g	0.12 pg/g	0.04 pg/g	0.003 pg/g
HxCDF	0.010 pg/m^3	0.003 pg/m^3	10 $pg/m^2/d$	3 $pg/m^2/d$	0.5 pg/g	0.2 pg/g	0.24 pg/g	0.07 pg/g	0.006 pg/g
HpCDF	0.010 pg/m^3	0.003 pg/m^3	10 $pg/m^2/d$	3 $pg/m^2/d$	0.5 pg/g	0.2 pg/g	0.24 pg/g	0.07 pg/g	0.005 pg/g
OCDF	0.018 pg/m^3	0.005 pg/m^3	20 $pg/m^2/d$	6 $pg/m^2/d$	1.0 pg/g	0.3 pg/g	0.5 pg/g	0.1 pg/g	0.01 pg/g
Non-PCB	0.010 pg/m^3	0.003 pg/m^3	10 $pg/m^2/d$	6 $pg/m^2/d$	0.5 pg/g	0.2 pg/g	0.24 pg/g	0.07 pg/g	0.008 pg/g
Mono-PCB	0.010 pg/m^3	0.003 pg/m^3	10 $pg/m^2/d$	6 $pg/m^2/d$	0.5 pg/g	0.2 pg/g	0.24 pg/g	0.07 pg/g	0.1 pg/g

3） Analytical method for polybrominated diphenyl ethers

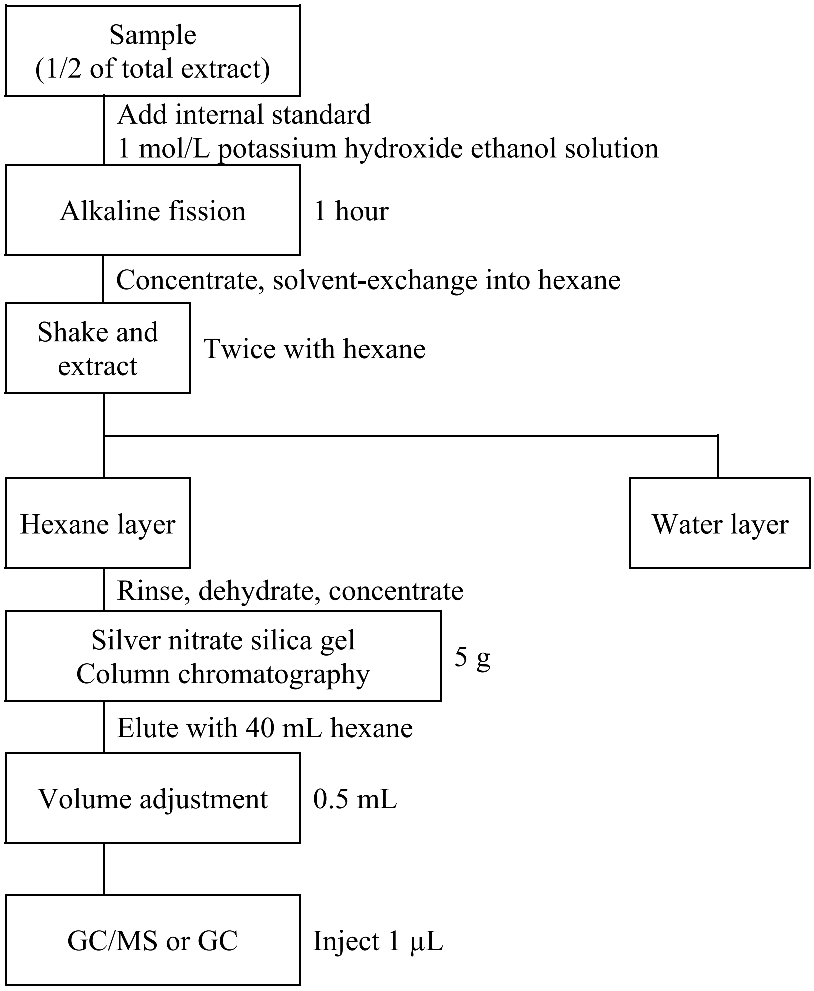


Figure 16. Flowchart of analytical method for determining polybrominated diphenyl ethers in ambient air and settled soot and dust

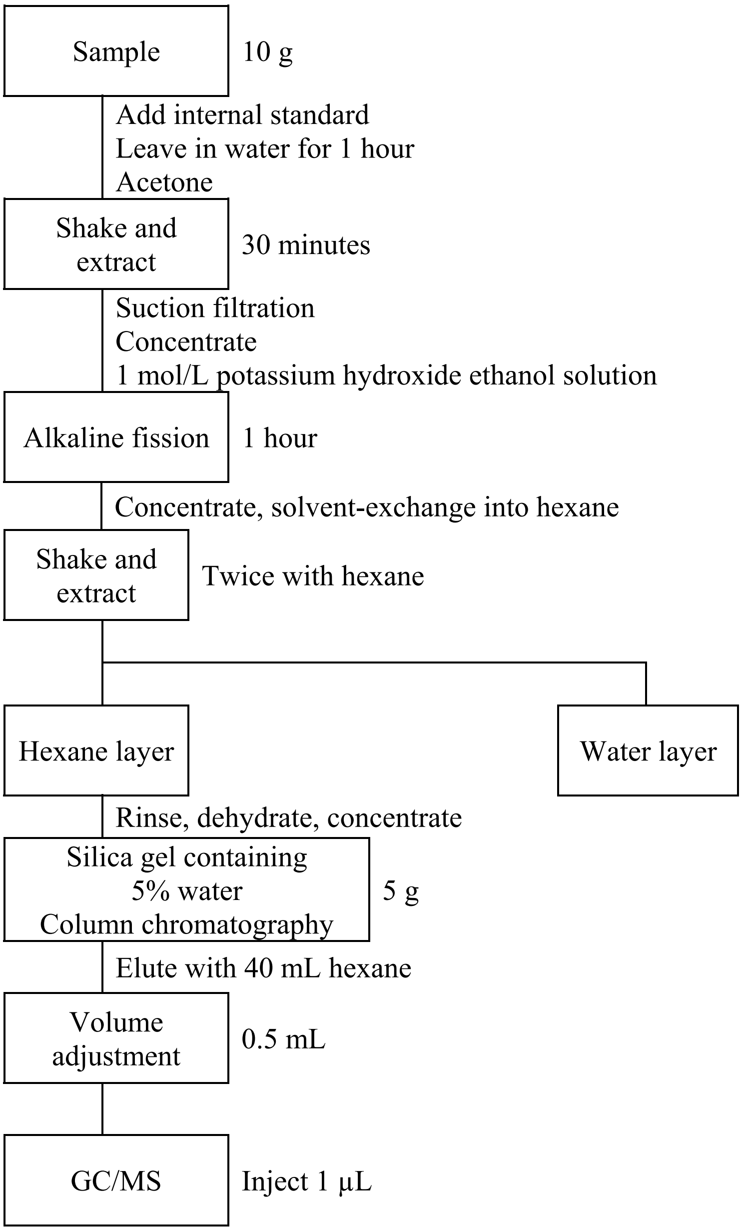


Figure 17. Flowchart of analytical method for determining polybrominated diphenyl ethers in soil

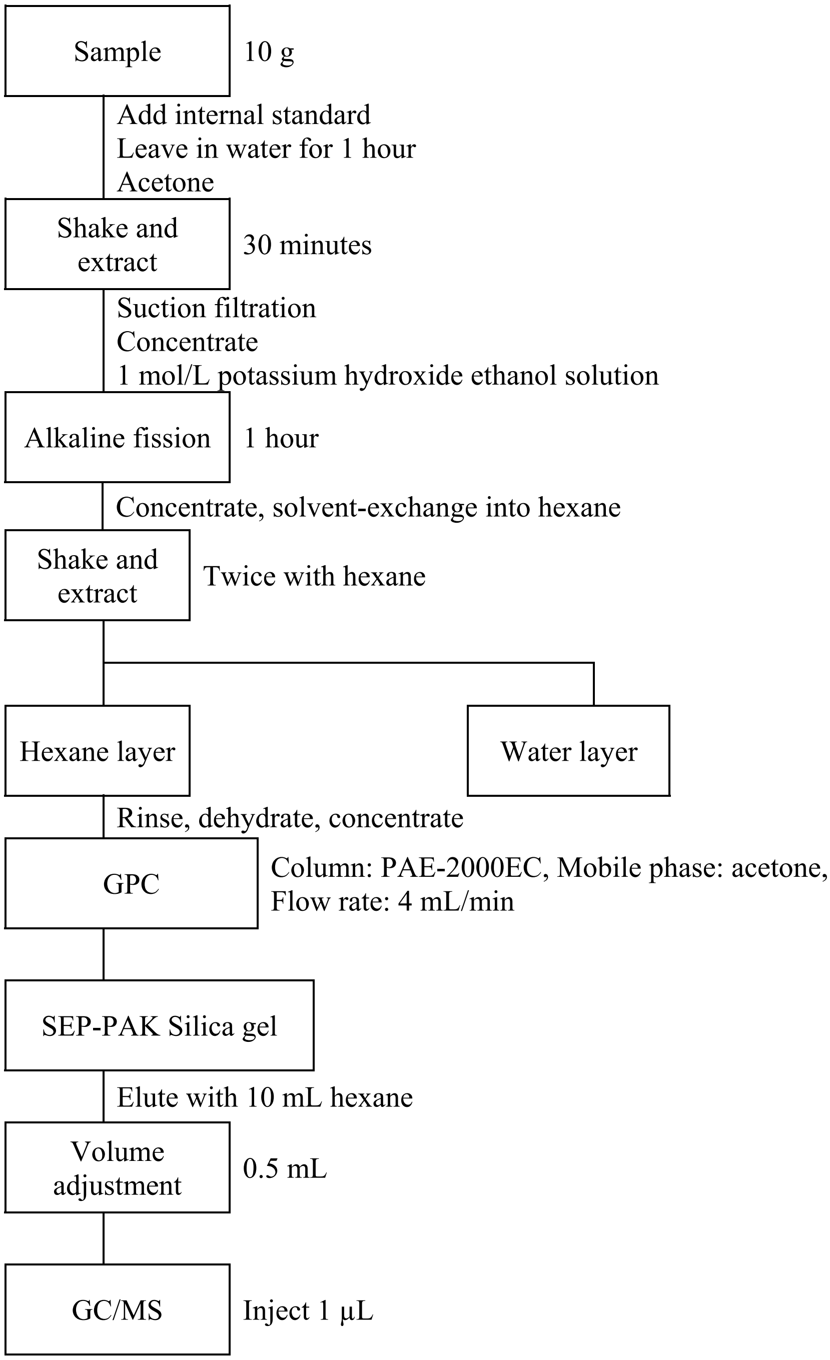


Figure 18. Flowchart of analytical method for determining polybrominated diphenyl ethers in sediment samples

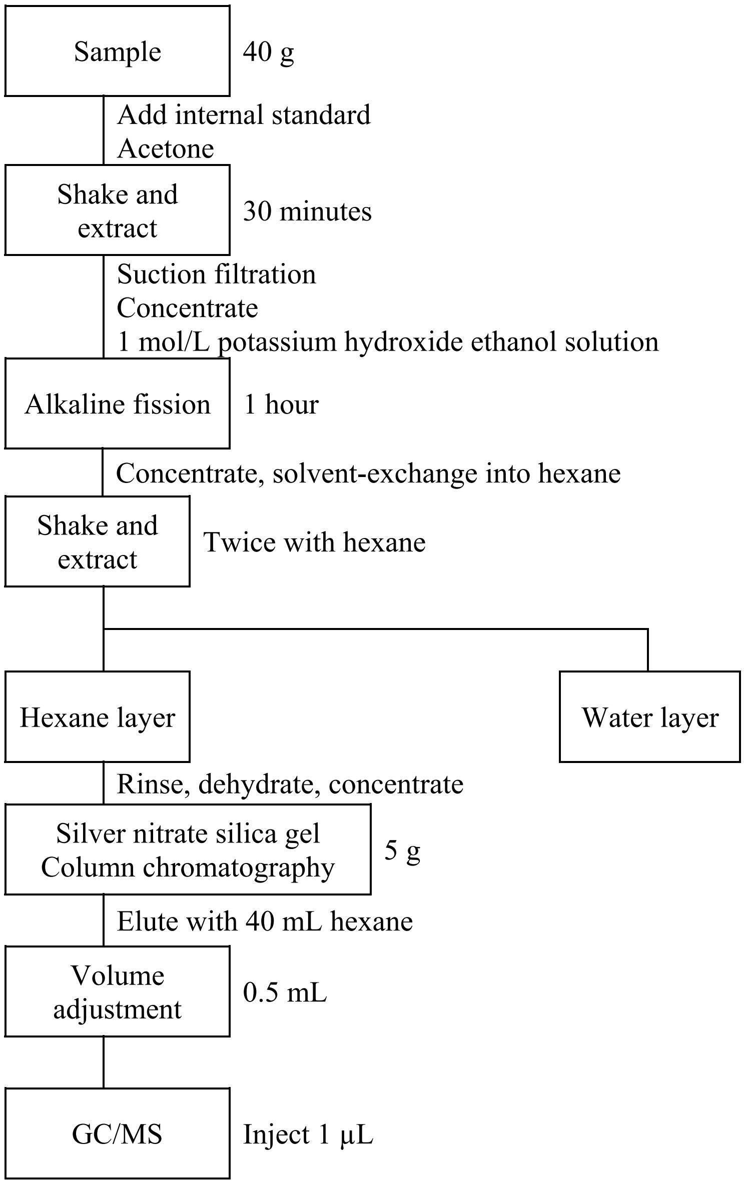


Figure 19. Flowchart of analytical method for determining polybrominated diphenyl ethers in food samples

[Gas chromatograph – high-resolution mass spectrometer operating conditions**]**

[Polybrominated diphenyl ether]

Model:	Aglient 5793	
Column:	Fused Silica TC-1	
	Length 30 m, inner diameter 0.25 mm, film thickness 0.25 μm	
Injection style:	Splitless	
Temperature:	Sample inlet 280 ºC	
	Column 120 ºC (retained 2 min.) → raised 10 ºC/min. →	
	320 ºC (retained 6 min.)	
Ion source temperature:	230 ºC	
EM voltage:	+1000 V	
Established mass:	TrBDE	m/z 405.8, 407.8
	[$^{13}C_{12}$]TrBDE	m/z 417.8
	TeBDE	m/z 485.7, 487.7
	[$^{13}C_{12}$]TeBDE	m/z 497.8
	PeBDE	m/z 563.6, 565.6
	[$^{13}C_{12}$]PeBDE	m/z 575.7
	HxBDE	m/z 643.6, 645.6
	[$^{13}C_{12}$]HxBDE	m/z 655.6
	HpBDE	m/z 721.5, 723.5
	[$^{13}C_{12}$]HpBDE	m/z 735.6

[Gas chromatograph operating conditions**]**

[Decabromodiphenyl ether]

Model:	HP 5890
Column:	Fused Silica Rtx-1
	Length 15 m, inner diameter 0.53 mm, film thickness 0.1 μm
Temperature:	Sample inlet 280 ºC
	Column 150 ºC (retained 1 min.)→ raised 10 ºC/min. →
	300 ºC (retained 10 min.)
Detector:	ECD
Temperature of detector:	300 ºC
Carrier gas flow:	20 mL/min.
Make-up gas flow:	40 mL/min.

5 Survey Findings and Observations

1) Ambient air

The determination results of brominated dioxins in ambient air are shown in Table 20, (chlorinated) dioxins in Table 21, and polybrominated diphenyl ethers in Table 22.

Table 20. Determination results of brominated dioxins (ambient air)

Unit: pg/m^3

Analyzed compound	Region A			Region B			Region C
	A1	A2	A3	B1	B2	B3	C1
2-MoB-3,7,8-TrCDD	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
1-MoB-2,3,7,8-TeCDD	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
2-MoB-3,6,7,8,9-PeCDD	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
1-MoB-2,3,6,7,8,9-HxCDD	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
1-MoB-2,3,4,6,7,8,9-HpCDD	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
3-MoB-2,7,8-TrCDF	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
1-MoB-2,3,7,8-TeCDF	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
MoB-TrCDDs total	0.03	0.05	0.26	0.02	N.D.	N.D.	N.D.
MoB-TeCDDs total	0.04	0.05	0.13	0.03	0.02	0.02	N.D.
MoB-PeCDDs total	0.06	0.09	0.10	0.06	0.06	0.22	N.D.
MoB-HxCDDs total	N.D.	N.D.	N.D.	N.D.	N.D.	0.13	N.D.
MoB-HpCDDs total	N.D.	N.D.	N.D.	N.D.	N.D.	0.2	N.D.
MoB-TrCDFs total	N.D.	0.02	0.08	0.06	N.D.	N.D.	N.D.
MoB-TeCDFs total	0.05	0.09	0.13	0.06	0.06	N.D.	N.D.
(MoBPCDDs+MoBPCDFs) total	0.18	0.30	0.70	0.23	0.14	0.57	N.D.
2,3,7,8-TeBDD	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
1,2,3,7,8-PeBDD	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
1,2,3,4,7,8-/ 1,2,3,6,7,8-HxBDD	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
1,2,3,7,8,9-HxBDD	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
2,3,7,8-TeBDF	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
1,2,3,7,8-PeBDF	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
2,3,4,7,8-PeBDF	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
1,2,3,4,7,8-HxBDF	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.

Table 21. Determination results of (chlorinated) dioxins (ambient air) Unit: pg/m^3

Analyzed compound			Region A			Region B			Region C
			A1	A2	A3	B1	B2	B3	C1
Dioxins		2,3,7,8-TeCDD	0.006	0.009	0.009	(0.004)	(0.003)	(0.003)	N.D.
		1,3,6,8-TeCDD	0.25	0.69	0.36	0.21	0.21	0.32	0.050
		1,3,7,9-TeCDD	0.14	0.44	0.19	0.091	0.10	0.15	0.025
		1,2,3,7,8-PeCDD	0.025	0.078	0.035	0.014	0.016	0.022	(0.004)
		1,2,3,4,7,8-HxCDD	0.027	0.074	0.034	0.016	0.025	0.025	(0.006)
		1,2,3,6,7,8-HxCDD	0.050	0.14	0.059	0.039	0.057	0.054	(0.008)
		1,2,3,7,8,9-HxCDD	0.036	0.12	0.046	0.034	0.038	0.033	(0.008)
		1,2,3,4,6,7,8-HpCDD	0.3	0.90	0.49	0.36	0.44	0.46	0.064
		OCDD	0.59	1.8	1.1	0.96	1.0	0.87	0.13
Dibenzofurans		2,3,7,8-TeCDF	0.051	0.12	0.058	0.030	0.036	0.032	0.009
		1,3,6,8-TeCDF	0.064	0.17	0.082	0.060	0.061	0.069	0.011
		1,2,7,8-TeCDF	0.091	0.22	0.14	0.062	0.077	0.061	0.012
		1,2,3,7,8-PeCDF	0.13	0.64	0.16	0.090	0.11	0.10	0.019
		2,3,4,7,8-PeCDF	0.10	0.51	0.13	0.076	0.11	0.11	0.020
		1,2,3,4,7,8-HxCDF	0.15	1.0	0.16	0.12	0.17	0.18	0.026
		1,2,3,6,7,8-HxCDF	0.13	0.78	0.14	0.11	0.16	0.17	0.025
		1,2,3,7,8,9-HxCDF	0.012	0.064	0.013	0.012	0.02	0.021	N.D.
		2,3,4,6,7,8-HxCDF	0.19	0.78	0.19	0.18	0.36	0.40	0.030
		1,2,3,4,6,7,8-HpCDF	0.49	3.5	0.47	0.52	0.98	1.1	0.092
		1,2,3,4,7,8,9-HpCDF	0.10	0.60	0.094	0.13	0.28	0.30	0.019
		OCDF	0.40	3.7	0.38	0.71	1.7	1.6	0.072
Co-planar PCBs	Non-ortho	3,4,4',5-TeCB (#81)	0.043	0.14	0.070	0.052	0.060	0.055	0.010
		3,3',4,4'-TeCB (#77)	0.29	1.3	0.52	0.34	0.41	0.32	0.067
		3,3',4,4',5-PeCB (#126)	0.072	0.26	0.10	0.066	0.083	0.077	0.013
		3,3',4,4',5,5'-HxCB (#169)	0.023	0.088	0.028	0.017	0.028	0.027	(0.004)
	Mono-ortho	2',3,4,4',5-PeCB (#123)	0.046	0.068	0.035	0.069	0.065	0.047	0.010
		2,3',4,4',5-PeCB (#118)	0.64	1.5	1.1	2.1	2.6	1.6	0.24
		2,3,3',4,4'-PeCB (#105)	0.24	0.69	0.43	0.71	0.82	0.51	0.080
		2,3,4,4',5-PeCB (#114)	0.037	0.12	0.055	0.087	0.097	0.065	0.011
		2,3',4,4',5,5'-HxCB (#167)	0.032	0.11	0.045	0.068	0.066	0.051	(0.009)
		2,3,3',4,4',5-HxCB (#156)	0.072	0.26	0.10	0.16	0.15	0.12	0.018
		2,3,3',4,4',5'-HxCB (#157)	0.028	0.098	0.038	0.050	0.040	0.043	(0.007)
		2,3,3',4,4',5,5'-HpCB (#189)	0.037	0.17	0.037	0.031	0.041	0.041	(0.006)
	Di-ortho	2,2',3,3',4,4',5-HpCB (#170)	0.12	0.41	0.13	0.22	0.22	0.21	0.030
		2,2',3,4,4',5,5'-HpCB (#180)	0.14	0.37	0.17	0.29	0.29	0.24	0.039
TEQ total			0.17	0.76	0.21	0.13	0.19	0.20	0.023
Congeners	Dioxins	TeCDDs total	0.62	1.7	0.97	0.44	0.49	0.66	0.10
		PeCDDs total	0.68	2.1	0.99	0.38	0.48	0.49	0.10
		HxCDDs total	0.74	2.3	0.97	0.61	0.73	0.74	0.18
		HpCDDs total	0.62	1.8	0.94	0.73	0.90	0.94	0.15
		OCDD	0.59	1.8	1.1	0.96	1.0	0.87	0.13
		PCDDs total	3.25	9.7	4.97	3.12	3.6	3.7	0.66
	Dibenzofurans	TeCDFs total	2.1	6.2	3.0	1.7	1.9	1.8	0.26
		PeCDFs total	1.7	7.8	2.1	1.3	1.7	1.7	0.24
		HxCDFs total	1.4	7.9	1.5	1.2	2.0	2.2	0.23
		HpCDFs total	0.98	6.0	0.92	1.2	2.3	2.6	0.17
		OCDF	0.40	3.7	0.38	0.71	1.7	1.6	0.072
		PCDFs total	6.58	31.6	7.9	6.11	9.6	9.9	0.972
	(PCDDs+PCDFs) total		9.8	41	13	9.2	13	14	1.6

Measured concentration values below the detection limit are indicated "N.D."; those above the detection limit but below the quantification limit are indicated in parentheses.

Table 22. Determination results of polybrominated diphenyl ethers (ambient air)

Unit: ng/m^3

Analyzed compound	Detection limit	Region A
		A1
2,4,4'-TrBDE	0.0004	0.0004
2,2',4,4'-TeBDE	0.0004	0.0011
2,2',4,4',6-PeBDE	0.001	N.D.
2,2',4,4',5-PeBDE	0.001	0.002
2,2',4,4',5,6'-HxBDE	0.002	N.D.
2,2',4,4',5,5'-HxBDE	0.002	N.D.
2,2',3,4,4',5,6'-HpBDE	0.004	N.D.
DeBDE	0.02	0.03

Summary and discussion

Regarding monobromopolychlorinated dioxins, 2,3,7,8-substituted congeners were all found to be below the detection limit. Other congeners, centering on monobromotrichlorinated compounds to monobromopentachlorinated compounds, were detected in all spots in regions A and B. The distribution of these congeners clearly differed from that of soil and sediment (Figure 20). In region C, none of the congeners were found. The total amount of monobromopolychlorinated dioxin congeners detected was approximately 1/140 to 1/20 the amount found for chlorinated dioxins (PCDDs and PCDFs).

Polybrominated dioxins were not detected in any of the regions.

(Chlorinated) dioxins were found at concentrations of 0.17 to 0.76 pg-TEQ/g in region A, 0.13 to 0.20 pg-TEQ/g in region B, and 0.023 pg-TEQ/g in region C. Spot A2 in region A had the highest concentration. The correlation factor between the sum of all monobromopolychlorinated dioxin congeners and total chlorinated dioxins (PCDDs and PCDFs) was 0.2339, indicating no significant correlation between them (Figure 21).

Polybrominated diphenyl ethers were analyzed in region A, spot A1, and as a result, 2,4,4'-TrBDE, 2,2',4,4'-TeBDE, 2,2',4,4',5-PeBDE, and DeBDE were detected.

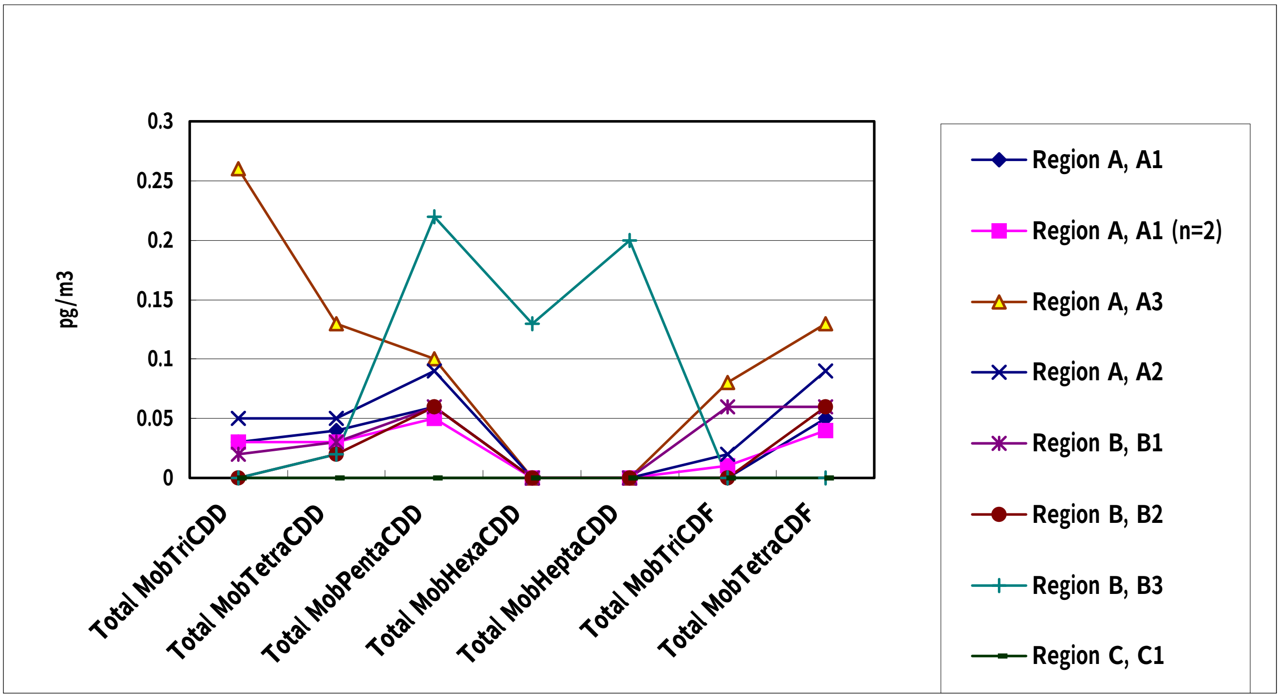


Figure 20. Distribution of monobromopolychlorinated dioxin congeners (ambient air)

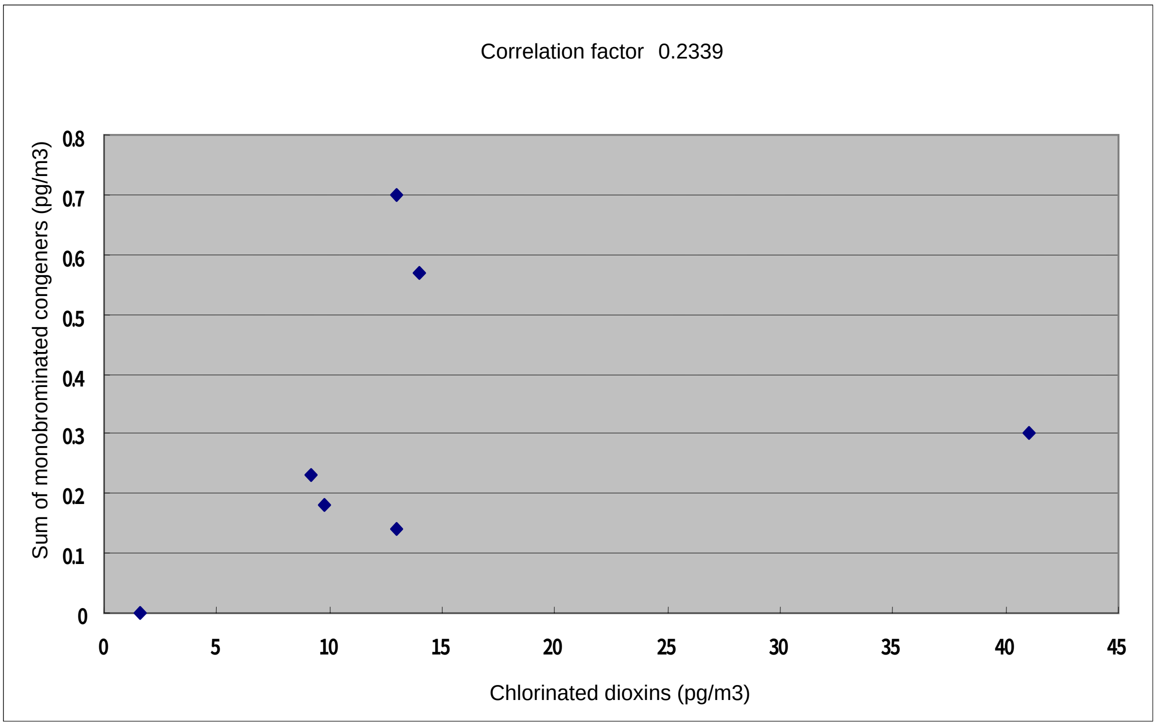


Figure 21. Correlation between sum of monobromopolychlorinated dioxin congeners and (chlorinated) dioxins (ambient air)

2） Settled soot and dust

The determination results of brominated dioxins in settled soot and dust are shown in Table 23, (chlorinated) dioxins in Table 24, and polybrominated diphenyl ethers in Table 25.

Table 23. Determination results of brominated dioxins (settled soot and dust)

Unit: pg/m^2/day

Analyzed compound	Region A			Region B			Region C
	A1	A2	A3	B1	B2	B3	C1
2-MoB-3,7,8-TrCDD	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
1-MoB-2,3,7,8-TeCDD	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
2-MoB-3,6,7,8,9-PeCDD	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
1-MoB-2,3,6,7,8,9-HxCDD	N.D.	80	N.D.	N.D.	N.D.	N.D.	N.D.
1-MoB-2,3,4,6,7,8,9-HpCDD	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
3-MoB-2,7,8-TrCDF	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
1-MoB-2,3,7,8-TeCDF	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
MoB-TrCDDs total	30	210	20	N.D.	N.D.	N.D.	N.D.
MoB-TeCDDs total	20	60	N.D.	N.D.	N.D.	N.D.	N.D.
MoB-PeCDDs total	N.D.	100	N.D.	N.D.	N.D.	N.D.	N.D.
MoB-HxCDDs total	N.D.	130	N.D.	N.D.	N.D.	N.D.	N.D.
MoB-HpCDDs total	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
MoB-TrCDFs total	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
MoB-TeCDFs total	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
(MoBPCDDs+MoBPCDFs) total	50	500	20	N.D.	N.D.	N.D.	N.D.
2,3,7,8-TeBDD	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
1,2,3,7,8-PeBDD	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
1,2,3,4,7,8-/ 1,2,3,6,7,8-HxBDD	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
1,2,3,7,8,9-HxBDD	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
2,3,7,8-TeBDF	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
1,2,3,7,8-PeBDF	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
2,3,4,7,8-PeBDF	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
1,2,3,4,7,8-HxBDF	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.

Table 24. Determination results of (chlorinated) dioxins (settled soot and dust) Unit: pg/m^2/day

Analyzed compound			Region A			Region B			Region C
			A1	A2	A3	B1	B2	B3	C1
Dioxins		2,3,7,8-TeCDD	N.D.	7	N.D.	N.D.	N.D.	N.D.	N.D.
		1,3,6,8-TeCDD	290	480	240	110	100	100	51
		1,3,7,9-TeCDD	130	230	100	52	50	40	20
		1,2,3,7,8-PeCDD	15	29	12	8	6	7	N.D.
		1,2,3,4,7,8-HxCDD	14	35	13	(9)	(6)	(5)	(6)
		1,2,3,6,7,8-HxCDD	29	70	22	14	11	10	(8)
		1,2,3,7,8,9-HxCDD	21	53	15	10	10	(9)	N.D.
		1,2,3,4,6,7,8-HpCDD	210	660	190	110	93	100	75
		OCDD	900	3100	940	560	500	560	400
Dibenzofurans		2,3,7,8-TeCDF	17	34	20	16	15	11	7
		1,3,6,8-TeCDF	12	36	16	13	13	11	7
		1,2,7,8-TeCDF	21	54	30	20	16	15	7
		1,2,3,7,8-PeCDF	31	76	36	28	19	19	13
		2,3,4,7,8-PeCDF	31	62	32	24	19	16	15
		1,2,3,4,7,8-HxCDF	44	88	37	32	14	21	18
		1,2,3,6,7,8-HxCDF	38	77	29	27	16	19	13
		1,2,3,7,8,9-HxCDF	(3)	(6)	(4)	N.D.	(4)	N.D.	N.D.
		2,3,4,6,7,8-HxCDF	50	91	48	36	22	24	24
		1,2,3,4,6,7,8-HpCDF	150	330	120	100	63	73	62
		1,2,3,4,7,8,9-HpCDF	25	47	27	20	15	13	17
		OCDF	130	280	120	120	67	65	53
Co-planar PCBs	Non-ortho	3,4,4',5-TeCB (#81)	15	84	18	39	14	11	(6)
		3,3',4,4'-TeCB (#77)	150	1100	160	680	150	88	44
		3,3',4,4',5-PeCB (#126)	28	96	32	56	26	20	10
		3,3',4,4',5,5'-HxCB (#169)	(8)	19	(8)	(7)	(4)	(4)	N.D.
	Mono-ortho	2',3,4,4',5-PeCB (#123)	23	120	20	90	23	200	10
		2,3',4,4',5-PeCB (#118)	640	3900	520	3400	900	380	130
		2,3,3',4,4'-PeCB (#105)	320	2100	270	1900	390	160	56
		2,3,4,4',5-PeCB (#114)	25	170	22	120	37	13	(6)
		2,3',4,4',5,5'-HxCB (#167)	38	130	25	140	44	210	(7)
		2,3,3',4,4',5-HxCB (#156)	99	340	72	420	150	54	16
		2,3,3',4,4',5'-HxCB (#157)	31	97	23	96	44	17	(6)
		2,3,3',4,4',5,5'-HpCB (#189)	14	39	16	35	26	(9)	(6)
	Di-ortho	2,2',3,3',4,4',5-HpCB (#170)	140	520	110	670	340	87	31
		2,2',3,4,4',5,5'-HpCB (#180)	180	760	140	1000	590	110	38
TEQ total			60	140	55	44	32	29	17
Congeners	Dioxins	TeCDDs total	500	1400	460	210	190	190	76
		PeCDDs total	340	880	230	140	110	120	52
		HxCDDs total	430	1200	340	190	140	160	95
		HpCDDs total	440	1400	390	240	190	210	150
		OCDD	900	3100	940	560	500	560	400
		PCDDs total	2610	7980	2360	1340	1130	1240	773
	Dibenzofurans	TeCDFs total	500	1300	590	480	400	380	200
		PeCDFs total	450	960	450	360	240	250	160
		HxCDFs total	410	840	340	300	170	210	150
		HpCDFs total	280	590	240	190	120	140	130
		OCDF	130	280	120	120	67	65	53
		PCDFs total	1770	3970	1740	1450	997	1045	693
	(PCDDs+PCDFs) total		4400	12000	4100	2800	2100	2300	1500

Measured concentration values below the detection limit are indicated "N.D."; those above the detection limit but below the quantification limit are indicated in parentheses.

Table 25. Determination results of polybrominated diphenyl ethers (settled soot and dust)

Unit: ng/m^2/day

Analyzed compound	Detection limit	Region A			Region B			Region C
		A1	A2	A3	B1	B2	B3	C1
2,4,4'-TrBDE	0.1	0.2	0.4	0.1	0.3	0.2	0.1	0.1
2,2',4,4'-TeBDE	0.1	0.2	0.9	0.2	1.0	0.5	0.3	N.D.
2,2',4,4',6-PeBDE	0.2	0.2	N.D.	N.D.	0.2	N.D.	N.D.	N.D.
2,2',4,4',5-PeBDE	0.2	2.0	2.2	1.0	1.8	0.8	0.6	N.D.
2,2',4,4',5,6'-HxBDE	0.4	2.4	1.6	1.4	1.6	0.6	N.D.	N.D.
2,2',4,4',5,5'-HxBDE	0.4	5.4	4.6	2.6	3.4	1.0	0.6	N.D.
2,2',3,4,4',5,6'-HpBDE	0.8	7.8	8.8	3.4	5.4	1.6	1.2	N.D.
DeBDE	4	240	160	110	120	32	30	5

Summary and discussion

Regarding monobromopolychlorinated dioxins, 1-MoB-2,3,6,7,8,9-HxCDD was detected at a concentration of 80 pg/m^2/day in region A spot A2. Other congeners were detected in all spots in region A, centering on monobromotrichlorinated to monobromopentachlorinated compounds, and showing a similar trend to that of ambient air (Figure 22). None of the compounds were present in regions B and C. The total amount of monobromopolychlorinated dioxin congeners detected was approximately 1/200 to 1/24 the amount found for chlorinated dioxins (PCDDs and PCDFs).

Concentrations of all polybrominated dioxins were below the detection limits in all spots.

(Chlorinated) dioxins were found at concentrations of 55 to 140 pg-TEQ/m^2/day in region A, 29 to 44 pg-TEQ/m^2/day in region B, and 17 pg-TEQ/m^2/day in region C. As with ambient air, the concentration in region A spot A2 was the highest.

Concentrations of monobromopolychlorinated dioxin congeners strongly correlated with chlorinated dioxins (PCDDs and PCDFs), with a correlation factor of 0.9769 (Figure 23).

For polybrominated diphenyl ethers, many isomers were determined in regions A and B, showing clearly higher levels than in region C. The correlation factor of the sum of monobromopolychlorinated dioxin congeners and total polybrominated diphenyl ethers was 0.4183, and indicated that they do not correlate conspicuously with each other (Figure 24).

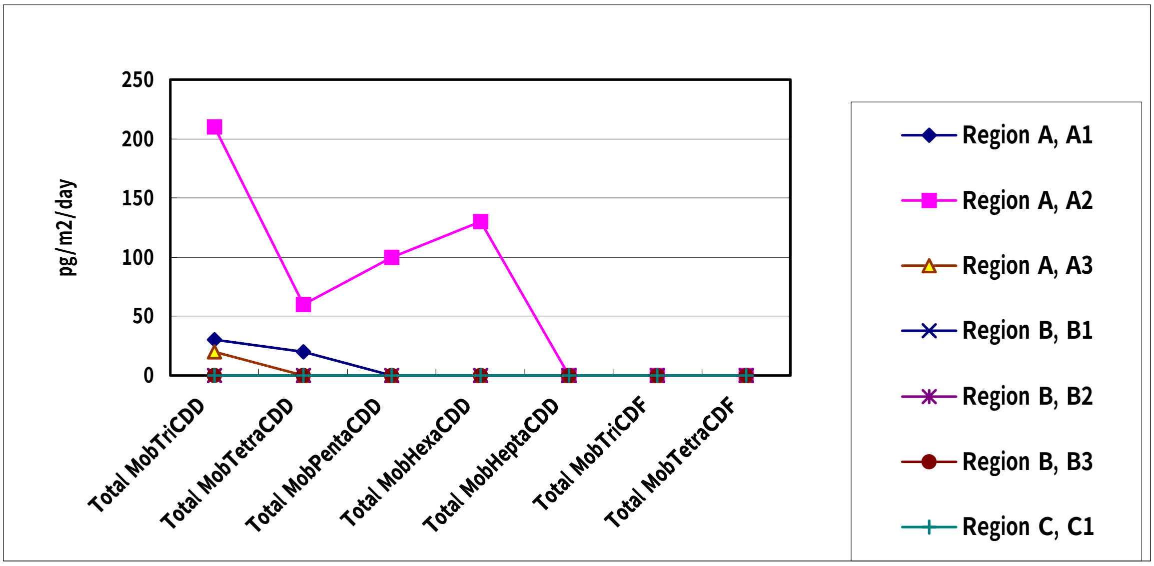


Figure 22. Distribution of monobromopolychlorinated dioxin congeners (settled soot and dust)

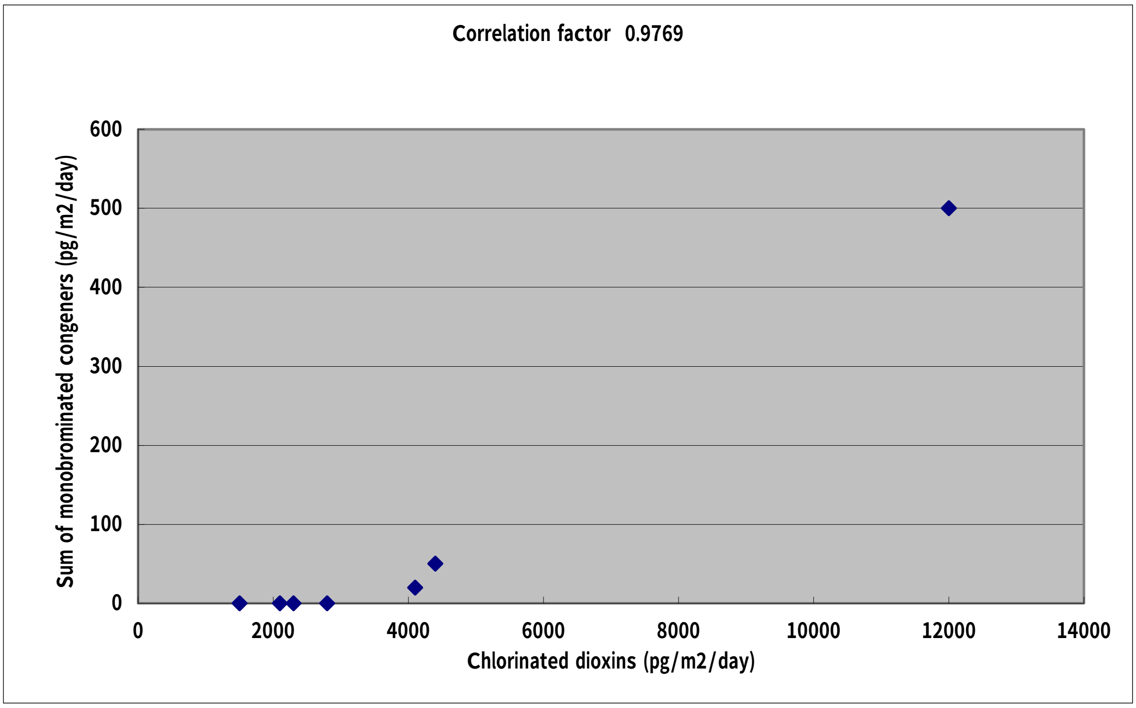


Figure 23. Correlation between sum of monobromopolychlorinated dioxin congeners and total (chlorinated) dioxins (settled soot and dust)

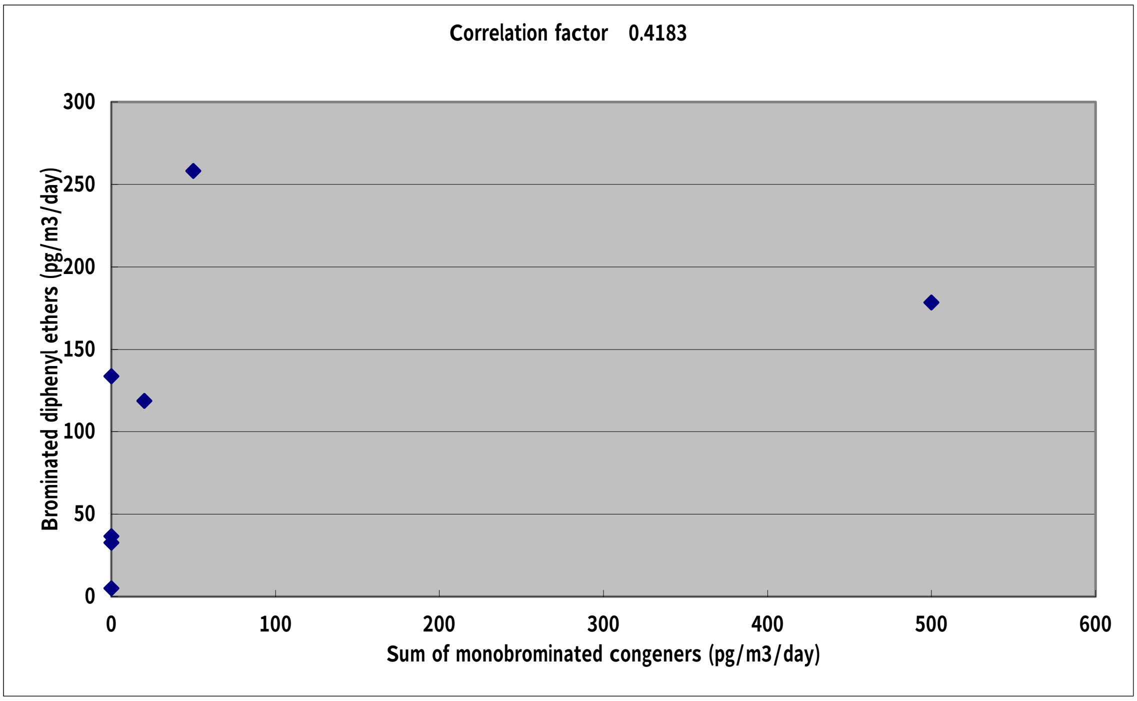


Figure 24. Correlation between sum of monobromopolychlorinated dioxin congeners and total polybrominated diphenyl ethers (settled soot and dust)

3) Soil

The determination results of brominated dioxins in soil are shown in Tables 26 and 27, (chlorinated) dioxins in Tables 28 and 29, and polybrominated diphenyl ethers in Table 30.

Table 26. Determination results of brominated dioxins (soil-1) Unit: pg/g

Analyzed compound	Region A				
	A1	A2	A3	A4	A5
2-MoB-3,7,8-TrCDD	N.D.	N.D.	N.D.	N.D.	N.D.
1-MoB-2,3,7,8-TeCDD	N.D.	N.D.	N.D.	N.D.	N.D.
2-MoB-3,6,7,8,9-PeCDD	N.D.	N.D.	N.D.	N.D.	N.D.
1-MoB-2,3,6,7,8,9-HxCDD	7	9	10	N.D.	N.D.
1-MoB-2,3,4,6,7,8,9-HpCDD	46	37	49	15	12
3-MoB-2,7,8-TrCDF	N.D.	N.D.	N.D.	N.D.	N.D.
1-MoB-2,3,7,8-TeCDF	N.D.	N.D.	N.D.	N.D.	N.D.
MoB-TrCDDs total	7	11	11	4	2
MoB-TeCDDs total	9	17	14	5	2
MoB-PeCDDs total	18	24	24	7	5
MoB-HxCDDs total	30	26	30	9	N.D.
MoB-HpCDDs total	79	62	90	38	12
MoB-TrCDFs total	5	6	7	2	N.D.
MoB-TeCDFs total	5	7	12	3	N.D.
(MoBPCDDs+MoBPCDFs) total	150	150	190	68	21
2,3,7,8-TeBDD	N.D.	N.D.	N.D.	N.D.	N.D.
1,2,3,7,8-PeBDD	N.D.	N.D.	N.D.	N.D.	N.D.
1,2,3,4,7,8-/ 1,2,3,6,7,8-HxBDD	N.D.	N.D.	N.D.	N.D.	N.D.
1,2,3,7,8,9-HxBDD	N.D.	N.D.	N.D.	N.D.	N.D.
2,3,7,8-TeBDF	N.D.	2	3	N.D.	N.D.
1,2,3,7,8-PeBDF	2	2	3	N.D.	N.D.
2,3,4,7,8-PeBDF	N.D.	N.D.	2	N.D.	N.D.
1,2,3,4,7,8-HxBDF	14	16	25	N.D.	N.D.

Table 27. Determination results of brominated dioxins (soil-2) Unit: pg/g

Analyzed compound	Region B			Region C
	B4	B5	B6	C1
2-MoB-3,7,8-TrCDD	N.D.	N.D.	N.D.	N.D.
1-MoB-2,3,7,8-TeCDD	N.D.	N.D.	N.D.	N.D.
2-MoB-3,6,7,8,9-PeCDD	N.D.	N.D.	N.D.	N.D.
1-MoB-2,3,6,7,8,9-HxCDD	N.D.	N.D.	N.D.	N.D.
1-MoB-2,3,4,6,7,8,9-HpCDD	N.D.	14	31	N.D.
3-MoB-2,7,8-TrCDF	N.D.	N.D.	N.D.	N.D.
1-MoB-2,3,7,8-TeCDF	N.D.	N.D.	N.D.	N.D.
MoB-TrCDDs total	N.D.	N.D.	1	N.D.
MoB-TeCDDs total	N.D.	1	N.D.	N.D.
MoB-PeCDDs total	2	N.D.	2	N.D.
MoB-HxCDDs total	N.D.	N.D.	N.D.	N.D.
MoB-HpCDDs total	N.D.	14	52	N.D.
MoB-TrCDFs total	N.D.	N.D.	N.D.	N.D.
MoB-TeCDFs total	N.D.	N.D.	N.D.	N.D.
(MoBPCDDs+MoBPCDFs) total	2	15	55	N.D.
2,3,7,8-TeBDD	N.D.	N.D.	N.D.	N.D.
1,2,3,7,8-PeBDD	N.D.	N.D.	N.D.	N.D.
1,2,3,4,7,8-/ 1,2,3,6,7,8-HxBDD	N.D.	N.D.	N.D.	N.D.
1,2,3,7,8,9-HxBDD	N.D.	N.D.	N.D.	N.D.
2,3,7,8-TeBDF	N.D.	N.D.	N.D.	N.D.
1,2,3,7,8-PeBDF	N.D.	N.D.	N.D.	N.D.
2,3,4,7,8-PeBDF	N.D.	N.D.	N.D.	N.D.
1,2,3,4,7,8-HxBDF	N.D.	N.D.	N.D.	N.D.

Table 28. Determination results of (chlorinated) dioxins (soil-1) Unit: pg/g

Analyzed compound			Region A				
			A1	A2	A3	A4	A5
Dioxins		2,3,7,8-TeCDD	1.9	1.3	2.1	1.0	0.39
		1,3,6,8-TeCDD	150	160	150	660	35
		1,3,7,9-TeCDD	73	67	74	230	14
		1,2,3,7,8-PeCDD	11	8.0	15	6.7	2.2
		1,2,3,4,7,8-HxCDD	16	8.9	16	7.2	3.0
		1,2,3,6,7,8-HxCDD	31	20	33	14	6.4
		1,2,3,7,8,9-HxCDD	29	16	30	16	6.4
		1,2,3,4,6,7,8-HpCDD	300	170	270	130	57
		OCDD	1500	770	1300	1400	150
Dibenzofurans		2,3,7,8-TeCDF	17	9.1	19	7.6	1.9
		1,3,6,8-TeCDF	10	8.0	14	6.6	1.9
		1,2,7,8-TeCDF	17	12	19	8.9	2.3
		1,2,3,7,8-PeCDF	33	21	34	16	4.6
		2,3,4,7,8-PeCDF	27	17	33	14	4.2
		1,2,3,4,7,8-HxCDF	42	25	43	20	6.7
		1,2,3,6,7,8-HxCDF	40	25	44	19	6.6
		1,2,3,7,8,9-HxCDF	3.0	2.2	3.2	1.4	0.6
		2,3,4,6,7,8-HxCDF	55	32	63	28	10
		1,2,3,4,6,7,8-HpCDF	190	110	190	100	33
		1,2,3,4,7,8,9-HpCDF	29	19	27	13	5.6
		OCDF	170	94	160	130	28
Co-planar PCBs	Non-ortho	3,4,4',5-TeCB (#81)	11	7.9	20	6.0	2.4
		3,3',4,4'-TeCB (#77)	62	43	210	39	30
		3,3',4,4',5-PeCB (#126)	46	25	95	21	5.9
		3,3',4,4',5,5'-HxCB (#169)	14	7.7	25	7.3	2.0
	Mono-ortho	2',3,4,4',5-PeCB (#123)	25	10	45	9.5	4.2
		2,3',4,4',5-PeCB (#118)	320	200	1000	160	120
		2,3,3',4,4'-PeCB (#105)	160	110	400	85	68
		2,3,4,4',5-PeCB (#114)	9.3	5.8	19	4.9	3.3
		2,3',4,4',5,5'-HxCB (#167)	49	25	120	21	10
		2,3,3',4,4',5-HxCB (#156)	91	50	220	43	27
		2,3,3',4,4',5'-HxCB (#157)	42	20	88	19	8.8
		2,3,3',4,4',5,5'-HpCB (#189)	38	16	54	15	4.4
	Di-ortho	2,2',3,3',4,4',5-HpCB (#170)	220	110	510	120	58
		2,2',3,4,4',5,5'-HpCB (#180)	210	140	620	160	72
TEQ total			62	38	76	32	11
Congeners	Dioxins	TeCDDs total	290	280	320	940	63
		PeCDDs total	240	200	310	170	51
		HxCDDs total	410	290	440	200	92
		HpCDDs total	560	330	570	250	110
		OCDD	1500	770	1300	1400	150
		PCDDs total	3000	1870	2940	2960	466
	Dibenzofurans	TeCDFs total	390	290	450	260	69
		PeCDFs total	410	270	470	220	66
		HxCDFs total	440	270	470	220	73
		HpCDFs total	360	200	330	200	61
		OCDF	170	94	160	130	28
		PCDFs total	1770	1124	1880	1030	297
	(PCDDs+PCDFs) total		4800	3000	4800	4000	760

Measured concentration values below the detection limit are indicated “N.D.”; those above the detection limit but below the quantification limit are indicated in parentheses.

Table 29. Determination results of (chlorinated) dioxins (soil-2) Unit: pg/g

Analyzed compound			Region B			Region C
			B4	B5	B6	C1
Dioxins		2,3,7,8-TeCDD	(0.21)	0.47	0.82	0.65
		1,3,6,8-TeCDD	10	17	26	31
		1,3,7,9-TeCDD	5.4	8.8	13	14
		1,2,3,7,8-PeCDD	1.5	2.0	6.5	3.5
		1,2,3,4,7,8-HxCDD	1.5	2.4	7.7	3.1
		1,2,3,6,7,8-HxCDD	3.2	4.9	18	10
		1,2,3,7,8,9-HxCDD	3.3	5.2	17	10
		1,2,3,4,6,7,8-HpCDD	40	71	330	63
		OCDD	490	1200	6900	360
Dibenzofurans		2,3,7,8-TeCDF	1.5	3.0	2.3	5.4
		1,3,6,8-TeCDF	1.4	2.2	1.9	3.9
		1,2,7,8-TeCDF	1.7	2.7	2.3	5.1
		1,2,3,7,8-PeCDF	3.0	4.7	4.9	7.6
		2,3,4,7,8-PeCDF	2.8	4.3	5.6	8.0
		1,2,3,4,7,8-HxCDF	4.7	6.7	10	9.5
		1,2,3,6,7,8-HxCDF	4.3	6.6	10	11
		1,2,3,7,8,9-HxCDF	(0.4)	0.5	0.7	0.8
		2,3,4,6,7,8-HxCDF	6.8	9.6	15	17
		1,2,3,4,6,7,8-HpCDF	26	39	110	47
		1,2,3,4,7,8,9-HpCDF	3.9	5.7	11	7.3
		OCDF	34	55	330	42
Co-planar PCBs	Non-ortho	3,4,4',5-TeCB (#81)	12	2.7	1.4	2.9
		3,3',4,4'-TeCB (#77)	130	38	13	38
		3,3',4,4',5-PeCB (#126)	8.2	9.6	8.8	18
		3,3',4,4',5,5'-HxCB (#169)	1.8	2.3	3.5	7.5
	Mono-ortho	2',3,4,4',5-PeCB (#123)	17	15	3.3	14
		2,3',4,4',5-PeCB (#118)	420	420	73	150
		2,3,3',4,4'-PeCB (#105)	260	220	36	68
		2,3,4,4',5-PeCB (#114)	16	9.9	2.1	3.2
		2,3',4,4',5,5'-HxCB (#167)	22	41	8.7	28
		2,3,3',4,4',5-HxCB (#156)	54	93	16	37
		2,3,3',4,4',5'-HxCB (#157)	17	28	8.0	23
		2,3,3',4,4',5,5'-HpCB (#189)	6.7	9.0	6.4	12
	Di-ortho	2,2',3,3',4,4',5-HpCB (#170)	130	180	47	110
		2,2',3,4,4',5,5'-HpCB (#180)	160	230	42	130
TEQ total			7.3	11	25	18
Congeners	Dioxins	TeCDDs total	22	36	48	60
		PeCDDs total	24	38	57	54
		HxCDDs total	38	64	160	110
		HpCDDs total	73	140	620	140
		OCDD	490	1200	6900	360
		PCDDs total	647	1478	7785	724
	Dibenzofurans	TeCDFs total	39	61	54	110
		PeCDFs total	44	63	84	110
		HxCDFs total	52	75	150	110
		HpCDFs total	50	76	280	83
		OCDF	34	55	330	42
		PCDFs total	219	330	898	455
	(PCDDs+PCDFs) total		870	1800	8700	1200

Measured concentration values below the detection limit are indicated “N.D.”; those above the detection limit but below the quantification limit are indicated in parentheses.

Table 30. Determination results of polybrominated diphenyl ethers (soil) Unit: ng/g

Analyzed compound	Detection limit	Region A					Region B			Region C
		A1	A2	A3	A4	A5	B4	B5	B6	C1
2,4,4'-TrBDE	0.02	N.D.	N.D.	0.12	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
2,2',4,4'-TeBDE	0.02	0.22	0.26	2.8	0.29	N.D.	0.07	0.07	0.10	0.08
2,2',4,4',6-PeBDE	0.05	N.D.	N.D.	0.19	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
2,2',4,4',5-PeBDE	0.05	0.17	0.26	1.9	0.36	N.D.	N.D.	0.06	0.10	N.D.
2,2',4,4',5,6'-HxBDE	0.1	0.2	0.1	0.3	0.3	N.D.	N.D.	N.D.	N.D.	N.D.
2,2',4,4',5,5'-HxBDE	0.1	0.2	0.3	0.9	0.8	N.D.	N.D.	N.D.	0.1	N.D.
2,2',3,4,4',5,6'-HpBDE	0.2	0.6	0.5	0.8	0.9	N.D.	N.D.	N.D.	N.D.	N.D.
DeBDE	1	11	15	44	195	N.D.	2	2	3	2

Summary and discussion

Regarding monobromopolychlorinated dioxins, 1-MoB-2,3,6,7,8,9-HxCDD was detected at concentrations of 7 to10 pg/g in three spots in region A, and 1-MoB-2,3,4,6,7,8,9-HpCDD in a range of 12 to 49 pg/g in all spots. The concentration of 1-MoB-2,3,4,6,7,8,9-HpCDD in region B was N.D. to 31 pg/g. Congeners were found in all spots in regions A and B, with particularly high ratios of monobromoheptachlorinated congeners followed by monobromohexachlorinated congeners (Figure 25). Concentrations in region A tended to be higher than in region B. None of the congeners were present in region C. The total amount of monobromopolychlorinated dioxin congeners detected was approximately 1/430 to 1/20 the amount found for chlorinated dioxins (PCDDs and PCDFs).

For polybrominated dioxins, polybrominated dibenzofurans were detected in spots A1, A2 and A3 in region A, but none were found in regions B and C.

(Chlorinated) dioxins were detected at concentrations ranging from 11 to 76 pg-TEQ/g in region A, 7.3 to 25 pg-TEQ/g in region B, and 18 pg-TEQ/g in region C. Region A tended to have higher concentrations, with a trend similar to that of brominated dioxins.

With a correlation factor of 0.4721, no conspicuous correlation was found between the sum of monobromopolychlorinated dioxin congeners and chlorinated dioxins (PCDDs and PCDFs) (Figure 26). However, when levels of total chlorinated dioxins (PCDDs and PCDFs) were plotted after eliminating 1,3,6,8-TeCDD, 1,3,7,9-TeCDDs and OCDD, which are thought to be produced from factors other than incineration, the correlation factor was as high as 0.9439, indicating a very strong correlation (Figure 27).

Regarding polybrominated diphenyl ethers, many congeners were detected in region A, excluding spot A5, and clearly showed a higher concentrations than regions B and C. With a correlation factor between the sum of monobromopolychlorinated dioxin congeners and polybrominated diphenyl ethers at 0.1865, no significant correlation was confirmed (Figure 28).

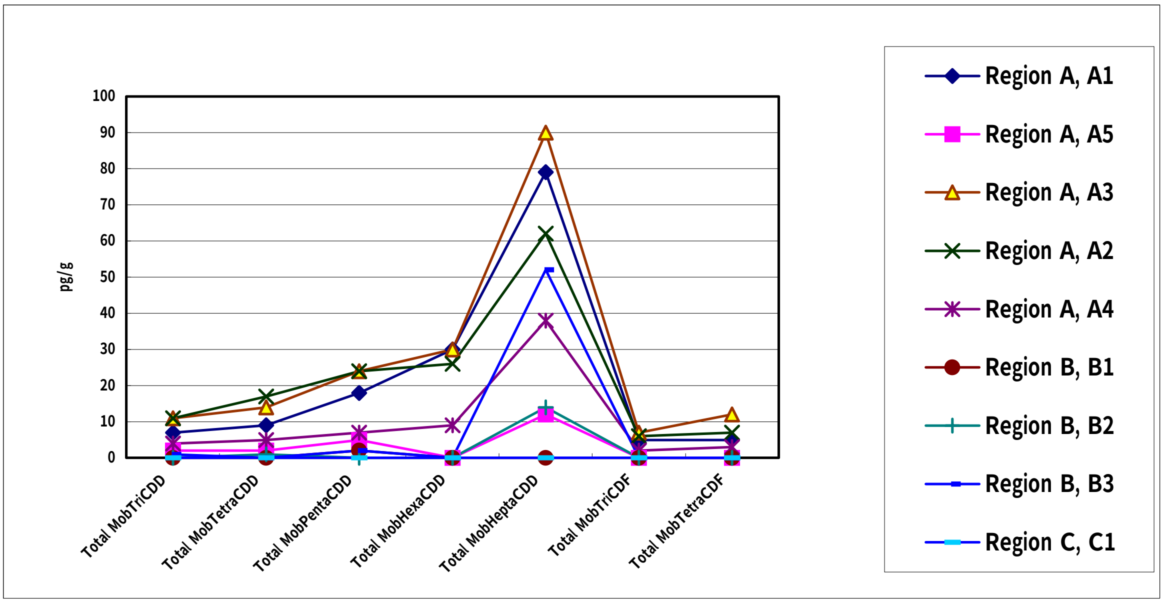


Figure 25. Distribution of monobromopolychlorinated dioxin congeners (soil)

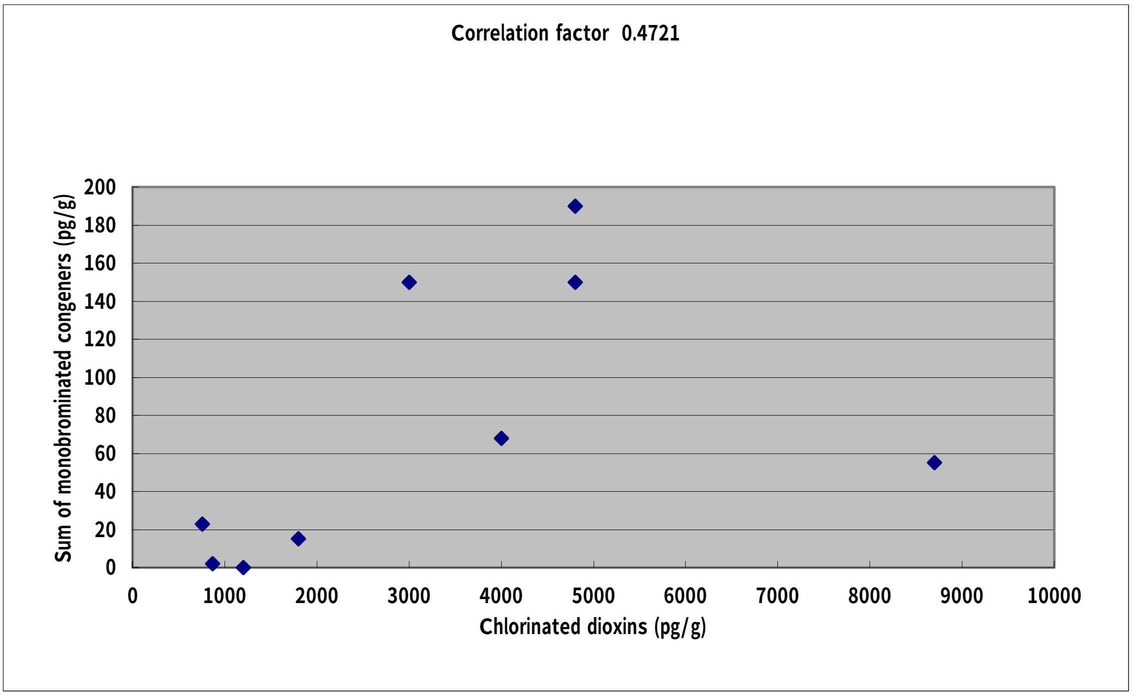


Figure 26. Correlation between sum of monobromopolychlorinated dioxin congeners and total (chlorinated) dioxins (soil)

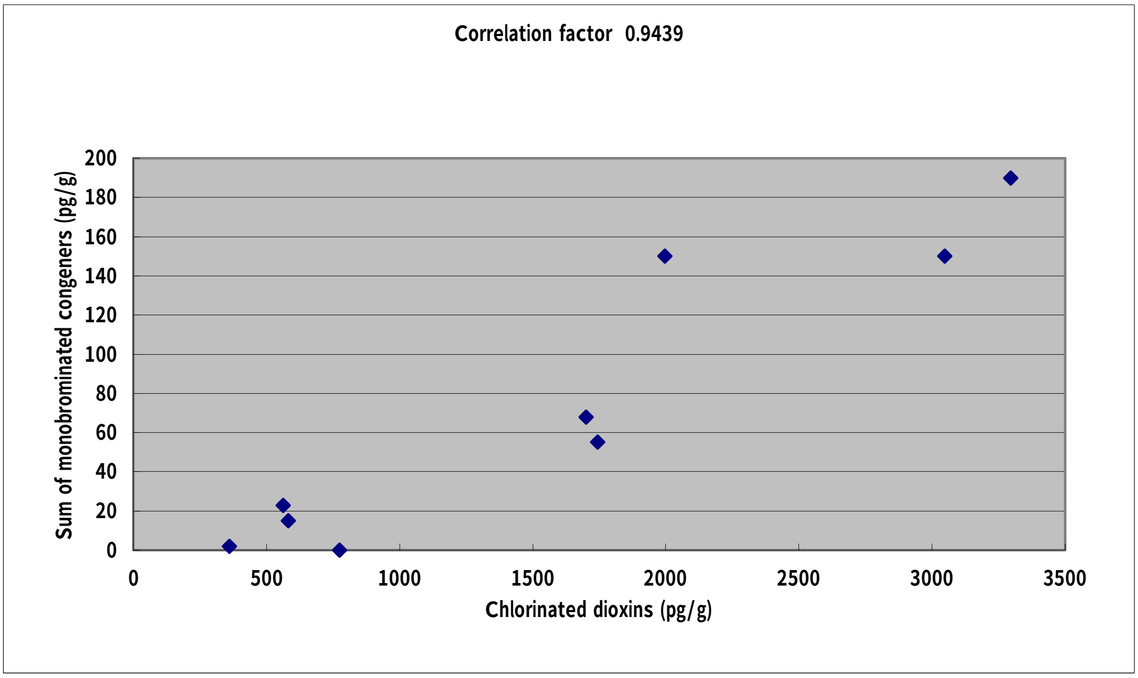


Figure 27. Correlation between sum of monobromopolychlorinated dioxin congeners and (chlorinated) dioxins (excluding 1,3,6,8-TeCDD, 1,3,7,9-TeCDD, and OCDD) (soil)

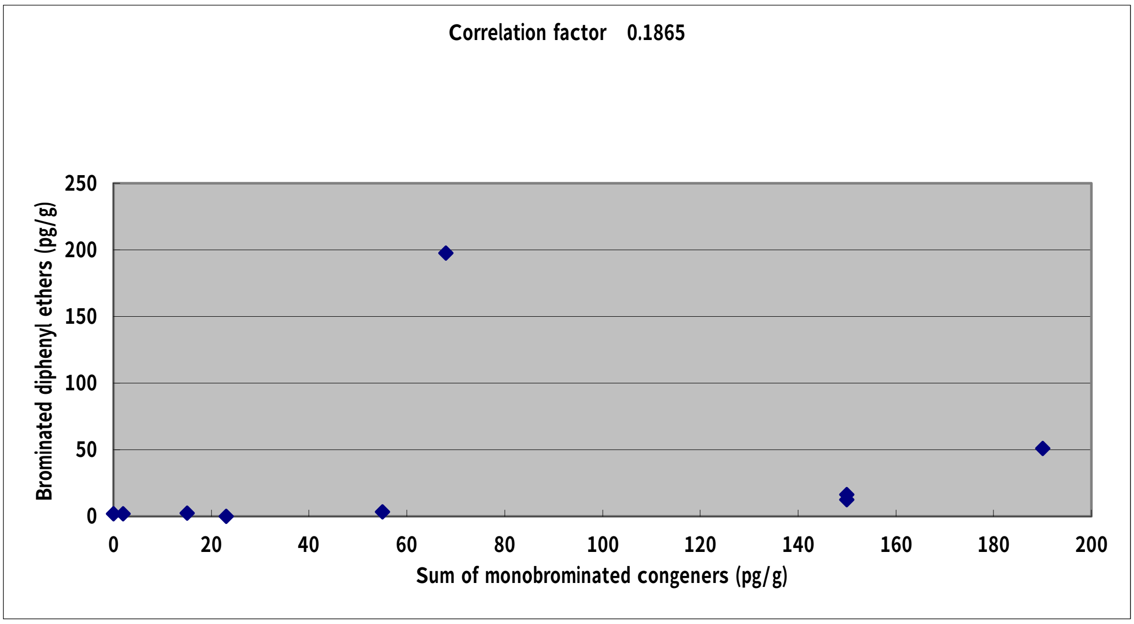


Figure 28. Correlation between sum of monobromopolychlorinated dioxin congeners and total polybrominated diphenyl ethers (soil)

4) Groundwater

Determination results of brominated dioxins in groundwater are shown in Table 31.

Table 31. Determination results of brominated dioxins (groundwater) Unit: pg/L

Analyzed compound	Region A		Region B		Region C
	A2	A6	B7	B8	C2
2-MoB-3,7,8-TrCDD	N.D.	N.D.	N.D.	N.D.	N.D.
1-MoB-2,3,7,8-TeCDD	N.D.	N.D.	N.D.	N.D.	N.D.
2-MoB-3,6,7,8,9-PeCDD	N.D.	N.D.	N.D.	N.D.	N.D.
1-MoB-2,3,6,7,8,9-HxCDD	N.D.	N.D.	N.D.	N.D.	N.D.
1-MoB-2,3,4,6,7,8,9-HpCDD	N.D.	N.D.	N.D.	N.D.	N.D.
3-MoB-2,7,8-TrCDF	N.D.	N.D.	N.D.	N.D.	N.D.
1-MoB-2,3,7,8-TeCDF	N.D.	N.D.	N.D.	N.D.	N.D.
MoB-TrCDDs total	N.D.	N.D.	N.D.	N.D.	N.D.
MoB-TeCDDs total	N.D.	N.D.	N.D.	N.D.	N.D.
MoB-PeCDDs total	N.D.	N.D.	N.D.	N.D.	N.D.
MoB-HxCDDs total	N.D.	N.D.	N.D.	N.D.	N.D.
MoB-HpCDDs total	N.D.	N.D.	N.D.	N.D.	N.D.
MoB-TrCDFs total	N.D.	N.D.	N.D.	N.D.	N.D.
MoB-TeCDFs total	N.D.	N.D.	N.D.	N.D.	N.D.
(MoBPCDDs+MoBPCDFs) total	N.D.	N.D.	N.D.	N.D.	N.D.
2,3,7,8-TeBDD	N.D.	N.D.	N.D.	N.D.	N.D.
1,2,3,7,8-PeBDD	N.D.	N.D.	N.D.	N.D.	N.D.
1,2,3,4,7,8-/ 1,2,3,6,7,8-HxBDD	N.D.	N.D.	N.D.	N.D.	N.D.
1,2,3,7,8,9-HxBDD	N.D.	N.D.	N.D.	N.D.	N.D.
2,3,7,8-TeBDF	N.D.	N.D.	N.D.	N.D.	N.D.
1,2,3,7,8-PeBDF	N.D.	N.D.	N.D.	N.D.	N.D.
2,3,4,7,8-PeBDF	N.D.	N.D.	N.D.	N.D.	N.D.
1,2,3,4,7,8-HxBDF	N.D.	N.D.	N.D.	N.D.	N.D.

Summary

Concentrations of brominated dioxins were below the detection limits for all compounds surveyed. Samples were not analyzed for (chlorinated) dioxins and polybrominated diphenyl ethers, as brominated dioxins were not detected.

5) Public water

Determination results of brominated dioxins in public water are shown in Table 32.

Table 32. Determination results of brominated dioxins (public water) Unit: pg/L

Analyzed compound	Region A		Region B		Region C
	A7 (river)	A8 (river)	B9 (sea)	B10 (river)	C3 (river)
2-MoB-3,7,8-TrCDD	N.D.	N.D.	N.D.	N.D.	N.D.
1-MoB-2,3,7,8-TeCDD	N.D.	N.D.	N.D.	N.D.	N.D.
2-MoB-3,6,7,8,9-PeCDD	N.D.	N.D.	N.D.	N.D.	N.D.
1-MoB-2,3,6,7,8,9-HxCDD	N.D.	N.D.	N.D.	N.D.	N.D.
1-MoB-2,3,4,6,7,8,9-HpCDD	N.D.	N.D.	N.D.	N.D.	N.D.
3-MoB-2,7,8-TrCDF	N.D.	N.D.	N.D.	N.D.	N.D.
1-MoB-2,3,7,8-TeCDF	N.D.	N.D.	N.D.	N.D.	N.D.
MoB-TrCDDs total	N.D.	N.D.	N.D.	N.D.	N.D.
MoB-TeCDDs total	N.D.	N.D.	N.D.	N.D.	N.D.
MoB-PeCDDs total	N.D.	N.D.	N.D.	N.D.	N.D.
MoB-HxCDDs total	N.D.	N.D.	N.D.	N.D.	N.D.
MoB-HpCDDs total	N.D.	N.D.	N.D.	N.D.	N.D.
MoB-TrCDFs total	N.D.	N.D.	N.D.	N.D.	N.D.
MoB-TeCDFs total	N.D.	N.D.	N.D.	N.D.	N.D.
(MoB-PCDDs+MoB-PCDFs) total	N.D.	N.D.	N.D.	N.D.	N.D.
2,3,7,8-TeBDD	N.D.	N.D.	N.D.	N.D.	N.D.
1,2,3,7,8-PeBDD	N.D.	N.D.	N.D.	N.D.	N.D.
1,2,3,4,7,8-/ 1,2,3,6,7,8-HxBDD	N.D.	N.D.	N.D.	N.D.	N.D.
1,2,3,7,8,9-HxBDD	N.D.	N.D.	N.D.	N.D.	N.D.
2,3,7,8-TeBDF	N.D.	N.D.	N.D.	N.D.	N.D.
1,2,3,7,8-PeBDF	N.D.	N.D.	N.D.	N.D.	N.D.
2,3,4,7,8-PeBDF	N.D.	N.D.	N.D.	N.D.	N.D.
1,2,3,4,7,8-HxBDF	N.D.	N.D.	N.D.	N.D.	N.D.

Summary

Concentrations of brominated dioxins were below the detection limits for all compounds surveyed. Samples were not analyzed for (chlorinated) dioxins and polychlorinated diphenyl ethers, as brominated dioxins were not detected.

6) Sediment

The determination results of brominated dioxins in the sediment are shown in Table 33, (chlorinated) dioxins in Table 34, and polybrominated diphenyl ethers in Table 35.

Table 33. Determination results of brominated dioxins (sediment) Unit: pg/g

Analyzed compound	Region A		Region B		Region C
	A7 (river)	A8 (river)	B9 (sea)	B10 (river)	C3 (river)
2-MoB-3,7,8-TrCDD	N.D.	N.D.	N.D.	1	N.D.
1-MoB-2,3,7,8-TeCDD	N.D.	N.D.	N.D.	N.D.	N.D.
2-MoB-3,6,7,8,9-PeCDD	N.D.	N.D.	N.D.	N.D.	N.D.
1-MoB-2,3,6,7,8,9-HxCDD	N.D.	N.D.	N.D.	N.D.	N.D.
1-MoB-2,3,4,6,7,8,9-HpCDD	N.D.	15	36	N.D.	N.D.
3-MoB-2,7,8-TrCDF	N.D.	N.D.	N.D.	N.D.	N.D.
1-MoB-2,3,7,8-TeCDF	N.D.	N.D.	N.D.	N.D.	N.D.
MoB-TrCDDs total	3	3	3	2	N.D.
MoB-TeCDDs total	2	3	2	1	N.D.
MoB-PeCDDs total	3	7	8	6	N.D.
MoB-HxCDDs total	N.D.	N.D.	18	6	N.D.
MoB-HpCDDs total	N.D.	26	56	N.D.	N.D.
MoB-TrCDFs total	N.D.	1	N.D.	N.D.	N.D.
MoB-TeCDFs total	1	4	2	N.D.	N.D.
(MoBPCDDs+MoBPCDFs) total	9	44	89	15	N.D.
2,3,7,8-TeBDD	N.D.	N.D.	N.D.	1	N.D.
1,2,3,7,8-PeBDD	N.D.	N.D.	N.D.	N.D.	N.D.
1,2,3,4,7,8-/ 1,2,3,6,7,8-HxBDD	N.D.	N.D.	N.D.	N.D.	N.D.
1,2,3,7,8,9-HxBDD	N.D.	N.D.	N.D.	N.D.	N.D.
2,3,7,8-TeBDF	N.D.	2	N.D.	N.D.	N.D.
1,2,3,7,8-PeBDF	N.D.	N.D.	N.D.	N.D.	N.D.
2,3,4,7,8-PeBDF	N.D.	N.D.	N.D.	2	N.D.
1,2,3,4,7,8-HxBDF	42	10	N.D.	N.D.	N.D.

Table 34. Determination results of (chlorinated) dioxins (sediment) Unit: pg/g

Analyzed compound			Region A		Region B		Region C
			A7 (river)	A8 (river)	B9 (sea)	B10 (river)	C3 (river)
Dioxins		2,3,7,8-TeCDD	0.42	0.7	1.1	0.54	N.D.
		1,3,6,8-TeCDD	76	120	140	100	2.7
		1,3,7,9-TeCDD	29	47	54	42	1.2
		1,2,3,7,8-PeCDD	2.2	4.7	4.0	3.1	0.15
		1,2,3,4,7,8-HxCDD	2.4	5.3	4.7	3.5	(0.17)
		1,2,3,6,7,8-HxCDD	5.5	11	9.0	7.6	0.36
		1,2,3,7,8,9-HxCDD	4.8	9.5	7.4	5.9	(0.22)
		1,2,3,4,6,7,8-HpCDD	53	110	130	94	2.5
		OCDD	370	660	1200	1300	14
Dibenzofurans		2,3,7,8-TeCDF	2.9	6.2	19	4.1	0.17
		1,3,6,8-TeCDF	2.9	6.5	6.6	4.3	0.26
		1,2,7,8-TeCDF	3.4	7.1	13	5.0	0.28
		1,2,3,7,8-PeCDF	6.3	15	18	8.1	0.32
		2,3,4,7,8-PeCDF	6.5	15	15	7.8	0.38
		1,2,3,4,7,8-HxCDF	8.8	22	27	13	0.50
		1,2,3,6,7,8-HxCDF	9.5	23	24	11	0.51
		1,2,3,7,8,9-HxCDF	0.78	1.9	2.2	0.92	N.D.
		2,3,4,6,7,8-HxCDF	15	36	41	17	0.71
		1,2,3,4,6,7,8-HpCDF	45	110	280	57	2.3
		1,2,3,4,7,8,9-HpCDF	8.3	21	42	9.5	0.42
		OCDF	51	120	1100	67	2.0
Co-planar PCBs	Non-ortho	3,4,4',5-TeCB (#81)	3.7	5.8	31	8.1	0.29
		3,3',4,4'-TeCB (#77)	55	86	690	120	3.3
		3,3',4,4',5-PeCB (#126)	9.1	19	44	16	0.68
		3,3',4,4',5,5'-HxCB (#169)	2.5	5.8	6.4	3.8	(0.21)
	Mono-ortho	2',3,4,4',5-PeCB (#123)	6.9	18	150	16	0.60
		2,3',4,4',5-PeCB (#118)	330	700	7400	700	13
		2,3,3',4,4'-PeCB (#105)	170	310	2900	340	7.0
		2,3,4,4',5-PeCB (#114)	10	18	140	22	0.43
		2,3',4,4',5,5'-HxCB (#167)	21	47	340	49	1.2
		2,3,3',4,4',5-HxCB (#156)	56	120	710	110	2.5
		2,3,3',4,4',5'-HxCB (#157)	15	33	180	35	0.80
		2,3,3',4,4',5,5'-HpCB (#189)	7.1	18	N.D.	N.D.	0.56
	Di-ortho	2,2',3,3',4,4',5-HpCB (#170)	100	260	1200	230	7.9
		2,2',3,4,4',5,5'-HpCB (#180)	150	380	2000	320	11
TEQ total			13	30	38	18	0.71
Congeners	Dioxins	TeCDDs total	120	200	270	200	4.4
		PeCDDs total	59	120	92	75	2.5
		HxCDDs total	81	170	130	99	4.7
		HpCDDs total	110	220	270	190	5.3
		OCDD	370	660	1200	1300	14
		PCDDs total	740	1370	1962	1864	30.9
	Dibenzofurans	TeCDFs total	92	200	710	130	6.1
		PeCDFs total	100	250	8400	130	5.6
		HxCDFs total	110	260	6900	130	5.4
		HpCDFs total	90	220	1400	110	4.3
		OCDF	51	120	1100	67	2.0
		PCDFs total	443	1050	18510	567	23.4
	(PCDDs+PCDFs) total		1200	2400	20000	2400	54

Measured concentration values below the detection limit are indicated “N.D.”; those above the detection limit but below the quantification limit are indicated in parentheses.

Table 35. Determination results of polybrominated diphenyl ethers (sediment) Unit: ng/g

Analyzed compound	Detection limit	Region A		Region B		Region C
		A7 (river)	A8 (river)	B9 (sea)	B10 (river)	C3 (river)
2,4,4'-TrBDE	0.04	0.06	0.07	0.11	0.07	N.D.
2,2',4,4'-TeBDE	0.04	0.51	0.42	0.55	0.62	N.D.
2,2',4,4',6-PeBDE	0.1	0.05	0.06	0.06	0.11	N.D.
2,2',4,4',5-PeBDE	0.1	0.67	0.41	0.68	0.61	N.D.
2,2',4,4',5,6'-HxBDE	0.2	N.D.	N.D.	N.D.	N.D.	N.D.
2,2',4,4',5,5'-HxBDE	0.2	0.2	N.D.	0.5	N.D.	N.D.
2,2',3,4,4',5,6'-HpBDE	0.4	N.D.	N.D.	0.4	N.D.	N.D.
DeBDE	2	11	37	90	11	N.D.

Summary and discussion

Regarding monobromopolychlorinated dioxins, 1-MoB-2,3,4,6,7,8,9-HpCDD was detected at a concentration of 15 pg/g in region A, spot A8 (river). In region B, 36 pg/g of 1-MoB-2,3,4,6,7,8,9-HpCDD was detected in spot B9 (sea), and 1 pg/g of 2-MoB-3,7,8-TrCDD from spot B10 (river). Congeners were detected in all spots in regions A and B, and as with the soil survey, particularly high ratios were found of monobromoheptachlorinated congeners followed by monobromohexachlorinated congeners (Figure 29). In region C, all compounds were below the detection limit. The total amount of monobromopolychlorinated dioxin congeners detected was approximately 1/220 to 1/55 the amount found for chlorinated dioxins (PCDDs and PCDFs).

For polybrominated dioxins, polybrominated dibenzofurans were detected in regions A and B. The rate of hexabrominated congeners was high in region A, but they were not detected in region B. None of the compounds were present in region C.

The concentration of (chlorinated) dioxins was highest in spot B9 (sea). Concentrations of the sum of monobromopolychlorinated dioxin congeners strongly correlated with total chlorinated dioxins (PCDDs and PCDFs), with a correlation factor of 0.9152 (Figure 30).

In the analysis of polybrominated diphenyl ethers, many isomers were detected in regions A and B, showing clearly higher levels than in region C. The correlation factor between the sum of monobromopolychlorinated dioxin congeners and total polybrominated diphenyl ethers was 0.9941, indicating a very strong correlation between the two (Figure 31).

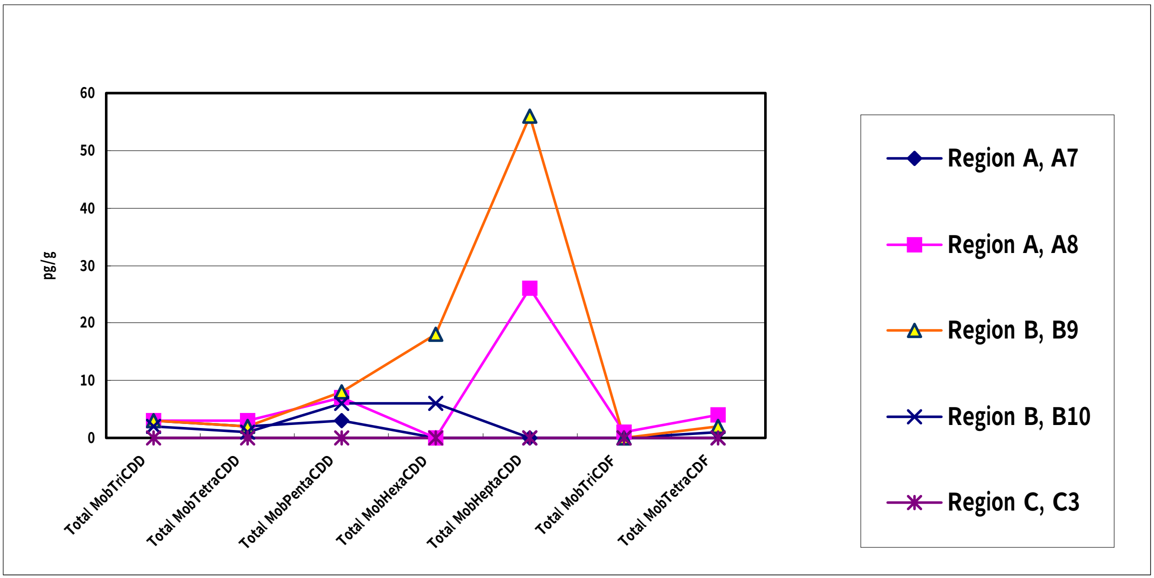


Figure 29. Distribution of monobromopolychlorinated dioxin congeners (sediment)

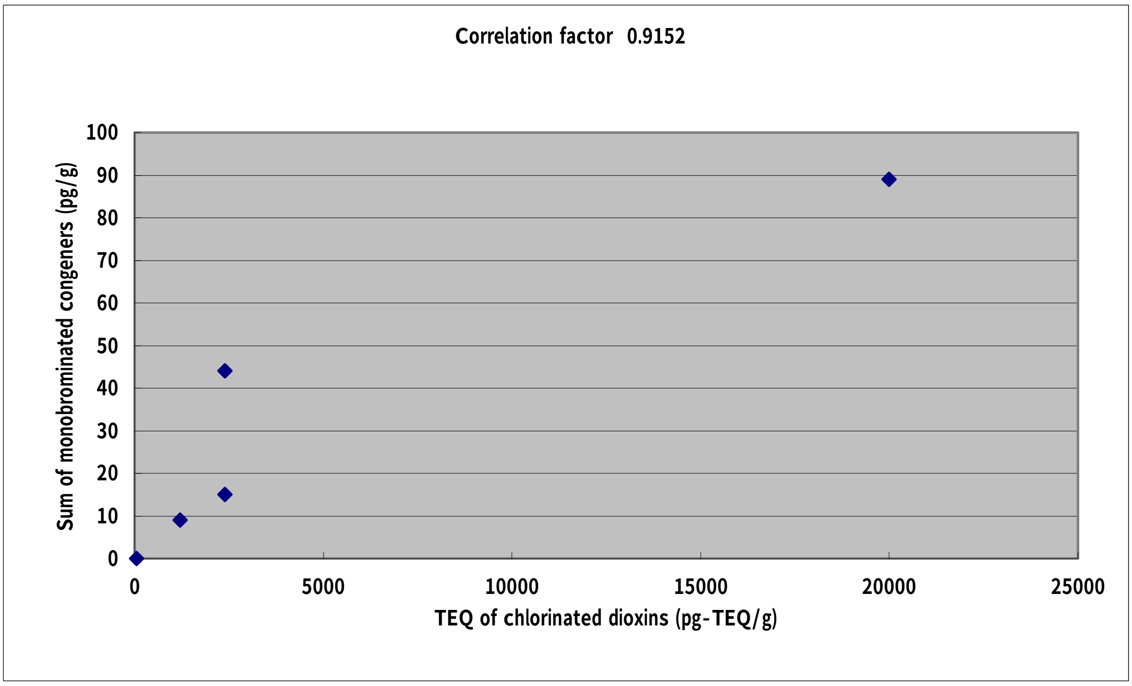


Figure 30. Correlation between sum of monobromopolychlorinated dioxin congeners and total (chlorinated) dioxins (sediment)

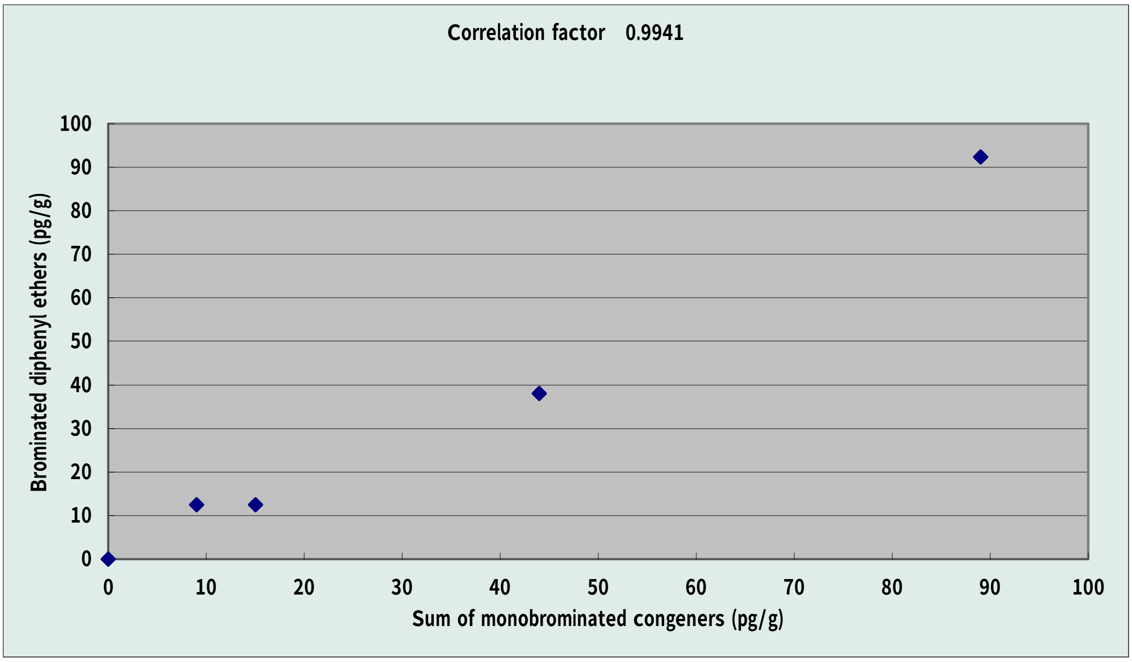


Figure 31. Correlation between sum of monobromopolychlorinated dioxin congeners and total polybrominated diphenyl ethers (sediment)

7) Aquatic life

The determination results of brominated dioxins in aquatic life are shown in Tables 36 and 37.

Table 36. Determination results of brominated dioxins (aquatic life-1) Unit: pg/g

Analyzed compound	Region A		Region B		
	A9	A10	B9 (sea)		
	Carp *(Cyprinus carpio)*	Carp *(Cyprinus carpio)*	Sea bass *(Lateolabrax japonicus)*	Mullet *(Mugil cephalus)*	Blue mussel *(Mytilus edulis)*
2-MoB-3,7,8-TrCDD	N.D.	N.D.	N.D.	N.D.	N.D.
1-MoB-2,3,7,8-TeCDD	N.D.	N.D.	N.D.	N.D.	N.D.
2-MoB-3,6,7,8,9-PeCDD	N.D.	N.D.	N.D.	N.D.	N.D.
1-MoB-2,3,6,7,8,9-HxCDD	N.D.	N.D.	N.D.	N.D.	N.D.
1-MoB-2,3,4,6,7,8,9-HpCDD	N.D.	N.D.	N.D.	N.D.	N.D.
3-MoB-2,7,8-TrCDF	N.D.	N.D.	N.D.	N.D.	N.D.
1-MoB-2,3,7,8-TeCDF	N.D.	N.D.	N.D.	N.D.	N.D.
MoB-TrCDDs total	N.D.	N.D.	N.D.	N.D.	0.96
MoB-TeCDDs total	N.D.	N.D.	N.D.	N.D.	N.D.
MoB-PeCDDs total	N.D.	N.D.	N.D.	N.D.	N.D.
MoB-HxCDDs total	N.D.	N.D.	N.D.	N.D.	N.D.
MoB-HpCDDs total	N.D.	N.D.	N.D.	N.D.	N.D.
MoB-TrCDFs total	N.D.	N.D.	N.D.	N.D.	0.07
MoB-TeCDFs total	N.D.	N.D.	N.D.	N.D.	N.D.
(MoBPCDDs+MoBPCDFs) total	N.D.	N.D.	N.D.	N.D.	1.0
2,3,7,8-TeBDD	N.D.	N.D.	N.D.	N.D.	N.D.
1,2,3,7,8-PeBDD	N.D.	N.D.	N.D.	N.D.	N.D.
1,2,3,4,7,8-/ 1,2,3,6,7,8-HxBDD	N.D.	N.D.	N.D.	N.D.	N.D.
1,2,3,7,8,9-HxBDD	N.D.	N.D.	N.D.	N.D.	N.D.
2,3,7,8-TeBDF	N.D.	N.D.	N.D.	N.D.	N.D.
1,2,3,7,8-PeBDF	N.D.	N.D.	N.D.	N.D.	N.D.
2,3,4,7,8-PeBDF	N.D.	N.D.	N.D.	N.D.	N.D.
1,2,3,4,7,8-HxBDF	N.D.	N.D.	N.D.	N.D.	N.D.

Table 37. Determination results of brominated dioxins (aquatic life-2) Unit: pg/g

Analyzed compound	Region B			Region C		
	B11			C4		
	Carp *(Cyprinus carpio)*	Crucian carp *(Carassius auratus)*	Japanese barbel *(Hemibarbus barbus)*	River crab *(Geothelphusa dehaani)*	Japanese dace *(Tribolodon hakonensis)*	Pale chub *(Zacco platypus)*
2-MoB-3,7,8-TrCDD	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
1-MoB-2,3,7,8-TeCDD	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
2-MoB-3,6,7,8,9-PeCDD	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
1-MoB-2,3,6,7,8,9-HxCDD	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
1-MoB-2,3,4,6,7,8,9-HpCDD	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
3-MoB-2,7,8-TrCDF	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
1-MoB-2,3,7,8-TeCDF	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
MoB-TrCDDs total	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
MoB-TeCDDs total	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
MoB-PeCDDs total	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
MoB-HxCDDs total	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
MoB-HpCDDs total	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
MoB-TrCDFs total	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
MoB-TeCDFs total	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
(MoBPCDDs+MoBPCDFs) total	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
2,3,7,8-TeBDD	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
1,2,3,7,8-PeBDD	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
1,2,3,4,7,8-/ 1,2,3,6,7,8-HxBDD	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
1,2,3,7,8,9-HxBDD	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
2,3,7,8-TeBDF	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
1,2,3,7,8-PeBDF	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
2,3,4,7,8-PeBDF	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
1,2,3,4,7,8-HxBDF	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.

Summary

Regarding brominated dioxins, a monobromopolychlorinated dioxin congener was detected in blue mussels (*Mytilus edulis*). Other compounds were below detection limits. Samples were not analyzed for (chlorinated) dioxins and polybrominated diphenyl ethers, as hardly no brominated dioxins were detected.

8) Terrestrial wildlife

Determination results of brominated dioxins in terrestrial wildlife are shown in Table 38.

Table 38. Determination results of brominated dioxins (terrestrial wildlife) Unit: pg/g

Analyzed compound	Region A	Region B	Region C	
	Crow	pigeon	Japanese deer	Boar
2-MoB-3,7,8-TrCDD	N.D.	N.D.	N.D.	N.D.
1-MoB-2,3,7,8-TeCDD	N.D.	N.D.	N.D.	N.D.
2-MoB-3,6,7,8,9-PeCDD	N.D.	N.D.	N.D.	N.D.
1-MoB-2,3,6,7,8,9-HxCDD	N.D.	N.D.	N.D.	N.D.
1-MoB-2,3,4,6,7,8,9-HpCDD	N.D.	N.D.	N.D.	N.D.
3-MoB-2,7,8-TrCDF	N.D.	N.D.	N.D.	N.D.
1-MoB-2,3,7,8-TeCDF	N.D.	N.D.	N.D.	N.D.
MoB-TrCDDs total	N.D.	N.D.	N.D.	N.D.
MoB-TeCDDs total	N.D.	N.D.	N.D.	N.D.
MoB-PeCDDs total	N.D.	N.D.	N.D.	N.D.
MoB-HxCDDs total	N.D.	N.D.	N.D.	N.D.
MoB-HpCDDs total	N.D.	N.D.	N.D.	N.D.
MoB-TrCDFs total	N.D.	N.D.	N.D.	N.D.
MoB-TeCDFs total	N.D.	N.D.	N.D.	N.D.
(MoBPCDDs+MoBPCDFs) total	N.D.	N.D.	N.D.	N.D.
2,3,7,8-TeBDD	N.D.	N.D.	N.D.	N.D.
1,2,3,7,8-PeBDD	N.D.	N.D.	N.D.	N.D.
1,2,3,4,7,8-/ 1,2,3,6,7,8-HxBDD	N.D.	N.D.	N.D.	N.D.
1,2,3,7,8,9-HxBDD	N.D.	N.D.	N.D.	N.D.
2,3,7,8-TeBDF	N.D.	N.D.	N.D.	N.D.
1,2,3,7,8-PeBDF	N.D.	N.D.	N.D.	N.D.
2,3,4,7,8-PeBDF	N.D.	N.D.	N.D.	N.D.
1,2,3,4,7,8-HxBDF	N.D.	N.D.	N.D.	N.D.

Summary

Regarding brominated dioxins, all surveyed compounds were below detection limits. Samples were not analyzed for (chlorinated) dioxins and polybrominated diphenyl ethers, as brominated dioxins were not detected.

9) Food samples

Determination results of brominated dioxins in food samples are shown in Table 39, (chlorinated) dioxins in Table 40, and polybrominated diphenyl ethers in Table 41.

Table 39. Determination results of brominated dioxins (food samples) Unit: pg/g

Analyzed compound	Region A		Region B		Region C
	Male, age 45	Female, age 50	Male, age 53	Male, age 59	Female, age 53
2-MoB-3,7,8-TrCDD	N.D.	N.D.	N.D.	N.D.	N.D.
1-MoB-2,3,7,8-TeCDD	N.D.	N.D.	N.D.	N.D.	N.D.
2-MoB-3,6,7,8,9-PeCDD	N.D.	N.D.	N.D.	N.D.	N.D.
1-MoB-2,3,6,7,8,9-HxCDD	N.D.	N.D.	N.D.	N.D.	N.D.
1-MoB-2,3,4,6,7,8,9-HpCDD	N.D.	N.D.	N.D.	N.D.	N.D.
3-MoB-2,7,8-TrCDF	N.D.	N.D.	N.D.	N.D.	N.D.
1-MoB-2,3,7,8-TeCDF	N.D.	N.D.	N.D.	N.D.	N.D.
MoB-TrCDDs total	N.D.	N.D.	N.D.	N.D.	N.D.
MoB-TeCDDs total	N.D.	N.D.	N.D.	N.D.	N.D.
MoB-PeCDDs total	N.D.	N.D.	N.D.	N.D.	N.D.
MoB-HxCDDs total	N.D.	N.D.	N.D.	N.D.	N.D.
MoB-HpCDDs total	N.D.	N.D.	N.D.	N.D.	N.D.
MoB-TrCDFs total	N.D.	N.D.	N.D.	N.D.	N.D.
MoB-TeCDFs total	N.D.	N.D.	N.D.	N.D.	N.D.
(MoBPCDDs+MoBPCDFs) total	N.D.	N.D.	N.D.	N.D.	N.D.
2,3,7,8-TeBDD	N.D.	N.D.	N.D.	N.D.	N.D.
1,2,3,7,8-PeBDD	N.D.	N.D.	N.D.	N.D.	N.D.
1,2,3,4,7,8-/ 1,2,3,6,7,8-HxBDD	N.D.	N.D.	N.D.	N.D.	N.D.
1,2,3,7,8,9-HxBDD	N.D.	N.D.	N.D.	N.D.	N.D.
2,3,7,8-TeBDF	N.D.	N.D.	N.D.	N.D.	N.D.
1,2,3,7,8-PeBDF	N.D.	N.D.	N.D.	N.D.	N.D.
2,3,4,7,8-PeBDF	N.D.	N.D.	N.D.	N.D.	N.D.
1,2,3,4,7,8-HxBDF	N.D.	N.D.	N.D.	N.D.	N.D.

Table 40. Determination results of (chlorinated) dioxins (food samples) Unit: pg/g

Analyzed compound			Region A: Male, age 45	Region A: Female, age 50	Region B: Male, age 53	Region B: Male, age 59	Region C: Female, age 53
Dioxins		2,3,7,8-TeCDD	N.D.	N.D.	N.D.	N.D.	N.D.
		1,3,6,8-TeCDD	0.074	0.18	0.064	0.23	0.24
		1,3,7,9-TeCDD	0.032	0.049	0.018	0.057	0.040
		1,2,3,7,8-PeCDD	N.D.	N.D.	0.004	0.014	0.010
		1,2,3,4,7,8-HxCDD	N.D.	N.D.	N.D.	N.D.	N.D.
		1,2,3,6,7,8-HxCDD	N.D.	N.D.	0.013	0.021	N.D.
		1,2,3,7,8,9-HxCDD	N.D.	N.D.	N.D.	0.014	N.D.
		1,2,3,4,6,7,8-HpCDD	0.018	0.012	0.029	0.064	0.034
		OCDD	0.09	0.07	0.20	0.29	0.26
Dibenzofurans		2,3,7,8-TeCDF	0.005	0.008	0.005	0.033	0.035
		1,3,6,8-TeCDF	0.009	0.005	N.D.	0.005	0.004
		1,2,7,8-TeCDF	0.007	0.004	N.D.	N.D.	N.D.
		1,2,3,7,8-PeCDF	0.005	0.004	N.D.	0.018	0.013
		2,3,4,7,8-PeCDF	0.008	0.005	0.008	0.027	0.026
		1,2,3,4,7,8-HxCDF	N.D.	N.D.	N.D.	N.D.	N.D.
		1,2,3,6,7,8-HxCDF	N.D.	N.D.	N.D.	0.010	0.007
		1,2,3,7,8,9-HxCDF	N.D.	N.D.	N.D.	N.D.	N.D.
		2,3,4,6,7,8-HxCDF	N.D.	N.D.	0.007	0.014	0.006
		1,2,3,4,6,7,8-HpCDF	0.010	0.006	0.01	0.008	0.008
		1,2,3,4,7,8,9-HpCDF	N.D.	N.D.	N.D.	N.D.	N.D.
		OCDF	N.D.	N.D.	N.D.	N.D.	N.D.
Co-planar PCBs	Non-ortho	3,4,4',5-TeCB (#81)	0.029	0.013	0.016	0.087	0.15
		3,3',4,4'-TeCB (#77)	0.19	0.14	0.18	1.4	0.80
		3,3',4,4',5-PeCB (#126)	0.057	0.040	0.072	0.86	0.44
		3,3',4,4',5,5'-HxCB (#169)	0.008	0.008	0.023	0.23	0.079
	Mono-ortho	2',3,4,4',5-PeCB (#123)	N.D.	N.D.	N.D.	1.5	0.7
		2,3',4,4',5-PeCB (#118)	3.9	4.7	7.3	97	34
		2,3,3',4,4'-PeCB (#105)	1.6	1.0	2.1	31	11
		2,3,4,4',5-PeCB (#114)	N.D.	N.D.	0.2	2.8	1.0
		2,3',4,4',5,5'-HxCB (#167)	0.3	0.3	0.3	5.2	1.7
		2,3,3',4,4',5-HxCB (#156)	0.6	0.3	0.7	9.0	3.1
		2,3,3',4,4',5'-HxCB (#157)	0.2	0.1	0.2	2.8	1.0
		2,3,3',4,4',5,5'-HpCB (#189)	N.D.	N.D.	0.1	1.0	0.5
	Di-ortho	2,2',3,3',4,4',5-HpCB (#170)	1.1	0.6	1.2	19	4.7
		2,2',3,4,4',5,5'-HpCB (#180)	3.0	2.1	3.2	54	13
TEQ total			0.012	0.0086	0.020	0.15	0.081
Congeners	Dioxins	TeCDDs total	0.13	0.25	0.083	0.29	0.28
		PeCDDs total	0.042	0.037	0.013	0.035	0.028
		HxCDDs total	0.027	0.014	0.031	0.066	0.010
		HpCDDs total	0.032	0.021	0.043	0.087	0.062
		OCDD	0.09	0.07	0.20	0.29	0.26
		PCDDs total	0.321	0.392	0.37	0.768	0.64
	Dibenzofurans	TeCDFs total	0.16	0.12	0.033	0.099	0.091
		PeCDFs total	0.063	0.046	0.016	0.07	0.075
		HxCDFs total	0.030	0.013	0.020	0.033	0.032
		HpCDFs total	0.016	0.006	0.015	0.011	0.008
		OCDF	N.D.	N.D.	N.D.	N.D.	N.D.
		PCDFs total	0.269	0.185	0.084	0.213	0.206
	(PCDDs+PCDFs) total		0.59	0.58	0.45	0.98	0.85

Measured concentration values below the detection limit are indicated “N.D.”

Table 41. Determination results of polybrominated diphenyl ethers (food samples)

Analyzed compound	Detection limit	Region A		Region B		Region C
		Male, age 45	Female, age 50	Male, age 53	Male, age 59	Female, age 53
2,4,4’-TrBDE	0.005	0.014	N.D	N.D	N.D.	N.D.
2,2’,4,4’-TeBDE	0.005	0.023	N.D	0.005	0.021	0.017
2,2’,4,4’,6-PeBDE	0.01	N.D.	N.D.	N.D	N.D.	N.D.
2,2’,4,4’,5-PeBDE	0.01	N.D.	N.D.	N.D	N.D.	N.D.
2,2’,4,4’,5,6’-HxBDE	0.025	N.D.	N.D.	N.D.	N.D.	N.D.
2,2’,4,4’,5,5’-HxBDE	0.025	N.D.	N.D.	N.D	N.D.	N.D.
2,2’,3,4,4’,5,6’-HpBDE	0.05	N.D.	N.D.	N.D	N.D.	N.D.
DeBDE	0.25	N.D.	N.D.	N.D	N.D.	N.D.

Summary and discussion

Regarding brominated dioxins, all compounds were below detection limits.

For (chlorinated) dioxins, the ratio to the tolerable daily intake (TDI) is shown in Table 42. As seen in the table, the level of (chlorinated) dioxins found in a 59 year old male in region B was slightly over the TDI of 4pg-TEQ/kg/day, but this high level is seen to be due to the large intake of fish and shellfish in his diet.

Among polybrominated diphenyl ethers, 2,4,4’-TrBDE was detected at a concentration of 0.014 ng/g in the food sample of a 45 year old male in region A, and 2,2’,4,4’-TeBDE in the range of 0.005 to 0.023 ng/g in all food samples, excluding those of a 50 year old female in region A. DeBDE, frequently found in environmental samples, were all below detection limits in food samples.

Table 42. Ratio to tolerable daily intake

	Region A		Region B		Region C
	Male, age 45	Female, age 50	Male, age 53	Male, age 59	Female, age 53
Weight (kg)	75	67	87	78	58
Food intake (g)*	7516	6567	5719	7096	6366
TEQ (pg-TEQ/g)	0.012	0.0086	0.020	0.15	0.081
Intake of dioxins (pg-TEQ)*	90.192	56.4762	114.38	1064.4	515.646
Daily Intake (pg-TEQ/kg/day)	0.400	0.281	0.438	4.55	2.96
Ratio to TDI (%)	10	7.0	11	114	74

＊：Total of 3 days

6 Summary

In this survey, monobromopolychlorinated dioxins and polybrominated dioxins, both of which are brominated dioxins, were found in environmental samples such as ambient air, settled soot and dust, and soil. However, the detection frequency and levels were low compared to those of chlorinated dioxins, and were barely present in aquatic life, terrestrial wildlife, and food samples. Therefore, within the scope of this survey, the impact of brominated dioxins on people and living organisms was considered to be smaller compared to that of chlorinated dioxins. Yet, because only limited types of brominated dioxins were analyzed in this survey, and due to the large difference in detection sensitivity compared to chlorinated dioxins, an accurate comparison of the impacts on people and living organisms is considered difficult.

Going forward, the development of a high-sensitivity analytical method for brominated dioxins and further analytical methods for 2,3,7,8-substituted compounds is necessary, and surveys of emission sources, environment and environmental behavior, and intake must be continued in order to clarify the impacts of brominated dioxins on human health and the ecosystem.

(Reference)

1. Estimated amount of human exposure by exposure route

The toxic equivalent (TEQ) of brominated dioxins has not been established internationally, however, the WHO Environmental Health Criteria state that "On the intim basis, it is suggested that current I-TEFs for the 17 2,3,7,8-subtituted PCDD/PCDF congeners be appliedto the comparable brominated and mixed hlogenatedcongeners". For MoBPCDDs, MoBPCDFs, PBDDs and PBDFs determined in this survey, assuming them to have the same toxicity as halogen-substitute compounds, their TEQs were calculated using the toxic equivalency factor for (chlorinated) dioxins [WHO-TEF (1998)], and levels of human exposure estimated by exposure route. Exposure through ambient air was estimated at 50 kg body weight and 15m^3 daily respiration volume, based on the concentration in ambient air. Estimated exposure through soil was calculated at 50 kg body weight, 100 mg daily soil intake (adults) based on the concentration in soil. Levels below detection limits were calculated as “0” or 1/2 the detection limit value. Items that were not surveyed were also calculated as “0”.

1) Levels below detection limits as “0”

Ambient air

Surveyed spot	Region A			Region B			Region C
	A1	A2	A3	B1	B2	B3	C1
Concentration of brominated dioxins (pg-TEQ/m^3) Bottom row: regional average	0	0	0	0	0	0	0
	0			0			0
Daily respiration volume (m^3)	15						
Weight (kg)	50						
Exposure through ambient air (pg-TEQ/kg/day)	0			0			0

Soil

Surveyed spot	Region A					Region B			Region C
	A1	A2	A3	A4	A5	B1	B2	B3	C1
Concentration of brominated dioxins (pg-TEQ/g) Bottom row: regional average	1.6	2.0	4.1	0.0015	0.0012	0	0.0014	0.0031	0
	1.5					0.0015			0
Daily intake (mg)	100								
Weight (kg)	50								
Exposure through soil (pg-TEQ/kg/day)	0.0030					0.0000030			0

Food

	Region A		Region B		Region C
	Male, age 45	Female, age 50	Male, age 53	Male, age 59	Female, age 53
Concentration of brominated dioxins (pg-TEQ/g)	0	0	0	0	0
Daily intake (g)	2505	2189	1906	2365	2122
Weight (kg)	75	67	87	78	58
Exposure through food (pg-TEQ/kg/day) Bottom row: regional average	0	0	0	0	0
	0		0		0

Estimated exposure in each region

	Through ambient air (pg-TEQ/kg/day)	Through soil (pg-TEQ/kg/day)	Through food (pg-TEQ/kg/day)	Total (pg-TEQ/kg/day)
Region A	0	0.0030	0	0.0030
Region B	0	0.0000030	0	0.0000030
Region C	0	0	0	0

2) Levels below detection limits as 1/2 the detection limit value

Ambient air

Surveyed spot	Region A			Region B			Region C
	A1	A2	A3	B1	B2	B3	C1
Concentration of brominated dioxins (pg-TEQ/m^3) Bottom row: regional average	0.11	0.11	0.11	0.11	0.11	0.11	0.11
	0.11			0.11			0.11
Daily respiration volume (m^3)	15						
Weight (kg)	50						
Exposure through ambient air (pg-TEQ/kg/day)	0.033			0.033			0.033

Soil

Surveyed spot	Region A					Region B			Region C
	A1	A2	A3	A4	A5	B1	B2	B3	C1
Concentration of brominated dioxins (pg-TEQ/g) Bottom row: regional average	5.8	6.2	7.7	4.8	4.8	4.8	4.8	4.8	4.8
	5.9					4.8			4.8
Daily intake (mg)	100								
Weight (kg)	50								
Exposure through soil (pg-TEQ/kg/day)	0.012					0.0096			0.0096

Food

	Region A		Region B		Region C
	Male, age 45	Female, age 50	Male, age 53	Male, age 59	Female, age 53
Concentration of brominated dioxins (pg-TEQ/g)	0.048	0.048	0.048	0.048	0.048
Daily intake (g)	2505	2189	1906	2365	2122
Weight (kg)	75	67	87	78	58
Exposure through food (pg-TEQ/kg/day) Bottom row: regional average	1.6	1.6	1.1	1.5	1.8
	1.6		1.3		1.8

Estimated exposure in each region

	Through ambient air (pg-TEQ/kg/day)	Through soil (pg-TEQ/kg/day)	Through food (pg-TEQ/kg/day)	Total (pg-TEQ/kg/day)
Region A	0.033	0.012	1.6	1.6
Region B	0.033	0.0096	1.3	1.3
Region C	0.033	0.0096	1.8	1.8

Summary

When levels below detection limits were calculated as “0”, estimated exposure to brominated dioxins was found to be extremely low. Exposures to (chlorinated) dioxins occurred mainly through food, but as the level of brominated dioxins in food samples were all below detection limits, estimated exposure through food was 0 pg-TEQ/kg/day. Compared to the tolerable daily intake of 4 pg-TEQ/kg/day, the estimated exposure of brominated dioxins was very low. However, when levels below detection limits were considered to be 1/2 the detection limit value, the estimated exposure amounted to 1.3 to 1.8 pg-TEQ/kg/day, which is equal to 33 to 45 % of tolerable daily intake. It is therefore necessary to clarify the actual state of concentration through high-sensitivity determination methods.