The Science of the Total Environment, 4 (1975) 219–247
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ENVIRONMENTAL AND FOOD CONTAMINATION WITH PCB's IN JAPAN

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(Received January 24th, 1975)

ABSTRACT

In Japan "Yusho", i.e., poisoning caused by ingestion of rice oil contaminated with PCB's, broke out in October 1968, and produced more than 1200 officially certified cases. Nevertheless, it was only regarded as a kind of food poisoning and its connection with environmental and biological contamination was only imperfectly taken into consideration.

Finally, in the autumn of 1970, two study groups, from the Ehime University and the Kyoto City Hygienic Institute, reported on the PCB contamination of salt water and fresh water fishes in Japan. Subsequently many reports about PCB's as an environmental contaminant have been published by several study groups throughout Japan, and nowadays the PCB polluted state of Japan has become rather clearly recognized.

This report will present information on environmental, food and human contamination with PCB's in Japan especially also in some typically contaminated local areas, in addition to summarizing some overall aspects of the PCB problem in Japan (e.g., the production, shipment and use of PCB's).

INTRODUCTION

PCB's were first commercially produced in the United States of America in 1930. Since then they have also been produced in Japan, France, Germany, Spain, Italy, Czechoslovakia and the Soviet Union. Because of their physical and chemical properties, PCB's have been used for many industrial purposes. However, in 1966 S. Jensen discovered environmental and biological contamination caused by PCB's, and problems with PCB's as a chlorinated hydrocarbon analogous to DDT and dieldrin were promptly disclosed all over the world.

Moreover, in Japan "Yusho", i.e., poisoning caused by ingestion of rice oil contaminated with PCB's, broke out in October, 1968, and resulted in more than

DSW 379210

STLCOPCB4100086

1200 officially certified cases. Nevertheless, it was only regarded as a kind of food poisoning, and its connection with environmental and biological contamination was only imperfectly taken into consideration. Finally, in the autumn of 1970, two study groups, from the Ehime University and the Kyoto City Hygienic Institute, reported on the PCB contamination of salt water and fresh water fishes in Japan. Subsequently many reports about PCB's as an environmental contaminant have been published by several study groups throughout Japan, and nowadays the PCB polluted state of Japan has become rather clearly recognized[1-4].

Following the rapid reconstruction of industry after World War II, many kinds of metals and chemical substances were dispersed in every district of the narrow territory of Japan, and PCB's are no exception to that pattern. In addition to summarizing some overall aspects of the PCB problem in Japan (e.g., the production, shipment, and use of PCB's), which have been clarified by many research groups, this report presents information on environmental, food, and human contamination with PCB's, especially in some typically contaminated areas.

PRODUCTION, SALES BY CATEGORY, AND SHIPMENT OF PCB's IN JAPAN

(a) *Annual change in PCB production in Japan*

In Japan, PCB's were produced on a commercial basis for the first time by the Kanegafuchi Chemical Co. in 1954. The output of production, which was initially 200 tons, rose to a maximum of over 11,000 tons in 1970. In 1969, the Mitsubishi-Monsanto Chemical Co. also started to produce PCB's; in 1972, production was finally halted voluntarily by the two manufacturers. During the period 1954–1972, a total of 57,330 tons of PCB's were produced in Japan. The annual change in production of PCB's in Japan is shown in Fig. 1[5].

In 1970, the production of PCB (Arochlor) in the United States[6] was 38,274 tons, about three times that of Japan. As Fig. 1 shows, a great deal of scientific

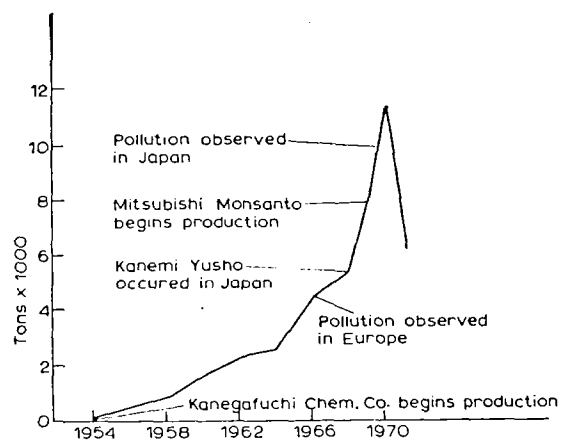

Fig. 1. Annual change in production of PCB's in Japan.

DSW 379211

STLCOPCB4100087

information about PCB environmental contamination in Europe (as well as information about pollution in Canada and the U.S.A.), and the miserable experience of "Yusho" in the Kita–Kyushu area, was entirely ignored in Japan. In the production curve for the United States, after 1968 the rate of increase of production slowed down gradually. In contrast, in Japan the output doubled in the two years after the outbreak of Yusho.

(b) Domestic sales of PCB's by category in Japan

The yearly change in domestic sales of PCB's by category in Japan is summarized[7] in Table 1. The use of PCB's in electrical goods accounts for half of total sales, followed by heat transmitters and non-carbon copy paper. In recent years, exports of PCB's tended to increase. During the period 1963–1970, total production of PCB's doubled in the United States, but in Japan it increased 600 percent.

TABLE 1

PCB's PRODUCTION AND DEMAND IN JAPAN, 1954–1971

Year	*Production (ton)*	*Imports (ton)*	*Breakdown of domestic use (ton)*				
			Electrical apparatus	*Heat-transmitters*	*Non-carbon copy paper*	*Other uses*	*Export*
1954	200		200				
1955	450		430	20			
1956	500		430	50		20	
1957	870		760	80		30	
1958	880		740	100		40	
1959	1260		1060	120		80	
1960	1640		1320	170		150	
1961	2220		1860	180		180	
1962	2190		1640	240	10	200	100
1963	1810		1270	240	30	170	100
1964	2670		1920	400	100	210	40
1965	3000		1980	450	170	240	160
1966	4410		2600	660	300	270	580
1967	4480	60	2370	730	390	270	720
1968	5130	100	2830	720	780	260	540
1969	7730	110	4220	1290	1320	330	590
1970	11110	150	5960	1890	1920	360	1000
1971	6780	170	4560	1160	350	100	730
Total	57330	590	36150	8500	5350	2190	4560

The commercial brand of PCB produced by the Kanegafuchi Chemical Co. is called Kanechlor, the grading code for which is similar to that for Arochlor, produced by Monsanto (see Table 2)[8]. However, statistics for domestic sales of PCB's by grade in Japan are not yet available.

DSW 379212

STLCOPCB4100088

TABLE 2

PHYSICAL PROPERTY OF KANECHLOR[8] CORRESPONDING TO AROCLOR NUMBER

Specimen	*Main component*	*Specific gravity**	*Viscosity***	*Evaporation loss****	*Corresponding Aroclor No.*
KC-200	Dichlorinated B.	1.223–1.243	2–3	<1.5	Ar. 1232
KC-300	Trichlorinated B.	1.310–1.322	3.5–4.4	<0.4	Ar. 1242
KC-400	Tetrachlorinated B.	1.376–1.389	5.4–7.3	<0.3	Ar. 1248
KC-500	Pentachlorinated B.	1.460–1.475	12–19	<0.2	Ar. 1254
KC-600	Hexachlorinated B.	1.539–1.555	46–87	<0.1	Ar. 1260
KC-1000	KC-500 Trichlorinated benzene	1.452–1.463	2.2–2.9	<2	Ar. T-100
KC-1300	KC-300 + Dichlorinated benzene Tetrachlorinated Be.	1.330–1.370	0.7–1.3	<5	
KC-C	Chlorinated triphenyl (95%) + PCB (5%)	1.56–1.57	(resin)	<0.1	Ar. 4465?

* 100 °C.
** 75 °C, centistokes.
*** %, 98 °C, 5 h.

(*c*) *PCB shipment in Japan*

Japan, which is surrounded by the sea, has only about one-thirtieth of the land area of the U.S.A. Consequently, close attention must be paid to the distribution of PCB contamination in the coastal and inland sea areas. For this purpose, data concerning shipments of PCB's to every district of Japan are necessary. In Fig. 2 the shipment of PCB's in Japan is illustrated[9], showing districts that have received shipments of less than 100 tons, 100–500 tons, 500–1000 tons, and over 1000 tons.

Figure 2 shows that the greater part of Japanese PCB's have been used in the industrial area along the Pacific coast and the Seto Inland Sea; generally speaking the

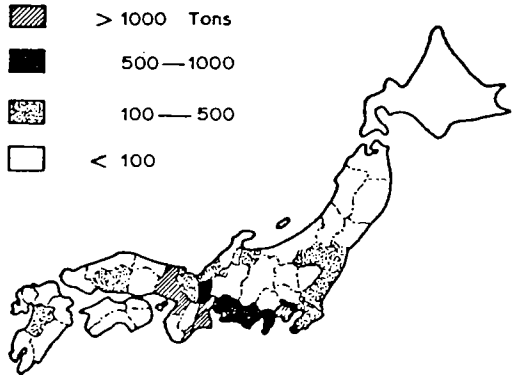

Fig. 2. PCB shipment in Japan.

DSW 379213

STLCOPCB4100089

western part of Japan consumed much more than the eastern. It is of great interest that the degree of PCB contamination in the environment, food, and human milk in Japan nearly corresponds to the distribution pattern shown in Fig. 2.

THE STANDARD ANALYTICAL METHOD FOR PCB's IN JAPAN

Because PCB's are fundamentally a mixture of polychlorinated biphenyl with different numbers of chlorine atoms and their isomers, there are many difficulties concerning the quantification of residual concentrations of PCB's. In Japan, beginning in August 1971 (when the social consequences of PCB contamination were noticed), a special committee of analytical chemists worked urgently under the sponsorship of the Ministry of Welfare to develop a standard analytical method for PCB's, so that the status of PCB contamination of food and the environment could be evaluated uniformly.

As a result of this work, a standard method of PCB analysis was arrived at in rough form, and in January 1972 the Ministry of Welfare published a pamphlet entitled "Research on an Analytical Method for PCB" and distributed it to all local district governments. From that time onward, research on PCB contamination throughout Japan was in principle carried on according to that method of analysis.

(*a*) *Outline of the standard method for PCB analysis in Japan*

A schematic outline of the standardized method for PCB analysis is shown in Fig. 3.

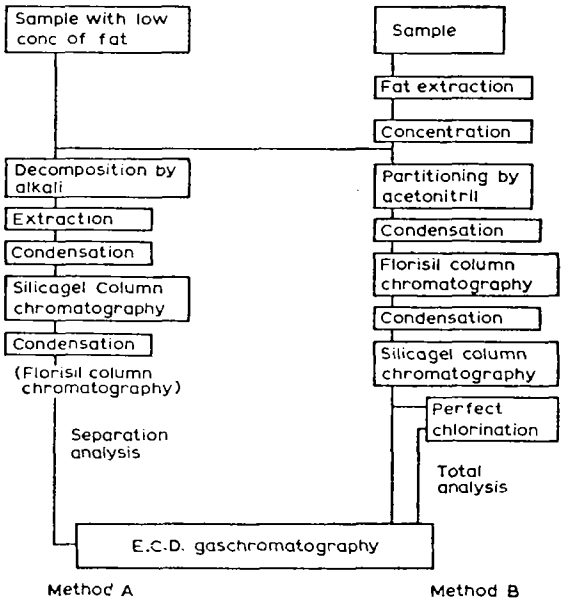

Fig. 3. Outline of the standard method for PCB analysis in Japan.

DSW 379214

STLCOPCB4100090

This method consists of a pre-examination analysis (A) based on the alkali-decomposition method, and a formal analysis (B). By means of method (A), the existence of PCB and an outline of PCB patterns and DDE contamination is estimated beforehand by gas chromatography. Then a more accurate analysis of the PCB (Method B) is carried out by simultaneous separation of the concomitant organochlorine pesticides. After separating the PCB and DDE fraction from the other pesticides by silica-gel chromatography, PCB and DDE should be perfectly separated by repeated silica-gel chromatography if the peak height of DDE is not higher than five times the peak of PCB at the corresponding retention time.

(*b*) *Quantification by gas chromatography*

The final measurement of the PCB quantity after the extraction and cleaning process is performed by using a gas chromatograph with an electron-capture detector. In this standard method the quantity of PCB is calculated from the sum of all peaks in the test gas chromatogram compared with a standard gas chromatogram produced from a mixture of Kanechlor number-samples made to simulate the test gas chromatographic peak pattern.

(*c*) *Perfect chlorination method*[11]

In theory, the quantification method that was defined above contains several weak points. In order to overcome these problems, it was decided to employ simultaneously the "perfect chlorination method" for theoretical comparison. In this method, because the chlorine content of the main PCB specimens in the environment ranges between 42 and 60%, the chlorine content of all PCB's is assumed to be 50%. The single peak of decachlorinated biphenyl obtained by means of perfect chlorination of the sample PCB is measured by a gas chromatograph with an electron capture detector. The PCB content is determined by doubling the quantity of biphenyl calculated from this single peak. The theoretical error of this method would seem to be $\pm 25\%$, and from the standpoint of complex microchemical analysis an error of this extent is negligible.

The Japanese standard method of analysis for PCB is characterized by the adoption of this special perfect chlorination method for the purpose of checking the results of Methods (A) and (B). Accordingly, for the most part the analytical data on PCB's in Japan illustrated in the figures and tables in this report are fairly uniformly reliable.

PCB LEVELS IN INDUSTRIALIZED AREAS

In 1972 the national government of Japan began for the first time to undertake research of environmental contamination with PCB's. This research, which was carried on co-operatively by the Ministry of the Environment, the Ministry of International Trade and Industry, the Ministry of Transportation, the Ministry of Construction, the Ministry of Agriculture and Forestry and the Ministry of Welfare, with the assistance of many laboratories of local district governments, produced very important

DSW 379215

STLCOPCB4100091

TABLE 3

SURVEY OF ENVIRONMENTAL PCB CONTAMINATION (ppm) IN JAPAN[12]

Locality	*Water*			*Deposits*						*Total*
	0.01>	*>0.01*	*Total*	*1>*	*1.1–10*	*11–50*	*51–99*	*100–499*	*>500*	*Total*	
The factories handling PCB	78	13	91	0	19	10	5	11	9	54	145
Municipal sewage treatment plant	125	0	125	—	—	—	—	—	—	—	125
Water areas near the factories	76	4	80	26	24	15	7	1	4	77	157
Public water areas	785	3	788	1216	73	20	2	3	0	1314	2102
Total	1064	20	1084	1242	116	45	14	15	13	1445	2529

DSW 379216

STLCOPCB4100092

data[12] for the clarification of the level of contamination, shortly after the cessation of manufacturing and use of PCB's in Japan.

Research about drainage, mud deposits and water quality, and mud deposits in water-supply areas with regard to 91 typical factories whose manufacturing processes synthesize, employ, or are contaminated with PCB's, is summarized in Table 3. The factories include 2 PCB synthesizing factories, 5 non-carbon copy paper factories, 28 electrical apparatus factories, 21 paper recycling factories, and 35 factories equipped with PCB heat transmitters.

Drainage and mud deposits of the factories

PCB's were detected in the drainage of 26% of the 91 factories; the mean value of the concentration was 0.035 ppm. Table 4 lists a sample of the names and locations of factories, levels of PCB contamination in ppm of drainage, and rank order of pollution, among the factories having a high level of pollution.

TABLE 4

PCB CONTAMINATION IN THE DRAINAGE OF TYPICAL FACTORIES IN JAPAN[12]

	Source	*Locality*	*ppm*
1	Fuji lab. capacitor	Tokyo, Ota	0.43
2	Kotobuki Paper industry	Hokkaido, Asahigawa	0.06
3	Goto iron and steel	Gifu, Gifu	0.06
4	Yahatahama paper industry	Ehime, Yahatahama	0.04
4	Dainihon ink	Tokyo, Itabashi	0.04
6	Fukui seiren silk	Fukui, Katsuyama	0.03
6	Toyo spinning	Fukui, Tsuruga	0.03
8	Kanegafuchi chemical industry	Hyogo, Takasago	0.02
8	Miyako chemical industry	Saitama, Koshigaya	0.02
8	Wakayama dye industry	Wakayama, Wakayama	0.02
8	Kanae painting industry	Osaka, Joto	0.02
8	Osaka titanium industry	Hyogo, Amagasaki	0.02

TABLE 5

PCB CONTAMINATION IN MUD DEPOSITS DIRECTLY BELOW THE DRAINAGE PIPES OF TYPICAL FACTORIES IN JAPAN[12]

	Source	*Locality*	*ppm*
1	Kyowa electric	Shizuoka, Takata	82600
2	Kurahashi gum	Tokyo, Adachi	14300
3	Teikoku condenser	Tokyo, Kita	10800
4	Fuji lab. capacitor	Tokyo, Ota	9200
5	Nihon condenser	Shiga, Kusatsu	7700
6	Miyako chemical industry	Saitama, Koshigaya	5100
7	Nagano condenser	Nagano, Iiyama	1200
8	Toyo spinning	Fukui, Tsuruga	650
9	Wakayama dye industry	Wakayama, Wakayama	520
10	Showa Electric industry	Nagano, Omati	380

DSW 379217

STLCOPCB4100093

Mud deposits directly below the drainage pipes of all factories on which research was conducted contained PCB's, with a mean concentration of 2500 ppm. Table 5 shows the names, locations, analytical data, and rank order of the ten worst cases among the 91 factories.

Water and mud deposits in water-supply areas in the neighborhood of the factories

PCB's were detected in 35% of 80 water samples with a mean concentration of 0.015 ppm. In mud deposits, 90% of 77 samples contained PCB with a mean concentration of 86 ppm. In Table 6 locations and analytical data are shown in rank order for the worst cases.

TABLE 6

WATER AND MUD DEPOSITS IN WATER SUPPLY AREAS IN THE NEIGHBORHOOD OF THE FACTORIES IN JAPAN[12]

Prefecture	*Locality*	*ppm*
Water		
1 Osaka	Drain, outlet of Mitaike, Toyonaka City (Matsushita electric)	0.290
2 Shiga	Agricultural service waterway, Kusatsu City (Nihon condenser)	0.021
3 Fukushima	Agricultural service waterway, Matsukawa Cho (Kitashiba electric)	0.020
3 Shizuoka	Drain, Gakunan (Recycling paper industry)	0.020
Deposit		
1 Osaka	Drain, outlet of Mitaike, Toyonaka City (Matsushita electric)	2666
2 Shiga	Agricultural service waterway, Kusatsu City (Nihon condenser)	1448
3 Saitama	The Shiba River (Factory area in Omiya)	1137
4 Tokyo	Service waterway, Rokugo, Tamagawa (Fuji lab. capacitor)	960
5 Oita	The Shotegawa River (Hida paper industry)	150
6 Gifu	Drain, to the Arata River (Recycling industry)	93
7 Mie	Drain, Yokkaichi (Ito oil)	92
8 Oita	The Oita River (Oita paper industry)	87
9 Gifu	The Shin-Arata River (Recycling paper industry)	79
10 Nagano	Drain, Iiyama City (Nagano condenser)	69

Water and mud deposits in public water-supply areas 1972

PCB's were detected in 3.8% of 788 samples collected from public water-supply areas throughout Japan; with a mean value of 0.023 ppm. At the same time, 58% of 1,314 mud deposit samples contained PCB's, which had a mean concentration of 2 ppm. Sample locations that show a high level of contamination are listed in Table 7.

On the basis of this research the national government of Japan decided to recommend that local government bodies re-inspect the drainage facilities of PCB-handling factories and paper-recycling factories that caused PCB contamination in excess of 0.01 ppm in the water of public water-supply areas, and if necessary dredge the drains of the factories. Moreover, in the case of PCB contamination of drainage mud deposits in excess of 100 ppm (dry weight), it was recommended to

DSW 379218

STLCOPCB4100094

conduct immediate detailed research in the contaminated area, and to undertake countermeasures to remove the contamination.

TABLE 7

WATER AND MUD DEPOSITS IN PUBLIC WATER SUPPLY AREAS IN JAPAN[12]

	Prefecture	*Locality*	*ppm*
Water			
1	Yamanashi	Service waterway, Daimoncho, Fuefukigawa Ichikawa	0.900
2	Oita	Chisaki, Nagahama, Oita City	0.024
3	Hyogo	Kukuchi Bridge, Shogegawa, Amagasaki City	0.020
Deposit			
1	Oita	Chisaki, Nagahama, Oita City	150
2	Shizuoka	Center of the port of Tagonoura	144
3	Yamanashi	Service waterway, Daimoncho, Fuefukigawa Ichikawa	130
4	Shizuoka	Yoshihara Pier, The port of Tagonoura	73
5	Hyogo	Tatsumi Bridge, Kanzakigawa, Amagasaki City	71
6	Tottori	The Hioki River	39
7	Hyogo	Southern waterway of Mitsubishi Electric Co. Shogegawa, Amagasaki City	35
8	Kagawa	The mouth of the River Somaba, Port of Takamatsu	33
9	Gifu	Sakigawa Bridge, the Sakaigawa River Nagaragawa	31
10	Hiroshima	Chisaki, Ono	30

TABLE 8

RIVER AND SEA WATER CONTAINING PCB IN EXCESS OF 0.5 ppb (ref. 12)

No.	*Locality*	*Prefecture*
1	Toyohira River	Hokkaido
2	Tama River	Tokyo
3	Fuefuki River etc.	Yamanashi
4	Arata River etc.	Gifu
5	Gakunan Waterway	Shizuoka
6	Sana River	Aichi
7	Kanzaki River Nakazima River	Osaka
8	Shoge River	Hyogo
9	Imakiri River	Tokushima
10	Sakai, Naka, Yamanoi River	Fukuoka
11	Oita River Shote River	Ōita
1	Iwakuni sea area	Yamagushi
2	Tokushima Offing	Tokushima
3	Minamata Port	Kumamoto
4	Hyakken Port	Kumamoto

DSW 379219

STLCOPCB4100095

Water and mud deposits in public water-supply areas (1974)

On September 5th 1974, The Environmental Ministry of Japan published the results of the latest environmental survey carried out by the National Government and Local Governments from July 1973 to March 1974 and it was confirmed that 51 water samples contain PCB's in the range from 0.5 to 6.9 ppb in 18 rivers and 4 sea areas as shown in Table 8 among 1281 samples collected from 282 water areas in Japan.

Mud deposits containing PCB's in excess of 10 ppm were detected in 42 rivers and 5 sea ports and 4 sea areas (6 areas are over 100 ppm, 8 areas are over 50 ppm) and especially in the Muya River (Tokushima prefecture), which is the most heavily contaminated and contained 386 ppm of PCB's.

PCB LEVELS IN AGRICULTURAL SOILS AND UNPOLISHED RICE

Parallel to research on water and drainage contamination, research was conducted on contamination of agricultural soil and unpolished rice in areas where there was a threat of PCB discharges from factories, or where PCB's had actually been found. Eighty-eight soil samples, and 37 farm crops containing 33 samples of unpolished rice, were collected from 75 locations in 21 local districts of Japan. The results of this survey are summarized in Table 9. 60% of soil samples, and 21% of unpolished rice samples contained more than 0.01 ppm of PCB's. The maximum residual contamination was 1,200 ppm in soil and 1.33 ppm in unpolished rice.

TABLE 9

PCB LEVELS IN AGRICULTURAL SOILS AND UNPOLISHED RICE

Environmental Ministry of Japanese Government and Local District Governments.

Total	*PCB conc. in soil*	*PCB conc. in unpolished rice*
	88 samples (100%)	*33 samples (100%)*
<0.01 ppm	35 (40%)	26 (79%)
0.01– 0.10	21 (24%)	5 (15%)
0.11– 1.0	19 (21%)	1 (3%)
1.1 – 10.0	6 (7%)	1 (3%)
10.1 –100.0	3 (3%)	
100.1	4 (5%)	

Based on these results, the national government of Japan recommended to local governments that more detailed research should be carried out in areas with soil contamination of more than 10 ppm of PCB's, and that if necessary suitable counter-measures should be studied.

DSW 379220

STLCOPCB4100096

PCB LEVELS IN RIVER WATER AND AIR

PCB concentrations in the water of rivers near several industrialized areas in Japan[13] are summarized in Table 10. Although analytical values <0.01 ppm are supposed to be recorded as "nd" according to the official Japanese standard method, the values (in ppb) given in Table 10 may be regarded as the true experimental results achieved by many analytical chemists employing the most accurate experimental methods available. As shown in Table 10, there were many samples of natural river water in urban areas that contained more than 0.1 ppb but not more than 1 ppb of PCB's. However, even at that level of concentration, contamination of fish through biological concentration processes would occur.

TABLE 10

PCB CONTAMINATION IN JAPANESE RIVERS AND BAYS

The values in parenthesis were analysed by Tachikawa[13].

Name	*Conc. (ppb)*	*Locality*
Shinkawa	0.16	Nagoya City
Shinhorikawa	0.81	Nagoya City
Lake Biwa	0.1 –0.5	Shiga Prefecture
Offing of Hikone Port		
Under the Bridge of Karahashi		
Setagawa, mouth of the river	0.01–0.1	Shiga Prefecture
Ujigawa	0.01–0.1	Kyoto Prefecture
Kisogawa	0.02–0.03	Aichi Prefecture
Edogawa	0.08 (0.04)	Tokyo Metropolis
Nakagawa	0.31 (0.19)	Tokyo Metropolis
Arakawa	0.18 (0.16)	Tokyo Metropolis
Sumidagawa	0.47 (0.07)	Tokyo Metropolis
Tamagawa	0.36 (0.08)	Tokyo Metropolis
Tsurumigawa	(0.12)	Tokyo Metropolis

For the analysis of PCB concentrations in air, a standard method employing a solvent absorbtion system was studied and adopted. However, before that method was adopted Dr. Ryo Tachikawa, Assistant Professor at Ehime University, employed a solid absorption system to analyse several air samples collected from the neighborhoods of electrical condenser and paper factories, and from rooms used to store non-carbon copy paper. The results[14] of his analysis are shown in Table 11. Because of the very different sampling methods in each case, it is not possible to compare the relative values, but the results provide confirmation of considerable levels of PCB concentration in air in the neighborhood of contaminated places. It is especially remarkable that a level of air contamination amounting to 7 $\mu g/m^3$ was detected in a room used for storing non-carbon copy paper at a savings-deposit service bureau.

DSW 379221

STLCOPCB4100097

TYPICAL EXAMPLES OF LOCAL CONTAMINATION WITH PCB's

In studying environmental contamination with PCB's, one encounters relatively few cases in which the distribution of pollution can be traced, by various criteria, directly to the source of the pollution. However, among the cases in Japan in which one can observe the dispersion of local contamination from a single clear source, we can point to Suruga Bay in Shizuoka Prefecture and the suburbs of Kusatsu City in Shiga Prefecture.

TABLE 11

PCB CONCENTRATIONS IN AIR AT DIFFERENT SAMPLING PLACES[13]

Locality	*Date*	*PCB* ($\mu g/m^3$)	*Type*	*Remarks*
Otsuka, Kusatsu City	6–8.6.1972	0.6	KC-200	Near the factory of Nihon Condenser, rainy day
Inatsucho, Toyonaka City	9–11.6.1972	1.2	KC-200	Near the condenser factory of Matsushita Electric Co. fine day
Bed of the Fujiwara-River	7–9.6.1972	0.12	KC-200+ KC-300	Paper sludge containing PCB was widely distributed in the river bed and formed dry deposits on the river bank, rainy day.
Mouth of the Chigirikawa River, Mishima City	11–13.5.1972	0.03	KC-300	In the area of paper industry, occasional rain
Laboratory of the Institute of Hygiene in Osaka City	6.1972	0.04	KC-300+ KC-400	
Sanbonyanagi, Matsuyama City	24–26.5.1972	0.003	KC-300+ KC-400	
Storage room of the Tokushima District Savings-deposit Service Bureau	17–18.6.1972	7	KC-200	Storage for noncarbon copy paper, inadequate air-conditioning
Business room of the above	7–8.7.1972	0.7	KC-200	Good airconditioning
Laboratory for agricultural analysis, Department of Agriculture, Ehime University	28–30.6.1972	0.04–0.06	KC-400+ KC-500	Laboratory of PCB analysis

Suruga Bay in Shizuoka Prefecture

There are many paper factories near the Fujigawa River and the Gakunan Drainage Canal, which empty into Tagono-Ura, Shizuoka Prefecture. Since about 1968 the production of non-carbon copy paper increased rapidly in Japan, but beginning in the spring of 1971 public opinion concerning the hazards of PCB's became so strong that the sale of non-carbon copy paper containing PCB's was suddenly stopped, and returned shipments of that paper accumulated in the ware-

DSW 379222

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houses of the manufacturers. Thereafter the accumulated returned paper was turned over on a large scale to paper recycling plants in those areas that previously had been dealing with spoiled or waste non-carbon copy paper, via the route shown in Fig. 4.

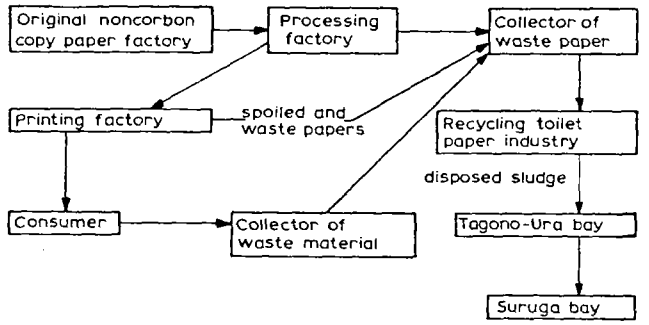

Fig. 4. The route to the Suruga Bay contamination with PCB's.

Through this process, toilet paper (made from recycled materials) containing PCB was sold in 1972; in one case the concentration of PCB's amounted to 700 ppm. According to an estimate calculated by Dr. J. Kondo of the Department of Urban Technology, Tokyo University, 10% of the PCB's in the original material was retained in the recycled-paper products, while the remaining 90% was poured into Tagono-Ura Bay via drainage canals as refuse scum, and thus ultimately contaminated Suruga Bay, and the total volume of PCB's discharged into Tagono-Ura before February 1972 amounted to 200–500 tons. Although most of the PCB's used for non-carbon copy paper in Japan was of the Kanechlor 300 low-chlorinated type, and the dispersion or degradation time of the lower chlorinated isomers of PCB, is relatively rapid, shortly after this time environmental research concerning PCB's was completed by

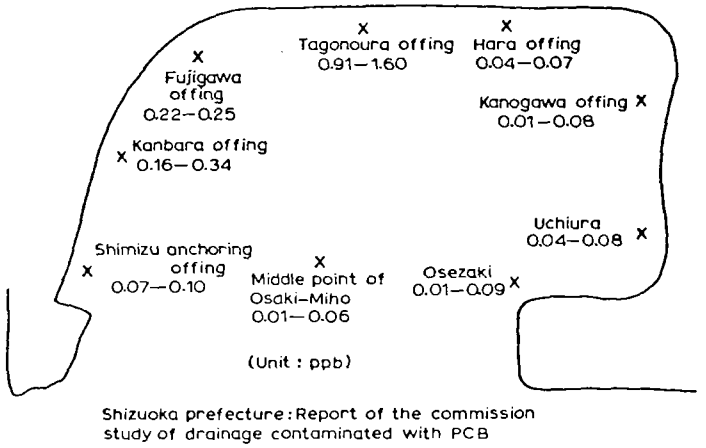

Fig. 5. The contamination of sea water in Suruga Bay with PCB's.

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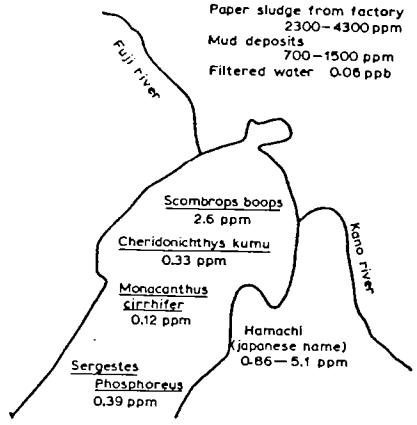

Fig. 6. PCB concentrations in several types of fish of Suruga Bay.

study groups from Shizuoka Prefecture and by several other scientists, and some influence of contamination from PCB discharges was made clear, as summarized in Figs. 5[15] and 6[16].

The contamination of sea water in Suruga Bay in the Tagono-Ura Bay area was at a fairly high level, and accordingly the concentration of PCB's in several types

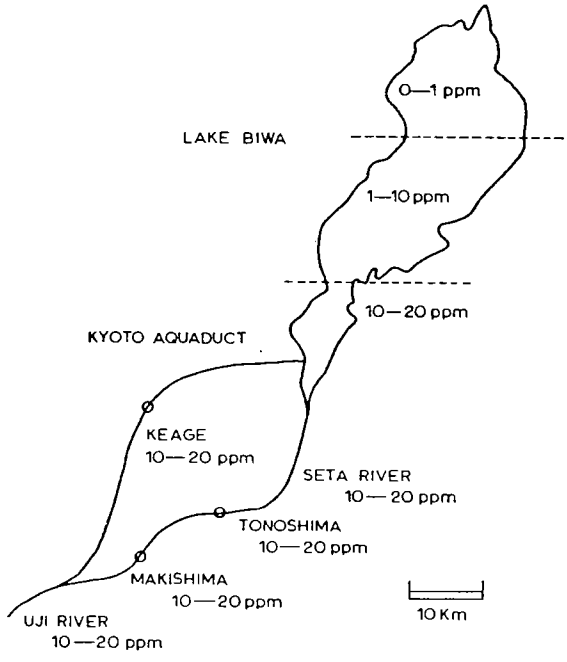

Fig. 7. Fresh-water fish contamination with PCB's in Lake Biwa and Uji River.

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of fish was also in the ppm order. It was said to be especially severe in the case of Sakura-ebi (pink shrimp), which was the main fishery product of this bay, which thereafter could only be caught at the entrance of the bay. High concentrations of PCB's were certified in the mud deposits and discharge scum in the drainage canal pouring into Tagono-Ura Bay.

Suburbs of Kusatsu City in Shiga Prefecture

Fresh-water fish contamination with PCB's in the Ujigawa River and Lake Biwa was confirmed as a result of environmental research begun in September 1970 by the Kyoto City Institute of Public Hygiene. The results[17] of this research are illustrated in Fig. 7.

Because it was assumed that the source of the pollution lay in Lake Biwa, and especially in its southern part, a second research project was undertaken to analyse corbicula along all of the coasts of the lake. The samples that were analysed in this research consisted of corbicula (freshwater lamellibranch.) collected at 15 locations in 1963, by Kyoto and Shiga University Study Groups engaged in research on the ecology of the lake; since collection the samples had been preserved in formalin. As a result of this research, it was concluded that although the residual concentrations of pesticides such as DDT and its homologues were nearly the same in all samples,

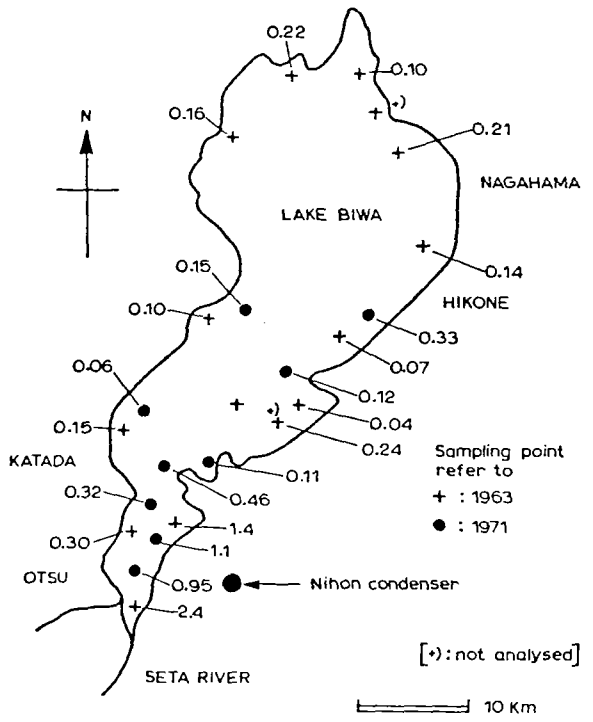

Fig. 8. PCB analysis of corbicula along all of the coasts of Lake Biwa. Unit: ppm in wt. tissue.

DSW 379225

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the concentration of PCB's was abnormally high in the corbicula of two sampling locations, as shown in Fig. 8.

Moreover, analytical research conducted on samples collected in August, 1971, yielded the same results[18].

As a result of the two research projects just described, attention began to focus on a factory of the Nihon Condenser Company in a suburb of Kusatsu City on the southeast coast of the lake. Subsequently, contamination of local farm soil and of mud deposits in drainage waterways originating from the factory have been further clarified by many study groups.

The factory, constructed there by the Nihon Condenser Co. in 1961, produced many kinds of capacitors using PCB's in a technical process like that shown in Fig. 9.

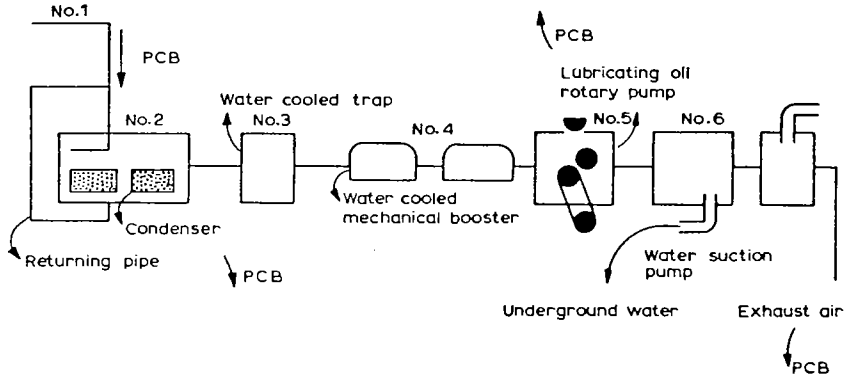

Fig. 9. Technical process for making capacitors using PCB's.

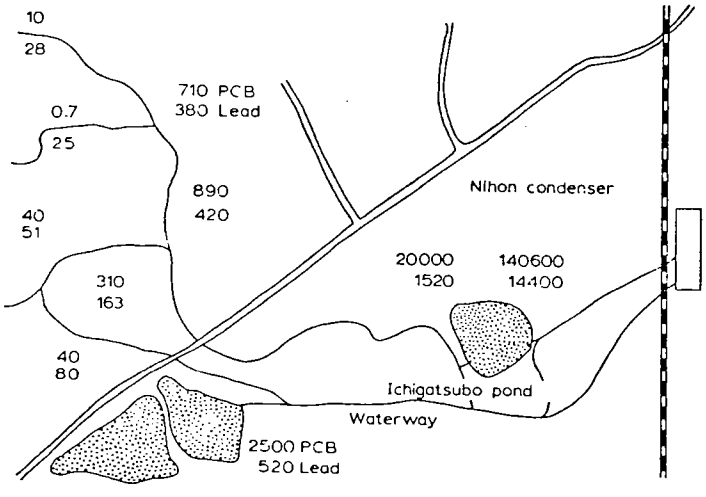

Fig. 10. Environmental contamination with PCB's and lead in the suburb of Kusatsu City. Unit:ppm.

DSW 379226

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It is estimated that the real causes of the contamination lie in the drum for filling the condensers with PCB (No. 2), the machine oil of the vacuum pump (No. 5), the drainage, and the air exhaust.

The results of environmental research commissioned by and presented to the Otsu District Court in 1973 are shown in Fig. 10[19]. In this study, heavy lead contamination was also discovered. Since 1972, rice cultivation has been stopped in rice fields with an area of 18 hectares. Although Ichigatsubo Pond, in which contamination of 140,600 ppm PCB was found in mud deposits, was originally a fish-farming pond, in recent times it has been said that no living animal could be found in the pond. (At the end of 1973 the pond was purchased by the Nihon Condenser Co. and perfectly reclaimed.)

PCB LEVELS IN FISH IN VARIOUS DISTRICTS OF JAPAN

Fish PCB levels in Japan (1972)

Results of research on contamination of fish with PCB's, based on 456 samples from sea-water areas and 143 samples from fresh-water areas all around Japan, were published in December, 1972. Summarizing this report, it was found that 16% of all samples contained over 1 ppm of PCB's, and 3% contained over 3 ppm, as shown in Table 12[20].

TABLE 12

FISH PCB LEVELS IN VARIOUS DISTRICTS IN JAPAN (1972)

Remarks: Researched by Environmental Ministry, The Ministry of Agriculture and Local District Governments.

PCB (ppm)	*0.09*	*0.1–0.4*	*0.5–0.9*	*1–2*	*3**	*>3**	*Total*
Division							
Sea Water Area	155	175	53	48	11	14	456
	(34)**	(38)	(12)	(11)	(2)	(3)	(100)
Fresh Water Area	21	63	33	19	2	5	143
	(15)	(44)	(23)	(13)	(1)	(4)	(100)
Total	176	238	86	67	13	19	599
	(30)	(40)	(14)	(11)	(2)	(3)	(100)

* Standard regulatory value of Japan.
** %.

The contaminated water area of Japan is now spread mostly along the Pacific coast and the Seto Inland Sea. In Fig. 11, the names of several species of fish containing contaminants in excess of the standard regulatory value (3 ppm in in-shore fish, 0.5 ppm in off-shore fish) are noted, together with the levels of residual concentration for each. Generally speaking, the level of contamination is higher in western Japan than in eastern Japan and is also higher in Pacific sea coast than in Japan Sea coast.

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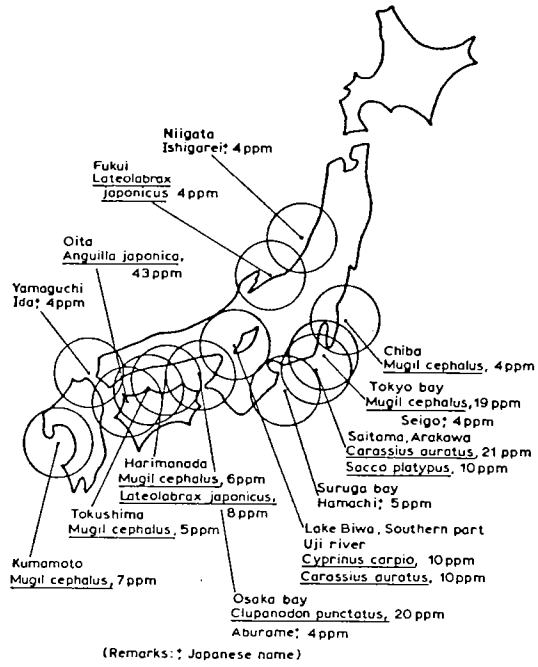

Fig. 11. Names of several species of fish containing PCB's in excess of the standard regulatory value.

TABLE 13

FISHES CONTAINING PCB's IN EXCESS OF THE TEMPORARY GUIDELINE OF JAPAN[31]

No.	*Locality*	*Prefecture*	*Name of fish*
1	Tama River	Tokyo	Konoshiro
2	Nagara River	Gifu	Namazu, Nigoi
3	Seki River	Niigata	All species
4	Sai River	Nagano	Ugui
5	Tenryu River	Nagano	Ugui
6	Tsuruga Port	Fukui	All species
7	Seta River Biwa River	Shiga	Oikawa, Namazu, Ginbuna
8	Uji River	Kyoto	Oikawa, Funa
9	Kōbe Port	Hyogo	Konoshiro Masaba
10	Takasago Port	Hyogo	All species
11	Shirahama, Himegi	Hyogo	Konoshiro, Suzuki, Bora
12	Monzen River	Yamaguchi	Ida, Bora, Anago, Konoshiro, Umitanago, Namako, Unagi, Shimaisaki, Hiiragi
13	Ōita River	Ōita	Unagi

DSW 379228

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Fishes containing PCB's in excess of the temporary guideline of Japan (1974)

On the 5th of September 1974, The Environmental Ministry of Japan published the results of the latest national survey carried out by the National and Local Governments from July 1973 to March 1974. Among 3,369 samples collected from 20 water areas in 17 districts, several species of fish containing PCB's in excess of the temporary guideline of Japan were found in many districts as shown in Table 13; by Government decree harvesting of these fish was prohibited.

RESIDUAL ORGANOCHLORINE COMPOUNDS IN BIRDS

In Japan there have been few reports about organochlorine compound contamination in wild birds; most notably there have been no reports based on systematic analysis of fish-eating birds in heavily polluted areas.

The results of research on the contamination of wild birds with organochlorines in several districts of northwestern Shikoku, carried out in May 1974 by Dr. R. Tachikawa at the request of the Nature Protection Bureau of the Environmental Ministry, have been released. Although that area is not one of the most polluted areas of Japan, the different degree of PCB contamination according to the dietary differences in various species is recognizable, as can be seen in Table 14[21].

TABLE 14

RESIDUAL ORGANOCHLORINE COMPOUNDS (ppm) IN BIRDS OF NORTHWESTERN SHIKOKU

R. Tachikawa and Environmental Ministry, Department of Nature Protection, May 1974.

Name	*Sample No.*	*PCB*		*BHC*		*DDT*		*Dield.*		*Total*	
		Max.	*Mean*	*Max.*	*Mean*	*Max.*	*Mean*	*Max.*	*Mean*	*Max.*	*Mean*
Black tailed gull											
Black headed gull	10	8.04	3.71	0.16	0.08	0.73	0.38	0.94	0.03	8.35	4.19
Kite	10	3.57	2.40	1.27	0.48	2.51	0.82	0.28	0.11	6.46	3.81
Kentish plover	11	2.44	1.03	0.30	0.11	0.90	0.35	0.03	0.02	2.74	1.62
Crow	10	1.20	0.28	0.32	0.10	1.01	0.24	0.43	0.05	2.96	0.75
Golden plover	6	0.16	0.06	0.14	0.08	0.13	0.07	0.02	0.01	0.42	0.21
Trush	9	0.05	0.02	0.12	0.04	0.05	0.03	0.00	0.00	0.27	0.20
Turtle dove	9	0.27	0.03	0.04	0.02	0.07	0.03	0.00	0.00	0.36	0.09
Bulbul	9	0.05	0.03	0.14	0.04	0.05	0.03	0.00	0.00	0.17	0.09
Sparrow	10	0.09	0.02	0.04	0.02	0.05	0.03	0.01	0.00	0.18	0.08
Skylark	10	Trace		0.03	0.02	0.27	0.06	No detect.		0.29	0.07

Research on contamination of sea birds in the Harimanada and Osaka Bay areas, carried out by T. Kashimoto, is summarized in Table 15[22], differences in the level of contamination according to diet can also be seen.

DSW 379229

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TABLE 15

RESIDUAL PCB's IN BIRDS OF HARIMANADA AND OSAKA BAY[22]

Seabrids	*Sex*	*Weight*	*Date, 1971*	*PCB (ppm)**
Redbreasted merganser	♀	670 (g)	14.2	7
Redbreaster merganser	♀	735	14.2	10**
Gull	♂	680	14.2	3
Black headed gull	♂	343	26.2	15
Black headed gull	♂	356	26.2	12
Black headed gull	♀	332	26.2	8
Black headed gull	♀	240	26.2	36
Black headed gull	♀	325	10.3	5
Herring gull	♂	1010	10.3	30
Black tailed gull	♂	620	26.2	21***
Black tailed gull	—	620	14.2	13
Black tailed gull	♂	290	10.3	27
Landbirds				
Dove	♂		3.1	tr.
Bulbul	♂	100	12.2	1.5
Bulbul	♀	92	12.2	0.9

* Concentration in muscle.
** 7 ppm in the internal organs.
*** 18 ppm in the internal organs.

JAPANESE FOOD CONTAMINATION WITH PCB's

The Welfare Ministry and the Ministry of Agriculture and Forestry published a report on the contamination with PCB's in various foods, e.g., milk, meat, eggs, and fish, collected from all around Japan, summarizing all data[23] obtained before August, 1972. In Table 16, Column A contains the results of the research sponsored by the ministries and Column B contains the results of all research completed apart from that contained in Column A; Columns A + B together contain all data analysed up to the present time in Japan.

It should be noted that the contamination of fish, especially fish from the inland sea, is abnormally higher than that of meat, eggs, and milk in Japan.

PCB's AND ORGANOCHLORINE COMPOUNDS IN HUMAN BLOOD PLASMA

Although the physiological meaning of PCB's in human blood is not certain, it is supposed that the level of PCB concentration indirectly reflects differences in eating habits, for instance between rural and urban areas. However, there has been no systematic study of these points.

PCB levels in blood

The concentrations of PCB's and other organochlorine compounds in human blood of the inhabitants of north Kyushu and the Kyoto area are indicated in Table

DSW 379230

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TABLE 16

JAPANESE FOOD CONTAMINATION WITH PCB's, ppm in fresh wt. (1972)

Specimen	*A**			*B***			*A + B*		
	No.	*Range*	*Mean*	*No.*	*Range*	*Mean*	*No.*	*Range*	*Mean*
Milk	26	nd–0.02	0.004	149	nd–0.056	0.02	175	nd–0.056	0.02
Condensed milk	5	0.001–0.01	0.004	1	±	±	6	0.001–0.01	0.003
Powdered milk	18	nd–0.02	0.003	37	nd–0.2	0.03	55	nd–0.2	0.02
Butter	22	nd–0.2	0.04	4	nd–0.433	0.2	26	nd–0.433	0.06
Cheese	6	0.03 –0.02	0.01	2	±–0.094	0.05	8	±–0.094	0.02
Beef	32	nd–0.2	0.02	17	nd–0.06	0.03	49	nd–0.2	0.02
Pork	30	nd–0.3	0.05	9	nd–0.015	0.05	39	nd–0.3	0.05
Mutton	7	nd–0.01	0.004	—	—	—	7	nd–0.01	0.004
Chicken	31	nd–0.2	0.03	21	±–2.21	0.1	52	nd–2.21	0.06
Egg	27	nd–0.08	0.02	15	nd–0.143	0.03	42	nd–0.143	0.02
Marine products	171	0.003–5	0.5	595	nd–2.0	0.5	766	nd–2.0	0.5
inland sea	95	0.01 –5	0.8						
offshore	76	0.003–0.5	0.1						
Vegetable									
Fruit	—	—	—	70	nd–1.0	0.1	70	nd–1.0	0.1
Rice	—	—	—	9	nd–1.33	—	9	nd–1.33	—
Other food	—	—	—	62	nd–0.28	—	62	nd–0.28	—
Sub-total	375			991			1366		
Food package	—	—	—	35	nd–4.13	—	35	nd–4.13	—
Water	—	—	—	225	—	—	225	—	—
Human milk	—	—	—	197	0.001–0.7	—	197	0.001–0.7	—
Total	375			1448			1823		

* Data published by many laboratories except those given in B.
** Data summarized by national research projects.

TABLE 17

PCB's AND ORGANOCHLORINE COMPOUNDS (ppb) IN HUMAN BLOOD PLASMA[24]

District	*No.*	*PCB*		*β-BHC*		*pp'-DDT*		*pp'-DDE*		*DDT+DDE*	
Kyoto Prefecture	11	5.1*	2.1**	11.1	8.3	3.8	2.5	15.4	8.2	19.2	7.5
Kurume City	16	3.5	1.1	11.9	6.7	3.4	1.4	14.5	7.4	17.7	7.3
Yokote City	21	2.2	0.9	4.8	2.7	2.5	1.1	9.6	6.2	12.1	6.2
Chikugo farm villages	29	2.7	0.9	9.3	4.7	5.3	3.6	18.0	8.0	23.0	9.3
Environs of X pesticide factory	15	2.3	1.3	14.1	8.3	4.5	2.4	10.2	4.0	14.7	5.8
Women nursing	11	2.3	0.9	6.4	3.6	3.0	2.8	7.6	5.9	10.6	8.3
Ordinary people (Western Japan)	82	3.1	1.5	10.6	6.5	4.2	2.9	14.0	7.8	17.9	8.7
Yusho patients	14	6.4	3.6	18.3	10.6	4.9	3.2	14.3	7.6	20.8	7.9

* Mean.
** Standard deviation.

DSW 379231

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17[24], using data obtained in research carried out in co-operation with Dr. Takamatsu of the Kurume Medical College. In the north Kyushu area even today, the level of PCB's in the blood of human Yusho patients is higher than in ordinary healthy people. Moreover, in general the tendency is for the level of contamination to be higher in the blood of urban dwellers than in that of rural people.

Gas chromatographic pattern of PCB's in human blood

It has become clear that in gas chromatographic patterns of PCB's in human blood, there is a significant difference between ordinary healthy people and Yusho patients who ingested a lot of PCB's in 1968. As shown in Fig. 12, in the gas chromatographic pattern of PCB's in human blood collected from Yusho patients, statistically there is a tendency for the peak height of the 13th peak to be lower and that of the 17th/18th to be higher than in the case of ordinary people[25]. These findings have been utilized as important reference data for official certification of Yusho patients.

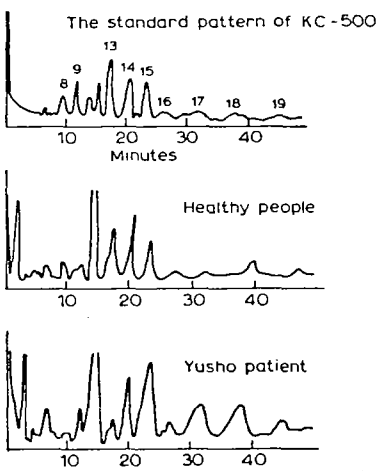

Fig. 12. Gas chromatographic pattern of PCB's in human blood of Yusho patients and ordinary people in Japan.

PCB AND ORGANOCHLORINE COMPOUNDS IN THE BODY FAT OF THE JAPANESE

Residents of the Kyoto area

In order to analyse organochlorine compounds deposited in the body fat of ordinary people, waste adipose tissues excised in abdominal surgical operations for gastric ulcers etc. were used as samples. The results of this research on PCB concentration in the body fat of inhabitants of the Kyoto area are summarized[26] in Table 18, which shows that the concentration of beta-BHC is amazingly high and that of PCB is also higher than is the case for the U.S.A.[27] but about the same as that reported for West Germany[28].

DSW 379232

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TABLE 18

PCB AND ORGANOCHLORINE COMPOUNDS IN HUMAN BODY FAT OF INHABITANTS IN KYOTO AREA (ppm in fat)

	PCB	*α-BHC*	*β-BHC*	*γ-BHC*	*T. BHC*	*pp'-DDT*	*pp'-DDE*	*T. DDT*	*Dield.*
Mean	4.7	0.22	10.9	0.55	11.7	1.4	7.5	9.8	0.19
Range	1.9–13.3	0.06–0.47	3.6–19.8	0.22–1.4	3.8–21.6	0.56–3.6	2.0–11.2	4.2–14.8	0.06–0.61
Median	4.3	0.16	10.5	0.58	11.1	1.3	7.9	9.9	0.13

Japanese Residents of different areas

Summarizing[29] many reports about the residual concentration of PCB's and other organochlorine compounds in human body fat of the inhabitants of several districts of Japan, it was found that the concentration of PCB is generally higher than in the case of the U.S.A., as reported by the Interdepartmental Task Force on PCB's, May, 1972; on the other hand the beta-BHC concentration is over ten times higher than that of Western countries in spite of the complete cessation of its manufacture and use as a pesticide in 1970. (See Table 19.)

TABLE 19

HUMAN BODY FAT PCB IN THE CASES OF JAPANESE RESIDENTS OF DIFFERENT AREAS (ppm in fat)

Locality	*Year*	*No.*	*PCB*	*Range*	*β-BHC*	*T. DDT*	*Dield.*
Kyoto	1971	19	4.7	1.9 –13.3	10.9	9.8	0.19
Tokyo	1971	40	3	0.1 –10			
Kochi	1971–1972	50	2.86	0.61–18.04	8.87	5.44	0.31
Man		31	3.71		8.62	5.51	0.26
Woman		19	1.48		6.66	5.33	0.22
Farmer		7	2.75		7.87	5.24	0.31
Fisherman		5	7.50		6.95	7.79	0.19
Company employee		6	2.60		7.26	4.97	0.21
Others		11	2.92		8.52	5.41	0.22
Without occupation		21	1.89		7.93	5.10	0.25
Kochi	1970	10	1.49				
Yamagata	1971	15	1.73	0.6 – 3.9			
Ehime	1971	16	1	0.1 – 2			
West Germany	1970	20	5.7	1.7 –16.6	0.45		
Yusho patient	1969	2	32.1 and 45.8 (skin fat)				
Yusho patient		1	13 (belly) and 75.5 (face)				

PCB LEVELS IN HUMAN MILK

It is not certain how much babies are affected by residues of organochlorine compounds in human milk as a definite reflection of environmental and food contamination. However, in Japan PCB's are usually detected in all samples analysed.

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TABLE 20

MEAN AND RANGE OF CHLORINATED HYDROCARBON RESIDUES IN HUMAN MILK, 43 SUBJECTS

(ppm on whole milk basis and fat basis). tr.: Trace. ppm on fat basis is parenthesized.

	PCB	*α-BHC*	*β-BHC*	*γ-BHC*	*Total BHC*	*pp'-DDT*	*pp'-DDE*	*Total DDT*	*Dieldrin*	*Fat (%)*
Mean	0.05 (1.9)	0.002 (0.07)	0.11 (4.4)	0.004 (0.17)	0.12 (4.6)	0.019 (0.67)	0.076 (2.4)	0.095 (3.1)	0.005 (0.17)	2.6
Range	0.01–0.31 (0.5–12.2)	tr–0.008 (0.03–0.21)	0.02–0.28 (1.3–9.2)	tr–0.033 (0.04–1.3)	0.02–0.23 (1.4–9.4)	tr–0.12 (tr–2.9)	0.006–0.32 (0.45–7.4)	0.006–0.44 (0.45–10.3)	tr–0.021 (tr–0.67)	0.83–5.5
Germany[28] (43 subjects)	0.103 (3.5)		0.018 (0.54)			0.031 (1.1)	0.081 (2.7)	0.112 (3.8)		
Sweden[32] (22 subjects)	(0–1.0)									

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TABLE 21

HUMAN MILK CONTAMINATION WITH PCB IN JAPAN[31] (ppm in fresh weighth)

PCB	*Urban area*		*Agricultural area*		*Fishery area*		*Surroundings of factory*	
	Prefecture 37 City 7		Prefecture 34 City 2		Prefecture 13 City 1		Prefecture 5 City 1	
	1972	*1973*	*1972*	*1973*	*1972*	*1973*	*1972*	*1973*
<0.009	20 (7.3)	28 (11.6)	16 (8.0)	22 (13.3)	2 (2.3)	6 (7.8)	2 (4.)	2 (6.7)
0.01	28 (10.3)	36 (14.9)	34 (17.0)	23 (13.9)	5 (5.8)	10 (13.0)	5 (12.2)	5 (16.7)
0.02	58 (21.2)	55 (22.7)	64 (32.0)	46 (27.7)	20 (23.0)	20 (26.0)	9 (22.0)	3 (10.0)
0.03	51 (18.7)	48 (19.8)	43 (21.5)	37 (22.3)	14 (16.1)	9 (11.7)	8 (19.5)	3 (10.0)
0.04	31 (11.4)	25 (10.3)	18 (9.0)	11 (6.6)	16 (18.4)	8 (10.4)	3 (7.3)	9 (30.0)
0.05	31 (11.4)	18 (7.4)	12 (6.0)	9 (5.4)	9 (10.3)	4 (5.2)	6 (14.6)	2 (6.7)
0.06	17 (6.2)	14 (5.8)	6 (3.0)	10 (6.0)	3 (3.4)	4 (5.2)	3 (7.3)	1 (3.3)
0.07	10 (3.7)	5 (2.1)	1 (0.5)	2 (1.2)	1 (1.2)	4 (5.2)	2 (4.9)	3 (10.0)
0.08	11 (4.0)	6 (2.5)	3 (1.5)	3 (1.8)	5 (5.8)	4 (5.2)		1 (3.3)
0.09	5 (1.8)	1 (0.4)		1 (0.6)	4 (4.6)	3 (3.9)		
0.1	8 (2.9)	6 (2.5)	3 (1.5)	2 (1.2)	5 (5.8)	3 (3.9)	3 (7.3)	1 (3.3)
0.2	3 (1.1)				3 (3.4)	2 (2.6)		
Total	273 (100%)	242 (100%)	200 (100%)	166 (100%)	87 (100%)	77 (100%)	41 (100%)	30 (100%)
Mean V.	0.038	0.038	0.026	0.027	0.047	0.041	0.037	0.037
Central V.	0.031	0.025	0.023	0.023	0.037	0.028	0.031	0.037

DSW 379235

STLCOPCB4100111

PCB and organochlorine compounds in human milk of residents of Kyoto City

The residual concentrations of PCB and organochlorine compounds were analysed in 43 samples of human milk, collected three months after giving birth, from healthy mothers between 21 and 32 years old living in Kyoto City. The results are summarized[30] in Table 20, in which the pattern of detected PCB is analogous to that of KC-500; it is notable that 95% of the total BHC was beta-BHC.

Research on human milk contamination in Japan

The Ministry of Welfare of Japan carried out a national research study on PCB concentrations in human milk based on 671 and 595 women in 1972 and 1973, respectively[31]. In this study, the results were compared on the basis of habitation in urban, farm, fishery, and near factory areas, as shown in Table 21. Figure 13 shows the

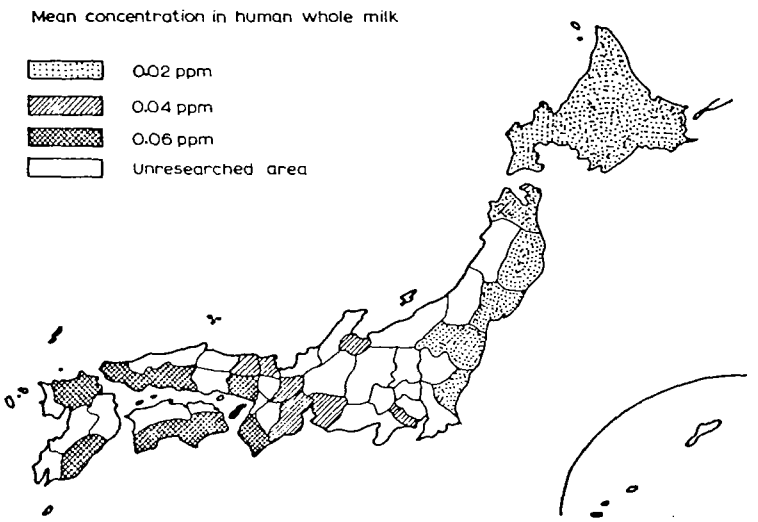

Fig. 13. Human milk contamination with PCB's in fishery areas of Japan.

results obtained for fishery areas in the standard division of the sampling areas.

The Ministry of Welfare summarized this research study as follows:

(a) In the classification of areas according to industrial patterns, the extent of PCB contamination of human milk is rather higher in fishery and factory areas than in farm and urban areas.

(b) In the classification of geographical patterns, PCB concentrations in western Japan, especially in the Seto Inland Sea area, are higher than in eastern Japan.

(c) Comparing the results for 1972 and 1973, the concentration in urban areas became slightly lower in 1973, but in fishery, farm, and factory areas the difference was not recognizable.

Moreover, medical examination of women in childbed and their babies carried out at the same time as this analysis showed no abnormalities attributable to PCB's.

DSW 379236

STLCOPCB4100112

Assuming that babies usually consume 150 ml of human milk a day per 1 kg of body weight, it is calculated that 5.3 and 4.8 μg of PCB's per 1 kg of body weight per day was ingested by babies in human milk in 1972 and 1973, respectively, with the average value of contamination being 0.035 ppm in 1972 and 0.032 ppm in 1973. These values are nearly equal to 5 μg/kg which is the allowance level for PCB's for Japanese adults set by the Official Committee for Food Hygienic Research. It is estimated that 30% of all Japanese babies are ingesting more than the adult maximum allowance of PCB's.

DISCUSSION

Japan is a relatively small nation, completely surrounded by the sea. In Japan the production of PCB's increased rapidly in the late 1960's, and in 1970 the production was about 10 times that of the United States per unit of land area. However, the production and use of PCB's in Japan was abruptly stopped between March and June, 1971.

Under these circumstances, in such an isolated territory the history and future course of PCB contamination is worthy of worldwide attention.

Fortunately, a standard analytical method for PCB's was published in 1972, and since then a great deal of research has been carried out.

As shown in this report, research in Japan on marine products, environmental contamination, human adipose tissue, and human milk, in the light of Japanese dietary habits as a fish-eating people, is of great significance in clarifying the long-term behavior and meaning of PCB contamination.

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DSW 379238

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