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# Distribution Differences between Polychlorinated Terphenyls and Polychlorinated Biphenyls in Human Tissues

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Polychlorinated terphenyls (PCTs) are compounds which require further studies to investigate their effects on human health and on the environment (U.S. ENVIRONMENTAL PROTECTION AGENCY 1978). PCTs are similar to polychlorinated biphenyls (PCBs) in their chemical characteristics and have been used industrially in the same way as PCBs, which are ubiquitous pollutants. PCT residues were identified in the eggs and fatty tissue of herring gulls by ZITKO *et al.*(1972). In Japan, PCT residues were subsequently reported in various samples, including human tissues (DOGUCHI 1977, MINAGAWA 1979). It was also reported that the PCT distributions in the environment and human body were not necessarily the same as those of PCBs. For instance, the levels of PCTs in human fat and blood were almost equal to those of PCBs, although the PCT residue levels in environmental samples such as water, fish and foodstuffs were much lower than those of PCBs.

The present study was performed in order to clarify the tissue distribution of PCTs in the human body. Several differences between the PCT and PCB distributions in human tissues were found.

## EXPERIMENTAL

Materials. Seventeen samples of human adipose tissues and 6 liver samples were obtained through hospitals located in the Osaka area from 1975 to 1978. Human milk and blood from 24 nursing women were collected in 1975. Blood samples from 17 children, aged from 0 to 6 years, and from 16 of the mothers were collected in 1976. Thirty fetal samples (skin, liver, and fat) were obtained through Kyoto University in 1976.

Extraction and clean-up procedures. According to the standard analytical method for PCBs (Ministry of Health and Welfare, Japan, 1972), 0.5 g of adipose or milk fat, 10 g of whole blood, or 1 g of other tissues was refluxed in 20 ml of 2N ethanolic potassium hydroxide for on hour. Each saponified solution was poured into 40 ml of water, then extracted with 30 ml of n-hexane. The extract was washed twice with 2% (w/v) sodium chloride and dried over anhydrous sodium sulfate.

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Twenty-five ml of the extract was placed in a 10 mm x 20 cm glass column containing 5 g of Florisil, 60 - 100 mesh, non-activated. The elute was concentrated to a suitable volume and assayed for PCTs and PCBs by gas chromatography. Recovery rates of PCTs and PCBs by this procedure were better than 90 %.

Gas chromatographic analysis. The sample extract was injected into a Varian 2100 gas chromatograph equipped with an electron capture detector ($^{63}Ni$). The glass column (150 cm x 0.2 cm, packed with 2 % OV-1 on Gas Chrom Q, 100-120 mesh) was held at 245°. The injector and detector temperature were 255° and 300°, respectively. The nitrogen flow rate was 10 ml per minute. The PCT residues in the samples were quantified by comparison of the total peak height of the 11 major peaks given by Aroclor 5460 with those given by the samples.

The quantitation of PCBs followed the method of UGAWA *et al.* (1973), using a 2 % OV-1 column at 180°.

## RESULTS AND DISCUSSION

Figure 1 showes the gas chromatograms obtained with Aroclor 5460 and hexane extracts of human tissue samples. It can be seen that there is a characteristic PCT profile. Though the early peaks (peaks 1 to 5) in the PCT patterns of the sample extract profiles differed slightly, the similarity between the profiles of the sample extracts and that of standard Aroclor 5460 is apparent.

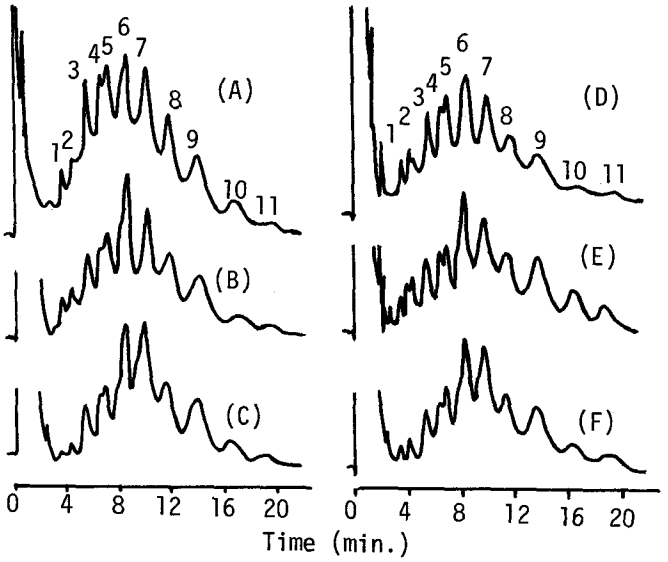


Fig.1. Gas chromatograms of PCTs in human tissues. (A) Aroclor 5460, (B) Adipose tissue (adult), (C) Liver (adult), (D) Milk (adult), (E) Blood (adult), and (F) Liver (fetus).

Adipose tissue and liver. The analytical data for the tissues of Japanese are given in Table 1. PCT residues were found in almost all samples. The average level of PCTs in adipose tissue was 0.89 ppm on a fat basis, which was about one-half that of PCBs. The results obtained in this study are similar to the data reported by FREUDENTHAL *et al.* (1973), MINAGAWA (1979) and DOGUCHI (1977).

The avrage level of PCTs in human liver was 0.05 ppm, with a range of 0.007 - 0.162 ppm on a whole liver basis. The ratio of PCT/PCB was again about one-half.

Human milk and blood. The average levels of PCTs and PCBs in milk were 0.001 and 0.023 ppm on a whole milk basis, respectively. The levels of PCTs were extremely low (4 or 5 % of the PCB content). The present results are consistent with the data reported by MINAGAWA (1979). The PCB content of body tissues is greatly influnced by their fat content. The PCB concentration

TABLE 1

PCT and PCB concentrations in the tissues of Japanese

| Tissue sample | N[b] | PCTs | | PCBs | |
|---|---|---|---|---|---|
| | | Conc.[a] | Occurrence | Conc.[a] | Occurrence |
| Adult(over 20 years) | | | | | |
| Adipose | 17 | 0.89 ± 1.3[c,d] (0.89 -39.3) | 24/24 | 1.52 ± 0.47 (0.93 - 2.95) | 17/17 |
| Liver | 6 | 0.05 ±0.058 (0.007 -0.162) | 6/6 | 0.091 ±0.116 (0.025 -0.323) | 6/6 |
| Milk | 24 | 0.001 ±0.001 (0.0001-0.003) | 24/24 | 0.023 ±0.011 (0.006 -0.051) | 24/24 |
| Blood | 24 | 0.003 ±0.003 (0.0005-0.025) | 24/24 | 0.002 ±0.001 (0.0006-0.005) | 24/24 |
| Child(0 to 6 years) | | | | | |
| Blood | 17 | 0.001 ±0.002 ( ND -0.007) | 6/17 | 0.004 ±0.004 ( ND -0.013) | 13/17 |
| Mother's Blood | 16 | 0.005 ±0.007 (0.001 -0.025) | 16/16 | 0.003 ±0.001 (0.002 -0.005) | 16/16 |
| Fetus(4 to 9 months) | | | | | |
| Skin | 12 | 0.007 ±0.014 ( ND -0.050) | 9/12 | 0.084 ±0.137 (0.004 -0.448) | 12/12 |
| Liver | 14 | 0.009 ±0.011 ( ND -0.033) | 12/14 | 0.014 ±0.005 (0.005 -0.020 | 14/14 |
| Fat | 4 | 0.005 ±0.004 ( ND -0.008) | 3/4 | 0.006 ±0.003 (0.004 -0.009) | 4/4 |

*a*) Mean±S.D. on a whole organ basis. Values in parentheses indicate the range.
*b*) N is the number of samples.
*c*) On a fat basis.
*d*) One sample, having 39.3 ppm PCTs, was rejected on the basis of Grubb's test.

in milk fat was the same as that in adipose tissue (YAKUSHIJI *et al.* 1978). However, the PCT level in milk fat was about 0.03 ppm and was significantly lower than that in adipose tissue, *i.e.*, 0.89 ppm. The reason for this difference between the PCT and PCB tissue distributions in the human body is unclear.

Blood samples obtained from 24 nursing women were analyzed. The average level of PCTs in these blood samples was 0.003 ppm on a whole blood basis, and was slightly higher than that of PCBs, *i.e.*, 0.002 ppm. DOGUCHI (1977) reported a similar result. The average PCT/PCB ratio of blood was about 1.5, while the ratio in adipose tissue was about 0.5. Thus, it appears that PCT tends to accumulate preferentially in the blood. In animal experiments, SOSA-LUCERO *et al.* (1973) and MINAGAWA (1979) reported that PCTs tended to accumulate more in the liver and blood compared with PCBs. However, the reason for this is not clear.

Children's blood. The levels of PCTs and PCBs in the blood of children and their mothers are given in Table 1. The average PCB level in children's blood was 3.8 ppb on a whole blood basis, which was slightly higher than in the mother's blood, *i.e.*, 2.8 ppb. KUWABARA *et al.* (1979) reported that an increase in the feeding period of mother's milk tended to cause an increase in the PCB level in the blood of children. They suggested that most of the PCBs in the children had been transported via their mother's milk. On the other hand, the average PCT level in children's blood was very low, *i.e.*, 1.0 ppb, while that in mother's blood was 5.4 ppb. In addition, only six out of 17 samples of children's blood were contaminated by PCTs. This may be due to the low level of PCTs in milk mentioned above. It appears that the amount of PCTs transported into children via their mother's milk was less than in the case of PCBs.

Fetal organ. The placental transfer of PCBs was reported in humans by NISHIMURA *et al.* (1977). However, there is no information available on the placental transfer of PCTs. Table 1 shows the levels of PCTs and PCBs in fetal organs. The average levels of PCTs in fetal skin, liver, and fat were 0.007, 0.009, and 0.005 ppm on a whole organ basis, respectively. These PCT levels were much lower than those in adult tissue, suggesting that the extent of placental tranfer of PCTs is relatively small.

There was a difference between the PCT and PCB tissue distributions in the fetus. NISHIMURA *et al.* (1977) reported that the PCB concentration in fetal organ was highest in the skin, and suggested that this was due to adipose tissue of the skin. The same result was obtained in the present study. On the other hand, the PCT level of fetal skin was almost the same as

that of the other organs. This again indicates that the placetal transfer of PCTs is less than that of PCBs. This may be because PCTs have less affinity for fat than PCBs.

The range of PCT levels in tissues. Figure 2 showes histograms of the PCT and PCB levels in adult adipose tissue and blood. There was a significant difference between the PCT and PCB concentration ranges not only in these tissues, but in all the tissues. The levels of PCTs showed a much wider range than those of PCBs. This may possibly be a result of relatively restricted PCT pollution in the environment. In contrast, environ mental pollution by PCBs is widespread, partly because of the higher volatility and solubility of PCBs compared with PCTs.

Comment. Several tissue distribution differences between PCTs and PCBs in the human body are described in this paper. It has been observed that the toxicity of PCTs is similar to or rather less than that of PCBs (SOSA-LUCERO *et al.* 1973, ALLEN & NORBACK 1973, and CECIL *et al.* 1975), and the present results indicate that little placental transport and little transfer via mother's milk occur in the case of PCTs. In fact, none of the fetuses or children in this study showed any clinical symptoms of toxicity due to PCTs and PCBs. Therfore, the effect of PCTs on the human fetus and suckling baby may be negligible.

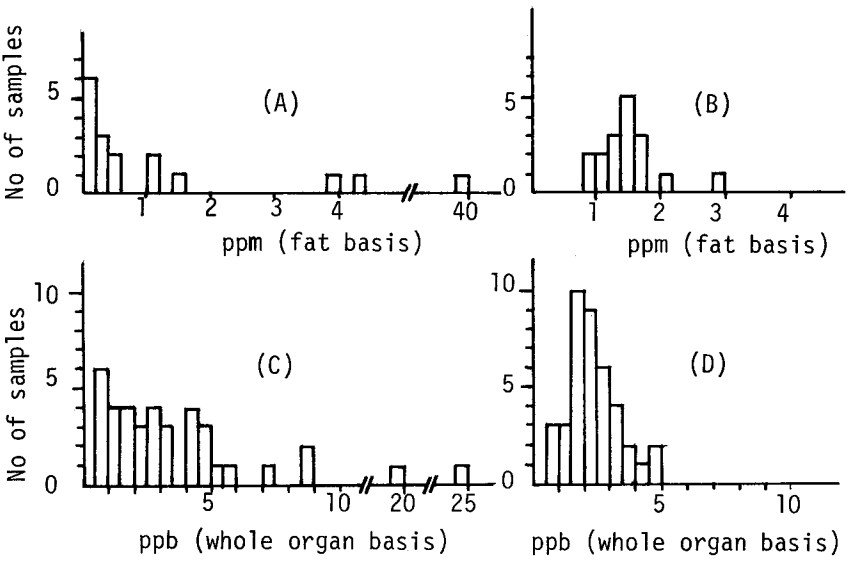


Fig. 2. Histograms of (A) PCT and (B) PCB concentrations in fat, and (C) PCT and (D) PCB concentrations in blood obtained from 24 nursing women and 16 mothers of children.

We mentioned above that the levels of PCTs showed a much wider range than those of PCBs in case of human exposure, though a few subjects in this study showed abnormally high PCT level, *i.e.*, over than 10 ppm in fat or 10 ppb in whole blood. In cases of human PCB exposure, such high levels have seldom been observed except in occupationally exposed workers (WATANABE *et al.* 1978). According to HARA *et al.* (1974), symptoms related to PCB toxicity, especially skin lesion, have been observed in workers in a Japanese condenser factory, but these symptoms disappeared when the use of PCB ceased.

Unfortunately, there is no information available on the carcinogenicity and chronic effects of PCTs at low levels of exposure. It is not possible at present to evaluate the health hazard of PCTs to man at any level of exposure.

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