A PCB INPUT-OUTPUT BALANCE ON A HUMAN

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Introduction

PCBs are widely distributed in the environment and adverse effects of human exposure to them have been suggested (1). Extensive studies have been undertaken using animals in order to understand the behaviour of these chemicals (2). Many surveys of PCB concentrations in human foodstuffs have also been carried out (3,4). However, there is very little research on the uptake and elimination of PCBs in humans. Since food is the major route of PCB intake and excretion via faeces is the major output, an intake and output mass balance study focusing on food intake and faecal output was conducted to help improve our understanding of the behaviour of these chemicals in humans.

Method

A 14 day study was carried out on one male volunteer aged 30. The volunteer had no history of occupational PCB exposure or liver function disorders. All meals, including drinks containing milk, were prepared in duplicate and a portion identical to that consumed by the volunteer was collected daily in precleaned glass jars and aluminium boxes. The volunteer followed his normal eating habits. Faeces were collected daily in precleaned aluminium boxes. Samples were frozen (at -20 ^{o}C) soon after collection. Sweetcorn was used as a biological tracer, eaten with the first meal and the last meal of the study. Blood serum was sampled every day and stored in precleaned glass vials at -20 ^{o}C until sample preparation.Samples of food, faeces or serum from a 2 day period were homogenised with sodium sulphate prior to Soxhlet extraction with a 4:1 hexane/acetone mixture. The clean-up of food or faeces included activated silica and acidified silica column chromatography and a Bio-beads S-X3 SEC column. The clean up of serum included deactivated Florisil chromatography. Analysis was carried out on a Fisons GC8000 series gas chromatograph coupled with an MD800 quadrupole MS. The details of the analytical method have been described more fully elsewhere (5).

Results

PCBs 44, 47, 49, 52, 60, 66, 74, 101, 105, 110, 118, 138, 149, 151, 153, 170, 180, 183, 187 and 194 were selected for analysis in this study because they were readily quantifiable in food. Because of problems with laboratory blank levels the analysis of tri-chlorinated congeners was precluded in this study. The lowest and highest ∑PCB input values were 160 and 300 ng/day and the output ranged from 90 to 180 ng/day. The average daily intake of all of the PCBs measured in this study (∑PCB) was 220 ± 82 ng and the average ∑PCB output in faeces was 120 ± 43 ng. Table 1 shows the mean, standard deviation and range of individual PCB intake and output (ng/2 days) measured throughout the study. The average individual PCB intake was from 4 ng (PCB 194) to 88 ng (PCB 153) per 2 days. The PCB output ranged from 2 ng (PCB 149) to 68 (PCB153) ng per 2 days. The congener patterns for food, faeces and serum were all dominated by the hexa-chlorinated congeners 138 and 153.

Table 1: Input and output fluxes and serum concentrations throughout the study

PCB	Intake (ng/2 days)	Output (ng/2 days)	Serum ng/g lipid
	Average ± S.D. (range)	Average ± S.D. (range)	Average ± S.D. (range)
44	10±4 (6-18)	nd	nd
47	12±6 (5-19)	nd	nd
49	10±3 (8-15)	5±2 (2-10)	0.8±0.8 (0.1-1.9)
52	18±4 (13-26)	7±4 (4-14)	1.2±1.1 (0.2-3.0)
60	11±5 (6-18)	nd	nd
66	22±13 (8-48)	6±2 (3-9)	1.7±1.1 (0.5-3.0)
74	18±8 (14-34)	9±4 (4-15)	2.5±1.1 (1.0-1.9)
101	16±2 (12-18)	2±1 (1-5)	0.9±0.6 (0.3-1.5)
105	14±7 (7-15)	4±1 (2-4)	0.8±0.2 (0.6-1.1)
110	12±3 (8-15)	3±1 (1-5)	0.7±0.4 (0.3-1.1)
118	51±11 (31-60)	18±5 (12-21)	3.9±0.7 (2.8-5.0)
138	63±31 (29-93)	59±16 (38-83)	7.8±1.2 (6.4-9.2)
149	20±6 (15-28)	2±1 (1-5)	0.6±0.2 (0.3-0.8)
151	10±3 (7-14)	nd	nd
153	88±37 (44-143)	68±18 (44-98)	11±1.4 (9.2-12)
170	17±7 (8-29)	21±6 (15-31)	3.7±1.0 (2.8-5.0)
180	29±13 (14-42)	40±11 (30-57)	7.0±1.2 (5.6-8.2)
183	8±3 (5-11)	4±1 (3-6)	0.6±0.1 (0.4-0.7)
187	10±5 (4-17)	12±3 (8-16)	1.5±0.2 (1.2-1.9)
194	4±1 (2-5)	4±1 (15-31)	0.9±0.1 (0.8-1.0)

Discussion and Conclusions

The PCB congener patterns of serum, food and faeces are presented in Figure 1. Each congener concentration is normalised to the concentration of the most abundant congener (PCB 153). PCBs 118, 138, 153, 138 and 180 appear to be the most dominant in all of the matrices. It can be seen that the congener patterns found for serum and faeces are quite similar and that the food congener pattern includes some congeners which are virtually removed from serum and faeces. It is assumed that these congeners are metabolised within the body since no metabolism of PCBs has been reported within the human GI tract. The correlation of the serum and faeces congener pattern is probably caused by a relatively high degree of exchange of PCBs between these compartments of the body i.e. partitioning equilibrium being approached or reached across the GI tract. A strong correlation between concentrations in faeces and serum has also been observed for PCDD/Fs by Rappe and Andersson (6).

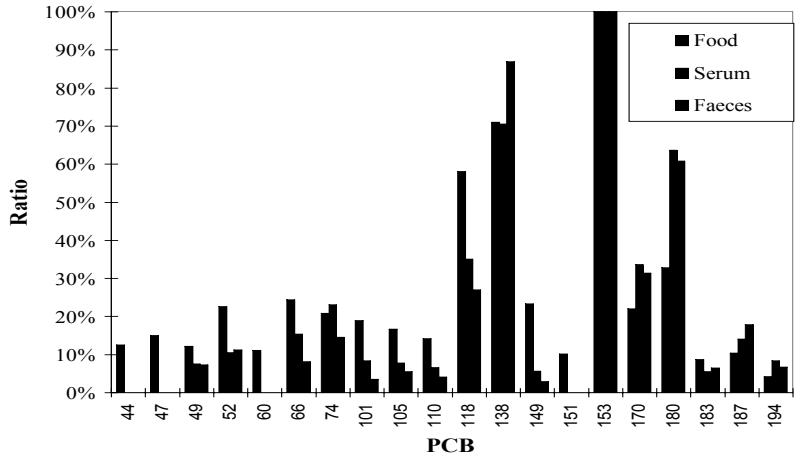

Figure 1: Congener patterns for food, serum and faeces normalised to PCB 153

The input-output mass balances for each PCB congener were calculated by dividing the amount of PCBs present in faeces by the input from food and are shown in Figure 2. It can be seen that higher input-output balance values were found for most of the hexa- and hepta-chlorinated congeners studied. Of these, PCBs 138, 187, 170, 180 and 194 gave over 100% input-output balance values. The input-output balance dropped to approximately 35% for tetra- and penta-chlorinated congeners.Individual PCBs exhibit different input-output mass balance values that reflect their rates of absorption, metabolism and excretion. Those PCBs with the highest mass-balance values in each homologue group (i.e. Tetra-CB:60; Penta-CBs:118; Hexa-CBs: 153,138; Hepta-CB: 180) are less metabolised than those with lower mass-balance values and PCBs found in food at appreciable concentrations but not detected in faeces (PCB 47, 44, 60, 151) were the most metabolised. The congeners which appear to be metabolised the most from the mass-balance data also show the most obvious reductions in relative importance in faeces compared to food (see Fig 1). It is not unreasonable to assume that the lower mass-balance values found for the more metabolised congeners may more closely reflect the actual absorption of these congeners since excretion of these congeners is much less important than for the unmetabolised congeners. The congeners seen to be metabolised to some degree in this study are in agreement with those which were found to be virtually, or fully removed from the congener pattern of human milk compared to Aroclor mixtures (1) and in the diet (7).PCBs 138, 170, 180, 187 and 194 each gave over 100% mass-balance. That is, for these congeners the PCB output via faeces exceeded the PCB intake from food. This is possibly due to the fact that PCB levels in food and average PCB intakes are declining with time (8), so the excretion of PCBs from the body fat reserves via the tissue-blood-faeces route may be important.

The work presented here is a pilot study. Further investigation with more volunteers and a longer sampling period is necessary to gain a better understanding of the factors determining the absorption and excretion of PCBs.

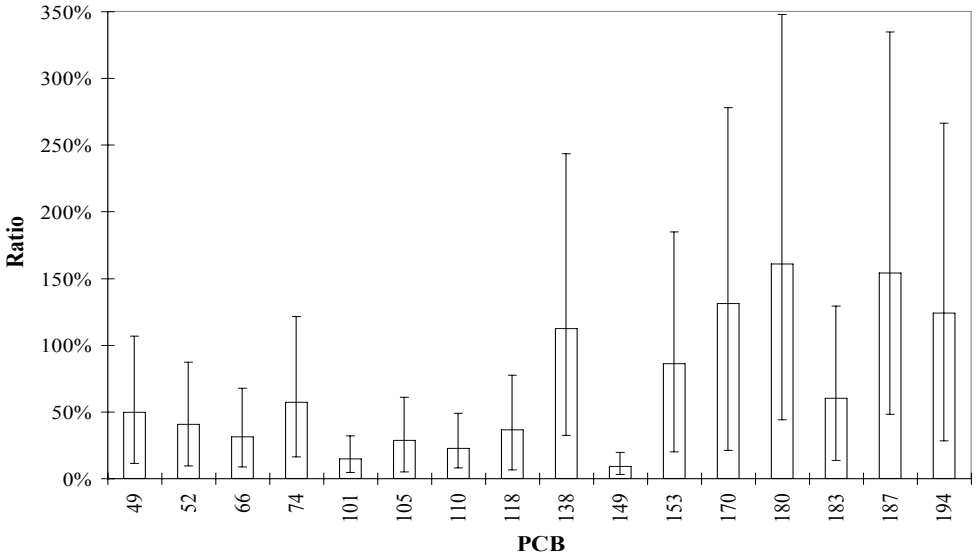

Figure 2: The input-output mass balance of PCBs
(The errors are the standard deviation, congeners not detected are not shown in the graph)

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