THE NET ABSORPTION OF PCBs IN HUMANS AT BACKGROUND CONCENTRATIONS

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Introduction

The presence of polychlorinated biphenyls (PCBs) in humans has attracted concern because of their potential teratogenic, carcinogenic, hormonal and immunological effects (1). There is a considerable body of human toxicity data on these compounds derived from accidental and occupational exposure occurring during the last 30 years (2,3). There is also a wide body of data on the toxicological and biochemical effects of individual and complex mixtures of PCBs in experimental animals (1). However, there is very little research on the uptake and elimination of individual PCB congeners in humans at typical background concentrations. These studies would be useful in helping to identify key processes affecting the absorption and clearance of PCBs and other organochlorine compounds by the human body.

Materials and Methods

A PCB input-output mass balance study was conducted in the UK with five men aged 24 to 30. The age, weight and the body fat index of each volunteer are shown in **Table 1**. The volunteers had no history of intestinal diseases, liver function disorders, or other abnormalities concerning eating habits, digestion, and faecal excretion. Sweetcorn was used as a biological tracer, eaten with the first and last meals of the study. Collection of the faeces samples lagged one day behind the food sampling in order to account for passage through the gastro-intestinal (G-I) tract. Duplicate portions of all food, and all beverages containing milk, consumed by the volunteers were collected in pre-cleaned glass bottles and aluminium boxes. Blood was sampled from a vein in the arm every day for the first volunteer, but every other day with the other 4 volunteers. Samples of serum from volunteer 1 from 2 consecutive days were mixed before analysis. The serum samples from the other volunteers were analysed individually.

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 (3%) 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 (4).

Table 1: Age, weight, body fat index and body density of the volunteers during the study period:

Volunteer	Age (yr)	weight (kg)	body fat index (%)	body density (kg/m^3)
1	29	83	15	1.07
2	24	70	17	1.06
3	25	67	8.9	1.08
4	27	70	7.0	1.09
5	30	89	17	1.06

Results and Discussion

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 the food samples received. Other compounds in the standard were often at or below the detection limit; there were high laboratory blank levels involved in the analysis of tri-chlorinated congeners which resulted in them being excluded from this study.

The net absorption in this study was defined as:

absorption (%) = 1- (Output flux via faeces/Input flux from food).

It should be noted that there is an important distinction between actual absorption and net absorption. Studies of this kind cannot be used to give a reliable measure of absorption efficiency. Studies to measure absorption efficiency using C-13 labelled compounds will produce rather clearer data to interpret, although it should be acknowledged that they are still subject to the confounding influence of metabolism and will only give a 'snapshot' value for a parameter which varies over an individual's lifetime. The main subject of this study was to investigate the 'real' situation, each volunteer having been exposed to PCBs for their entire life. **Figure 1** presents the net absorption efficiency in this study. A pattern can be clearly seen - the absorption behaviour shows a distinct difference between more readily metabolised congeners, such as 52, 49, 47, and 149 and less readily metabolised congeners such as 138, 153 and 180. All the less persistent congeners showed positive net absorption for the 5 volunteers, whilst the more persistent congeners showed widely varying absorption behaviours between volunteers. For example, PCB 149 gave approximately 85% net absorption efficiency for all the volunteers but PCB 153 gave 24, 61, -64, 0 and 83 % net absorption efficiency for volunteers 1-5, respectively. The body burden of the readily metabolised congeners will be lower than the more persistent congeners, therefore, the net diffusive gradient of readily metabolised congeners across the gastro-intestinal tract would be maintained in favour of the transfer *into* the body. It should be noted that the net absorption/excretion of congeners can also vary substantially between individuals, which appeared to be a function of body fat index (BFI), as well as the susceptibility to metabolism. The volunteers 3 and 4 with the lowest BFIs (8.9 and 7.0, respectively) showed net excretion for the greatest number of congeners, whilst volunteer 5, with the highest BFI (17%), was a net absorber of all the congeners studied. This indicates that the size (capacity) of fat compartment has a strong influence on whether a particular PCB congener is absorbed by or excreted from the body. In other words, individuals with a smaller fat volume will have less capacity to absorb a given dose of PCBs into their bodies than individuals with a bigger fat volume.

It is now appropriate to discuss the blood profile data with the hope of shedding light on the factors that influence the absorption of PCBs. **Figure 2** presents the average blood PCB concentrations for the 5 volunteers. A pattern can be clearly seen - concentrations of the lower chlorinated congeners such as 44, 47, 49 and 52 are relatively low, while higher concentrations are seen for the most recalcitrant congeners such as PCB 138, 153 and 180. The serum PCB congener profile supports the assumption (mentioned earlier) that the lower chlorinated congeners show higher net absorption efficiency, because they are metabolised fairly efficiently, while the higher chlorinated congeners are generally influenced strongly by the body burden. It should be noted that volunteers 3 and 4, who had the lowest fat capacities, had the highest blood concentrations, and showed net excretion for the most recalcitrant congeners. These results match our expectation that the PCB blood concentration is strongly influenced by the size (capacity) of the body fat pool.

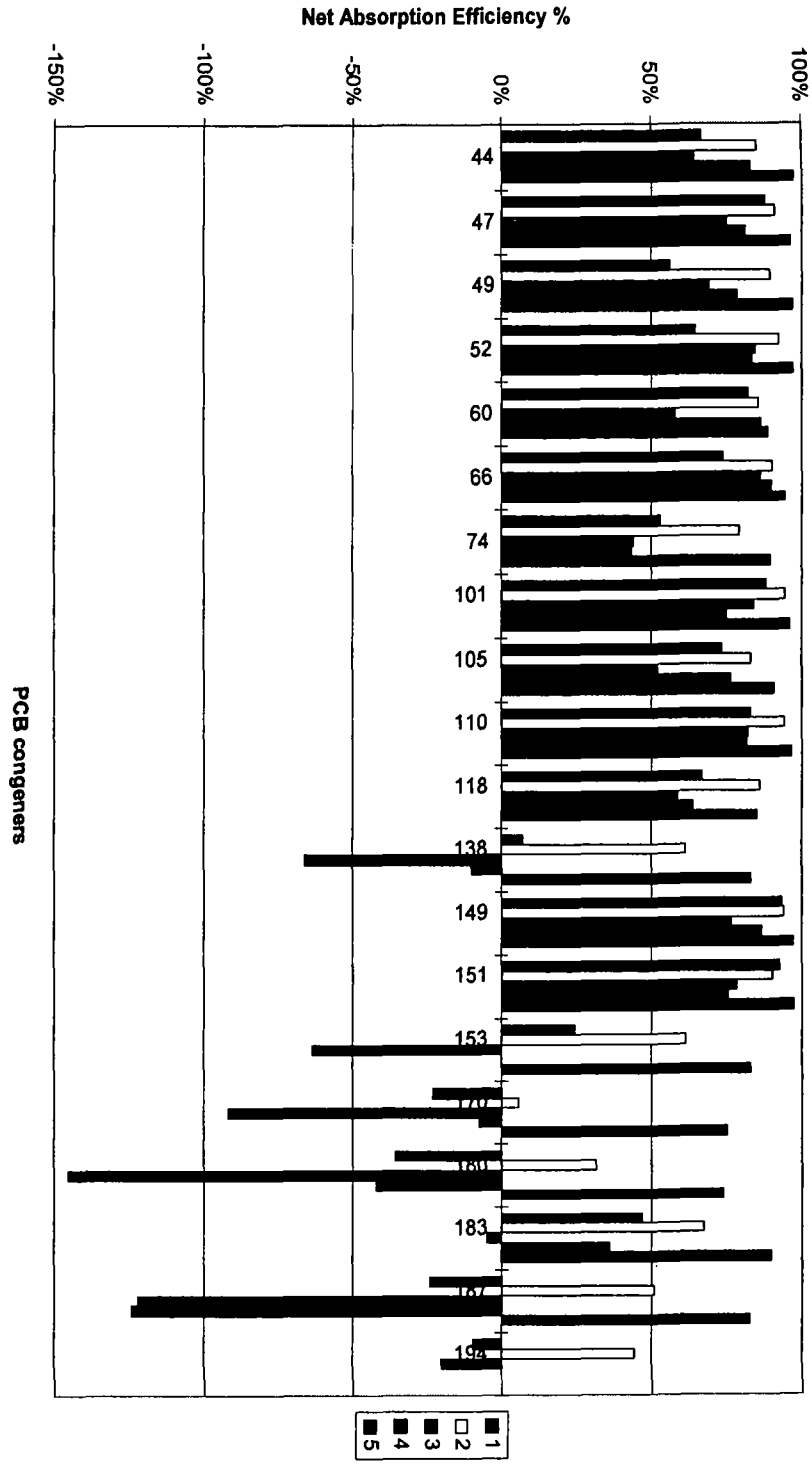
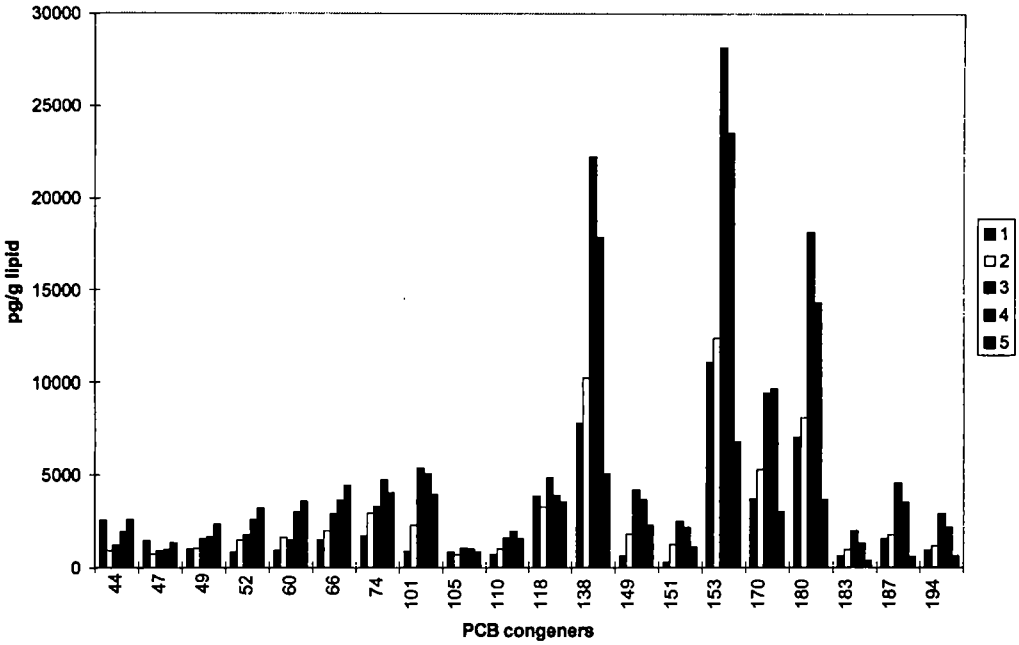


Figure 1: The 'net absorption efficiency' for the 5 volunteers

Figure 2: The average blood PCB concentrations for the 5 volunteers



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References

1. Nicholson, W. J. and Landrigan, P.J. (1994) in Dioxins and Health (Schecter, A., Ed.), Plenum Press, ISBN 0-306-44785-1.
2. Maroni, M., Colombi, A., Arbosti, G., Cantoni, S. and Foa, V. (1981) British J of Industrial Medicine. 38, 55.
3. Hsu, C.-C., Yu, M.-L. M., Chen, Y.-C. J., Guo, Y.-L. L. and Rogan, W. J. (1994) in Dioxins and Health (Schecter, A., Ed.), Plenum Press, ISBN 0-306-44785-1.
4. Juan. C.-Y., Thomas, G.O., Sweetman, A. and Jones, K.C., (1999). Chemosphere. 39, 1467.