

THE SIGNIFICANCE OF INHALATION EXPOSURE TO POLYCHLORINATED BIPHENYLS (PCB) FOR THE HEALTH OF SCHOOL CHILDREN

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Introduction.

In spite of different legal bans polychlorinated biphenyls (PCB) are still ubiquitous environmental contaminants. In Germany special concern is caused by the problem that PCB-containing building materials, which were formerly used e.g. in schools, can contaminate indoor air and thus cause PCB exposure not only to the staff but also to pupils.

Materials and Methods

With the aid of a literature study the present paper attempts to assess in how far the exposure through different environmental media constitutes a toxicologically relevant contribution to the internal exposure of children.

Results and Discussion

Approximately 90-95% of the PCB found in the body are taken in by food. According to the WHO [37] the daily PCB uptake with food around 1985 was between 5-200 ng/kg BW. In Germany an estimation of 60-120 ng/kg BW was made in 1985 [6]. However, in recent years the uptake by food has been decreasing markedly [8, 20, 36]. Also blood levels and PCB concentrations in breast milk have shown a steady decline [1, 18, 23, 25, 32]. Recently reference values for PCB in blood have been published in Germany, which take the age-related increase into account [15].

In the case of children transplacental and lactational transfer must also be considered. Thus in the plasma of 3½ year old children from Holland which had been breast-fed the PCB levels were 4 times higher than in bottle-fed children [24]. In the latter the inner exposure was mainly determined by transplacental transfer and by the uptake of milk products, processed food, meat, and fish.

A calculation of the amount inhaled in indoor air comes to the conclusion that this may in some cases represent a significant uptake pathway [5]. The actual inner exposure can, however, only be determined by biomonitoring. PCB measurements in the blood of school teachers and kindergarten staff, who had been exposed in PCB contaminated schools with air levels of up to several µg/m³ yielded the following results: (a) in most of the studies the human reference values proposed by the Commission "Human biomonitoring" of the German Federal Environmental Agency account [15] were not exceeded; only in a few studies were a few cases reported who had blood PCB levels above the reference values; (b) in some investigations with very low detection limits increases of the weakly chlorinated congeners were found - in this low concentration range. In the two only studies where PCB blood levels of children in contaminated schools were determined, no elevated values were detected (Table 1). Altogether it can be stated that the internal exposure by inhalation, even in contaminated buildings, is small compared to the background exposure by ingestion. Interesting is, however, the observation made in one study that the weakly chlorinated congeners

predominating in the indoor air could be detected, although at very low levels, in the blood of the exposed persons [9,] so that a correlation could be established between congener pattern in indoor air and in blood. However, the fact that these weakly chlorinated congeners are detected only at very low concentrations in exposed persons confirms that they are quickly metabolised and eliminated [37].

Table 1: Results of blood analyses of persons in exposed buildings [3]

Autors	Maximal air concentration	Subjects/controls	Detection limit	Elevated blood levels?
4	2,069 ng/m ³	77/ ^a adults	0.02 µg/l	no
2	2,700 ng/m ³	37/673 adults	0.1 µg/l	no
11, 12	1,489 ng/m ³	32/ ^b adults	0.1 µg/l	no
12	3,200 ng/m ³	13/13 ^{and b} adults 14/ ^{and b} children	0.1 µg/l	no
9	A) 10,655 ng/m ³ B) 10,130 ng/m ³ C) 1,588 ng/m ³	A) 35/55 B) 37/55 C) 24/55	0.02 µg/l	A) PCB #28 elevated B) no C) no
33	2,700	34/49 adults	0.05 µg/l	no
7	13,500	18 18 adults	0.1 µg/l	no
34	16,500	10/2414 adults	not stated	3/10 blood levels over reference values
10	2,879	270/ ³ adults	not stated	no ^c
22	10,220 ng/m ³	92 children/ ^{c, d} 38 adults/ ^{c, d}	0.1 µg/l	no ^f

^a Reference values own laboratory

^b Reference values [Lehnert et al. 1994]

^c Reference values [Kappos et al. 1998]

^d Reference values of own laboratory

^e 5.9-7.4% above reference values (95%ile)

^f borderline significant correlation between PCB in indoor air and blood following multivariate analysis

For the evaluation of the health significance of environmental exposure the existing epidemiological investigations of children are evaluated. Several studies were conducted in the United States, in the Netherlands and in Germany dealing with relationships between perinatal environmental PCB exposure and the neurological development of children. The available evidence shows some inconsistencies [30]. The first study, which was done on the Lake Michigan cohort [17] has been criticised because of poor exposure estimates and other methodological shortcomings [26, 31, 35]. Here cognitive deficits at 7 months and at 4 years of age were seen, which were believed to result from transplacental exposure, while no association breast milk levels could be demonstrated. In a further cohort studied in North Carolina 3-5% of the 6 months old babies with the highest intrauterine exposure showed deficits in the Psychomotor Development Index (PDI) of the Bayley Scales of Infant Development, with no effects regarding the Mental Development Index (MDI). At 4-5 years of age exposure effects could no longer be noted [27, 28]. In 3 months old children examined in the Netherlands a small negative effect in psychomotor

scores (PDI) was reported following elevated prenatal exposure. There was no significant influence of perinatal PCB exposure on the mental outcome at 3 or 7 months. Breast-fed children had altogether higher scores, although the quantitative contribution by mother's milk to PCB blood levels was considerably higher. The better performance of breast-fed children was also noted at later ages (18 months, 3½ years), however at 18 months a negative correlation could still be found between the mothers' PCB levels in plasma and performance - with very small absolute differences in scores (between the 5th and 95th percentiles there was a loss of only 2 points out of 50). No effects on the MDI was found at any age [13, 16]. In contrast to the two last studies described, the latest investigation conducted in Germany determined a negative association between the sum of PCB in breast milk with the MDI, but not with the PDI of the Bayley Scales at the age of 7 months, while the Fagan Test of Infant Intelligence (Visual Recognition Memory) used by Jacobson and coworkers [17] gave no correlations with exposure and proved unreliable due to considerable interrater-variability [38].

In spite of the observed discrepancies in the results, the authors agree that the earliest, i.e. transplacental exposure period is probably the most sensitive phase. In animals the perinatal period has also proved to be particularly sensitive to PCB and prenatal exposure is especially critical for the development of behavioural effects [14, 21, 31].

Considering the question whether inhalative exposure in PCB-containing indoor air of schools can cause adverse health effects to children the following tentative conclusions can be reached:

- the contribution of PCB in air to the inner exposure is small in relation to the quantities ingested.
- The epidemiological studies have demonstrated that the prenatal period is most sensitive to PCB exposure, while later exposure, e.g. through breast milk, although quantitatively more significant, did not produce measurable effects.
- The effects of environmental exposure observed to date, even at the most sensitive ages, are small.
- Thus the supposed health hazard of additional PCB uptake of school children by inhalation of contaminated indoor air seems to be clearly less than previously assumed.

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