

Miljömedicinsk riskbedömning av PCB på Furustugans förskola i Alunda

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Introduction

Polychlorinated biphenyls, also known as PCBs, are a family of aromatic, synthetic chemicals which do not occur naturally in the environment. They consist of the biphenyl structure with two linked benzene rings in which some or all the hydrogen atoms have been substituted by chlorine atoms. Risk for acute intoxication for PCBs is low as it requires an extremely high dose and therefore seldom needs to be considered in case of soil contamination. PCBs are usually divided into two different groups, dioxin-like PCBs and non-dioxin-like PCBs based on their chemical structure with the seven most common (PCB7) being the six non-dioxin-like PCBs (PCB6) - PCB 28, PCB 52, PCB 101, PCB 138, PCB 153, and PCB 180 – and one dioxin-like PCB - PCB 118. These are called PCB 7 and are the most common analyzed.

Exposure to PCBs can have several negative health outcomes and has been classified as Group I carcinogen. While PCB6 can be considered less toxic it is still considered a human carcinogen (1). Due to some individual differences in carcinogenicity each PCB has a Toxic Equivalent Factor (TEF) and therefore a tolerable daily intake (TDI) can be expressed in μg Toxic Equivalent Factor (TEQ) per kg bodyweight (bw) per day. The TEF varies considerably between different PCBs, but overall, the PCB 6 have lower values than the dioxin-like PCBs.

Additionally, a growing number of studies with laboratory animals show that non-dioxin-like PCB congeners affect the liver, endocrine and immune systems of adult laboratory animals. The development and function of the nervous system is also affected when exposure occurs during critical developmental stages like the fetal stage, making fetuses and young children particularly sensitive to PCBs (2).

Commercial PCB mixtures are clear to light yellow oils or resins which do not crystallize at low temperatures. PCBs are very resistant to fire (flash points 170–380 °C) and have low electrical conductivity, high thermal conductivity and high resistance to thermal degradation (3). Because of its practical properties, PCBs have been used commercially since 1929 as dielectric in capacitors, transformers, heat exchangers, sealants in houses, in colors and in a variety of other applications. However, several factors which among them the distribution of PCBs in the environment due to leakage and aerial deposition after combustion, eventually led to a ban in many countries including Sweden in the 1980's (4, 5). Due to its wide use in industry and construction and its persistency in the environment, even approximately 40 years after its ban, PCBs continue to be a problem not only in old building materials but also in the food chain (bioaccumulation and magnification of the food chain) and even old disposal as they survive and volatilize on low combustion spreading through air. PCBs are classified as persistent organic pollutant (POP) due to concerns about toxicity, persistency, long range transport and bioaccumulation (6).

Concentrations in the environment

There are still PCBs in use in Sweden mostly in transformers, cables, buildings, fluorescent lighting ballast and power factor correction/starter. However, there are very few examples, if any, of equipment still in use containing PCB-levels higher than 50 ppm. Based on former experience, PCB content in these transformers is generally low (less than 10 ppm) but PCB content up to 50 ppm could be present. By comparison with known data from similar transformers, total PCB inventory in the Swedish transformers all together is estimated to less than 1 kg. Identified cables contaminated with PCB that are still in use in Sweden and contain in total approximately 32 tons of oil. The content of PCB in such oil is generally low, less than 10 ppm. Hence, the total content of PCB in cables is estimated to 0.17 kg in Sweden (5, 6).

Daily intake of total PCBs in Sweden was recently estimated at 0.05 µg/kg bw, with a 50% contribution from fish. This is markedly lower than an earlier Finnish estimate of 0.24 µg/kg bw and might reflect the decreasing trends in PCB levels in Nordic food. The decline is similar in Germany, where daily intake is currently estimated to be somewhat below 1 µg/kg bw. The TDI for PCB7 is 0.004 µg /kg bw per day which was based on WHO, 2003, and recalculated to correspond to PCB-7 (7).

The current general guideline value for contaminated soil (KM) is 8 µg/kg TS för PCB7 (8). This reference value is taking in account exposure from human intake of soil, skin contact with dust and soil, inhalation of vapors and dust, drinking water and grown vegetables on the contaminated soil.

Exposure assessment

The highest PCB7 concentration measured on the outside soil by the windows was 100 µg /kg DS. A risk assessment standard procedure is to calculate a worst case as a precaution given that no one will exceed that intake. In this case, the worst-case scenario is an intake of 100 µg/kg PCB7. We have used Naturvårdsverkets parameters for exposure assessment to estimate the daily intake in a child weighing 15 kg characteristic with a daily intake of 120 mg soil (7):

$$x = \frac{100 \mu g \text{ PCB7} * 120 \text{ mg} \frac{\text{soil}}{\text{day}}}{1000000 \text{ mg soil}} = \frac{0.012 \mu g \frac{\text{PCB7}}{\text{day}}}{15 \text{ Kg bodyweight}}$$
$$= 0.0008 \mu g \text{ PCB7} / \text{kg bodyweight} * \text{day}$$

Due to their lipophilic characteristics, we know that PCBs have a high bioavailability, one study showed up to 95% uptake from infants through mothers' milk, but in this case, we do not know the exact bioavailability of the PCB mixture in the soil but it would be substantial lower. Therefore, as a worst-case an uptake of 100% is assumed even if it is more likely close to 42 % (11).

In any case the interval of bioavailability is likely between 50% uptake and 100% resulting in an uncertainty interval given as:

$$0.0003 \mu g PCB7/bodyweight * day \text{ ----- } 0,0008 \mu g PCB7/bodyweight * day$$

As a rough estimation for the intake via inhalation using the only air sampling taken from the indoor environment in the school (total PCB 0.0182 $\mu g/m^3$), the volume air inhaled by a child between ages 3 and 4 years of 10 m^3/day from USEPA (9) and the time frame of 4 hours per day (16.7 m^3) in that room we estimated an inhalation intake of:

$$x = 0.0182 \mu g \frac{PCB_{total}}{m^3} * 16.7 m^3 \frac{air}{day} = \frac{0.0304 \mu g \frac{PCB_{total}}{day}}{15 kg bodyweight}$$

$$= 0.002 \mu g \frac{PCB_{total}}{kg bodyweight * day}$$

This goes well with the background inhalation exposure assumed by the WHO of 0.001 $\mu g PCB_{total}/kg bodyweight*day$ (3).

These intake calculations must be regarded as estimations with inborn uncertainties. The worst-case approach will likely overestimate the true exposure given there are no other hot spots with higher contamination of the soil. Additionally, a single measurement by itself is a source of uncertainty and therefore, the contribution from inhalation can only be interpreted as a rough estimate.

Conclusion

In conclusion the PCB7 exposure in the school via daily soil intake does not exceed the toxicological tolerable daily intake for PCB7 of 0.004 µg/kg bw per day being in fact 5 times under the TDI. For the total PCB measured in the air, the estimated inhalation is about 500 times lower than the German proposed TDI of 1 µg/kg bodyweight*day (3).

When we consider the already high background exposure from PCB in food which will also be included in the total exposure and the possibility of accumulation in the body, Naturvårdsverket guides that the contribution from contaminated soils should not exceed 10% but in the worst-case scenario there is a possibility of exceeding 10%.

Furthermore, it is of particular concern that the exposure is available on a place where the most susceptible population - infants, small children, and potentially pregnant working woman – are residing during a large period of their day.

Considering the level of contamination in the soil there is no risk of acute intoxication even after a single relatively large intake of the most contaminated soil.

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