RISK EVALUATION OF COMPOUNDS CONTAINING DIOXIN IMPURITIES: LESSONS OF A GROUNDWATER CONTAMINATION CASE

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Several accounts have been published on the carcinogenicity of chlorophenoxy acids or chlorophenols, but the issue remains controversial.[1,2,3] It has been assumed that the potential carcinogenic common denominator is TCDD or other impurities of PCDD/PCDF group.[4] Although the most toxic dioxin derivative TCDD is a potent animal carcinogen, there is no agreement on the extrapolation of carcinogenicity to human levels, and acceptable daily intake varies by a factor of 1500 in various countries (Canada 10 pg/kg/d, USEPA 0.0064 pg/kg/d). Since PCDD/PCDFs are present only in combination with other chemicals, there is no explicit epidemiological evidence on their carcinogenicity at environmental or even occupational levels. In fact even the early epidemiological studies on chlorophenols and phenoxy acids implied little difference between compounds containing TCDD over such that did not.[5,6,7] Since exposure to chlorophenols or phenoxy acids may be many orders of magnitude greater than to PCDD/PCDF impurities, it is important to be able to compare the risks. Since there is no good animal model for chlorophenol/chlorophenoxy acid carcinogenicity, this is best done in epidemiological studies whenever pure exposures are encountered. In December 1987 a water intake plant supplying groundwater to 3500 people was closed because of chlorophenol concentrations of 70 to 140 μg/l, in Kärkölä municipality in Southern Finland. High concentrations of chlorophenols (100 to 1000 μg/kg) were also found in fish from a lake which is a popular local fishing resort. There is only one inlet brook to the lake, this is a connection to another lake about 2 km upstream, and it passes by the polluted water intake plant (Fig. 1).

Since the contamination was revealed, both epidemiological studies and exposure assessment studies have been performed. After closing the water intake plant, elevated chlorophenol excretion to urine was found in the population. The concentrations were clearly elevated in those people consuming fish from the downstream lake Valkjärvi. Somewhat elevated chlorophenol excretion was also seen in consumers of local water, even though immediate water use had been discontinued two months earlier. No elevated PCDD/PCDF levels were found in breast milk.[8]

Lake bottom sediments indicate that the pollution started not later than during early 1970s, and the chlorophenols came via the inlet brook from a large groundwater reservoir

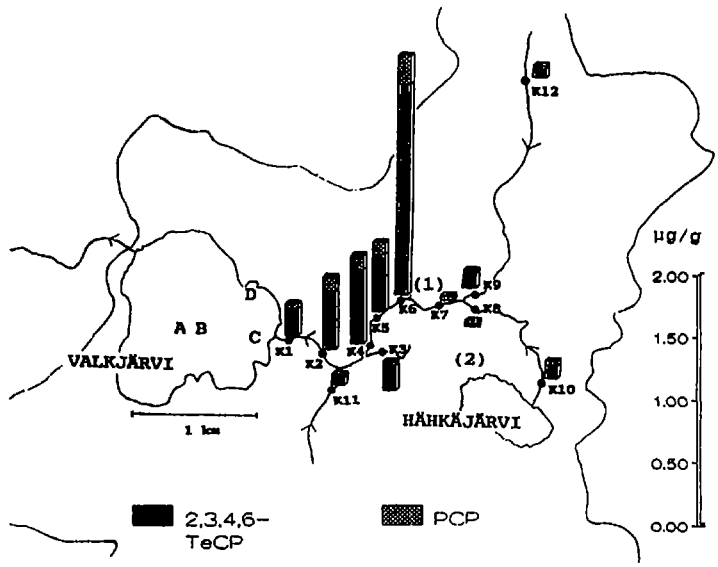

Figure 1. Map of the drainage area of lake Valkjärvi, brook Pyhäoja, village, closed water intake plant (1), sawmill (2), core sites A–D for lake bottom sediment samples, and sampling sites of the inlet brook Pyhäoja and its watercourse (K1–K12). The bars along brook Pyhäoja show 2,3,4,6-tetrachlorophenol and pentachlorophenol concentrations in brook sediment samples in μg/g dry weight.

under the village.[8,9] The brook bottom sediments show clearly that a major part by far of the chlorophenols came from the ground water source, since the contamination of brook bottom starts at the spring (point K6 in Fig. 1). In the bottom samples from the branch coming from the upper lake, only background levels are observed. The nearest likely source of chlorophenols is a sawmill (2 in Fig. 1) by the upper lake at a distance of almost a kilometer from the spring, but the most likely route is thus not via surface waters but penetration to the soil and transportation via ground water flows which are in fact directed straight to the spring.[8]

In a cohort study significant increases in non–Hodgkin lymphoma and soft tissue sarcoma were found during the last three five–year periods (1972–1986) in Kärkölä municipality. The observed numbers were small for soft tissue sarcoma (6 vs. about 2 expected), but higher for non–Hodgkin lymphoma (12 vs. about 5 expected). An association to chlorophenol–related factors such as consuming fish from the Lake Valkjärvi or community water was verified in a case–control study for non–Hodgkin lymphoma.[10] Point estimate of the risk for those eating fish and/or consuming water was 6.9 (95% confidence interval 1.1 – 74).

The major chlorophenol preparation used in Finland from 1940s to 1984 contained only hepta– and octa PCDD/PCDF impurities with low toxicity. The lake bottom sediments are in agreement with the chlorophenol composition of this preparation, and it was also used in the upstream sawmill until 1984. Dioxin analyses are underway, and will be needed to exclude the possibility that surface water contaminated the lake at some time. However, preliminary results on fish suggest that there is no PCDD/PCDF contamination, and levels are

about the same as in other lakes in Finland (Table 1). On the other hand, it is not conceivable that poorly soluble dioxins could travel long distances with ground water, nor could they exist in drinking water in such concentrations as to cause a major source of exposure.

This study is of importance for the evaluation of carcinogenicity risk of chlorophenols as related to their dioxin impurities. There has been a heavy chlorophenol exposure of 3500 people probably for at least 20 years, and qualitatively and quantitatively similar risk profile is seen as described by the Swedish investigators more than ten years ago: a three to sixfold risk of non-Hodgkin lymphoma and/or soft tissue sarcoma.[5,6,11] The present study suggests that at least these two types of tumors are due to chlorophenols rather than PCDD/PCDFs,

Table.

PCDD/PCDF concentrations of fish samples from Lake Valkjärvi as pg/g wet weight and the sum of them as Nordic toxic equivalents (TEQ).

congener	pike N=3	pike perch N=2	bream N=3	perch N=3
2,3,7,8-Cl_4DF	<0.01-0.69	<0.01, 0.02	<0.01-0.45	<0.01-1.92
2,3,7,8-Cl_4DD	<0.05	<0.01	<0.01	<0.01
1,2,3,7,8-Cl_5DF	0.08-0.38	<0.01, 0.08	0.06-0.14	0.12-0.32
2,3,4,7,8-Cl_5DF	0.15-0.71	<0.01, 0.16	0.41-0.75	0.16-0.91
1,2,3,7,8-Cl_5DD	0.09-2.40	<0.01, 0.21	0.20-0.32	0.32-0.68
1,2,3,4,7,8-Cl_6DF	<0.01-0.02	<0.01	<0.01	<0.01-0.10
1,2,3,6,7,8-Cl_6DF	<0.01- 0.03	<0.01	<0.01	<0.01-0.09
1,2,3,7,8,9-Cl_6DF	<0.01	<0.01	<0.01	<0.01
2,3,4,7,8,9-Cl_6DF	<0.01	<0.01	<0.01	<0.01
1,2,3,4,7,8-Cl_6DD	<0.01	<0.01, 0.06	0.07-0.21	0.01-0.15
1,2,3,6,7,8-Cl_6DD	0.06-0.21	<0.01, 0.08	0.09-0.21	0.01-0.15
1,2,3,7,8,9-Cl_6DD	<0.01-0.13	<0.01	<0.01-0.11	<0.01
1,2,3,4,6,7,8-Cl_7DF	<0.01-0.24	<0.01, 0.13	<0.01-0.18	<0.01-0.21
1,2,3,4,7,8,9-Cl_7DF	<0.01	<0.01	<0.01	<0.01
1,2,3,4,6,7,8-Cl_7DD	0.09-2.0	0.01, 0.64	0.11-1.02	0.18-1.02
OCDF	<0.01-0.26	<0.01	<0.01	<0.01-0.22
OCDD	0.78-1.4	0.10, 0.78	0.30-1.14	0.62-1.14
TEQs	0.21-0.54	<0.01, 0.21	0.33-0.59	0.45- 0.67

since there is no evidence nor any likelihood that the population were also exposed to any particularly high concentrations of PCDD/PCDFs. A three to sixfold risk of non-Hodgkin lymphoma means a lifetime extra risk of the order of 1 to 2% (the incidence in the Nordic countries is about 5 per 100,000 per year). Such risk ratios have not been seen in occupational studies with very high dioxin exposure as documented by high serum TCDD levels.[4] Therefore it is not likely that the cancer risk due to probably low PCDD/PCDFs is even close to the risk due to chlorophenols in the water contamination case reported here, and there is a possibility that even in studies where PCDD/PCDFs have been high, simultaneous chlorophenols or phenoxy acids are more important than generally thought. Ongoing dioxin analyses from lake bottom sediments and the adipose tissue of the population are expected to clarify this point.

Hence due care seems to be necessary before automatically implying the cancer risk to PCDD/PCDF impurities in case of such products as chlorophenols and chlorophenoxy acids.

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