Relationship of Concentrations of Pentachlorophenol and Chlorinated Dioxins and Furans in Wood from Livestock Facilities

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Introduction

A survey of concentrations of polychlorinated dibenzo-*p*-dioxins (PCDD) and dibenzofurans (PCDF) in beef produced in research facilities at several locations revealed residue concentrations much higher than average background levels (1). Environmental samples were collected in follow-up work and the subsequent PCDD/F analyses suggested that the high PCDD/F concentrations in beef were associated with the presence of pentachlorophenol(PCP)-treated wood in the animal housing and confinement facilities (2,3). Wood and other environmental samples were analyzed for PCDD/Fs to show this relationship, but PCDD/F analyses are costly and time consuming. This work was carried out to determine if PCP analysis could substitute as screening tool for predictions of the approximate concentrations of PCDD/Fs in treated wood.

Materials and Methods

The samples were collected from five research facilities. Two of the five facilities involved two sites separated by several kilometers with little transfer of feed or animals between the sites. The numbers and types of samples analyzed for each site are summarized in Table 1. Environmental samples included feeds, soil, and road surface material. The number with both PCP and PCDD/F analyses is limited because it was soon apparent that only wood samples had residue concentrations greater than background. Wood samples were obtained by shaving several grams of material from the surface. All generic types of wood to which animals had access, such as fence posts and boards, building supports and walls, braces, pen dividers and feed bunks, were sampled at each location. Samples were ground before analyses. Samples for PCP analysis were extracted with toluene and derivatized with acetic anhydride. Quantitation was by single ion monitoring GC-MS in negative ionization mode. Analysis for PCDD/Fs followed the standard EPA 1613 method.

Results and Discussion

The concentrations of PCP in the wood samples from this study were in a range from less than the limit of quantitation to approximately 8,500 μg/g (Table 2). Concentrations of PCDD/Fs are expressed in toxic equivalents (TEQs) as a convenience in summarizing

Table 1. Number of wood and environmental samples from each location analyzed for PCDD/Fs and PCP.

	Number of Samples			Number of Analyses		
Location	Wood	Other	Total	PCP	PCDD/F	Both
PA - 1	13	1	14	13	4	4
PA - 2	14	2	16	16	3	3
MD	8	0	8	8	4	4
OR	7	6	13	13	7	7
ND	14	3	17	11	15	9
IN - 1	11	0	11	11	10	10
IN - 2	3	0	3	3	3	3
TOTAL	70	12	82	75	46	40

the data. Use of TEQs to characterize environmental samples may at times be misleading because of differences in transport and biological uptake of various congeners. Generally, 85 to 95% of the total residue was composed of PCDDs. A few samples, however, had reduced percentages of PCDD because of high concentrations of OCDF. The dominate congener in all samples was OCDD followed by 1,2,3,4,6,7,8-HpCDD and OCDF. The prominence of these congeners would be expected if PCP was the primary residue source.

Although a number of non-wood samples were analyzed for either PCP or PCDD/Fs, results for both are only available for two samples (Table 2). These two samples, however, are typical of all non-wood samples for which only PCP or PCDD/F analyzes were performed. Concentrations of PCP were below the quantitation limit and TEQs were in the range of 1 to 3 pg/g. These low concentrations made it unlikely that non-wood materials were the sources of animal residues.

Concentrations of PCP and PCDD/Fs in the wood samples covered a range of several orders of magnitude and the data were arbitrarily separated into classes based on concentrations of PCP (Table 2). The distribution of concentrations of PCP did not have a distinctive break below the concentration of 875 μg/g. No information is available on the time and method of PCP application to the wood, but the broad range in concentrations could reflect the many ways that PCP was applied before its uses were restricted. High concentrations would expected with pressure treatment, intermediate concentrations with surface applications, and low concentrations may be associated with low-level applications in sawmills to prevent fungus growth (sapstain) in undried lumber (4).

The concentrations of PCDD/Fs expressed as TEQs reflected the concentrations of PCP in general but the dynamic range in concentrations was wider (Table 2). It is interesting that the concentrations of PCDD/F in wood that had PCP concentrations below the

Table 2. Range of concentrations of PCP and toxic equivalents of PCDD/F in environmental and wood samples.

Class	Number	Range of Concentrations	
		PCP, μg/g	TEQ[1], pg/g
Non-wood	2	BLQ[2] - 0.9	1.3 - 2.4
Wood			
PCP < quantitation	6	BLQ	11 - 1,685
PCP low	12	2.5 - 82.4	16 - 2,425
PCP intermediate	13	110 - 875	1,636 - 52,586
PCP high	7	1,580 - 8,540	27,222 - 314,968

[1] Toxic equivalents were calculated based on the PCDD/Fs in these samples using half the detection limit for congeners less than the detection limit.
[2] Below limit of quantitation.

quantitation limit were 1 to 3 orders of magnitude greater than PCDD/F concentrations in comparable non-wood samples.

The relationship of 1,2,3,6,7,8-HxCDD and TEQ concentrations to concentrations of PCP are shown in Figure 1. Logarithmic plots were used because of the wide range in concentrations. The 1,2,3,6,7,8-HxCDD congener is used in this illustration because it is a congener that is typically associated as a contaminants of PCP. Concentrations of other HxCDDs, 1,2,3,4,6,7,8-HpCDD, and OCDD would have provided similar plots. The correlation coefficients of the log concentrations of 1,2,3,6,7,8-HxCDD and total TEQs with the log concentrations of PCP were 0.895 and 0.891, respectively.

Our findings indicate that PCP analysis is a useful screening technique for identifying treated wood that may contain PCDD/Fs. Concentrations of PCDD/Fs in wood of confinement and feeding facilities is only one factor in determining the animal exposure to this source. The nature and duration of animal access to the wood may be more important than the concentrations.

References

1. Feil, V.J., Davison, K.L., Larsen, G.L., and Tiernan, T.O.; Organohalogen Compd. **1995**, 26, 117.
2. Feil, V.J., Davison, K.L., Tiernan, T.O., and Anderson, V.L.; Organohalogen Compd. **1996**, 28, 152.
3. Fries G.F., Feil, V.J., and Davison, K.L.; Organohalogen Compd. **1996**, 28, 156.
4. U. S. Department of Agriculture. Chapter 3, p. 55-103, in *The Biologic and Economic Assessment of Pentachlorophenol, Inorganic Arsenicals, Creosote. Volume 1: Wood Preservatives*, **1980**, USDA Tech. Bull. No. 1658-1.

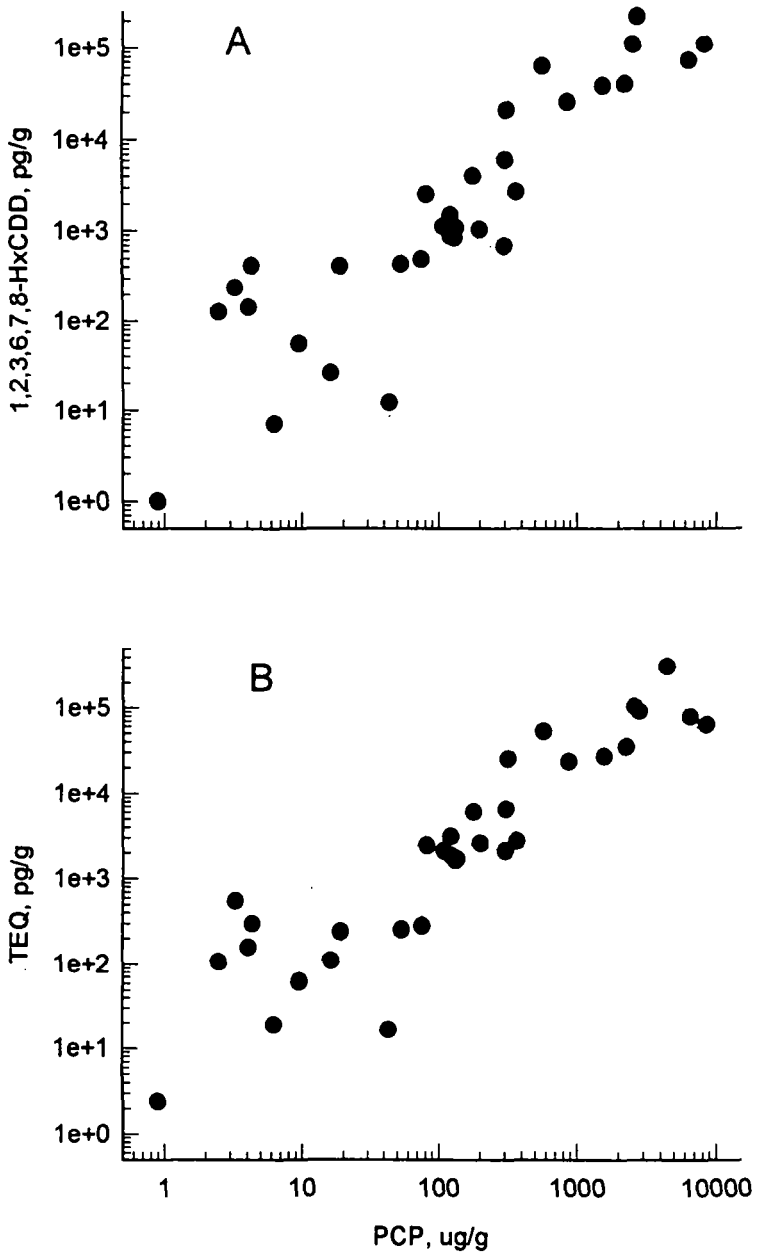

Figure 1. Relationship of concentrations of 1,2,3,6,7,8-HxCDD (A) and total TEQs (B) to concentrations of pentachlorophenol (PCP) in wood and environmental samples.