

### A Field Study to Evaluate the Potential for the Release of Dioxins from Pentachlorophenol-Treated Utility Poles

Dwain L. Winters<sup>1</sup>, Robert G. Barton<sup>2</sup>, Kathy E. Boggess<sup>2</sup>, Mark Davis<sup>2</sup>, David S. Alburty<sup>2</sup>, Matthew N. Lorber<sup>3</sup>

<sup>1</sup>OPPTS, US EPA, 401 M St, SW, Wash, DC. 20460; <sup>2</sup>Midwest Research Institute, 425 Volker Boulevard, Kansas City, MO, 641110-2299; <sup>3</sup>NCEA, USEPA, 401 M St, SW, Wash, DC. 20460

#### Introduction

In 1996, the United States (US) Environmental Protection Agency (EPA) estimated that the use of technical grade pentachlorophenol (PCP) over the previous 25 years to treat wood was approximately 336,000 metric tons in the US and an associated 672 kg of dioxin toxic equivalents (TEQs; calculated using the international TEF scheme<sup>1</sup>). Assuming a 3% replacement rate for treated wood, EPA<sup>2</sup> estimated that 468 kg of TEQ could be present in in-service PCP-treated wood in 1996, and that most of it, about 80%, was in treated utility poles. EPA has been unable, however, to estimate the rate of release of dioxin-like compounds (polychlorinated dibenzodioxins and polychlorinated dibenzofurans concentrations, subsequently referred to as dioxins and furans, or CDD/Fs) from treated utility poles into the environment. There is some evidence that CDD/Fs leaches from treated poles into the surrounding soils<sup>3,4</sup>, but these studies do not allow for the calculation of a rate of release from this mechanism. Another possible release mechanism is the volatilization of dioxins into the atmosphere, but there is no data to demonstrate, much less quantify, this release. Bremmer, et al.<sup>5</sup> estimated an annual release of 15-125 g of TEQ from PCP-treated wood in the Netherlands, based on estimates of dioxin in treated wood and a range of half-lives of dioxin in treated wood from 15 years to 150 years. If these same release assumptions were applied to the 468 kg estimate, the potential annual release in the US in 1996 would be 3 to 19 kg. If actual releases were of this magnitude, they would constitute a significant contemporary source. For these quantities of dioxin to be released to the environment from in-use poles requires that dioxin be able to migrate from the interior of a pole to a pole's surface. The purpose of this study is to gain empirical evidence regarding the mobility of CDD/Fs in PCP-treated utility poles as poles age.

#### Study Design

The study was designed to meet these objectives: 1) develop a reliable method for measuring spatial distributions of dioxin in treated poles, 2) determine if a measurable change in CDD/F concentration occurs over time, and 3) provide information from which the need for and design of a more exhaustive study can be assessed. The general approach taken was to collect cross-sections of poles of varying ages, to remove and analyze multiple samples from each pole cross section, and to compare the spatial distribution of CDD/F congeners among poles of different ages. Figure 1 displays the pole sampling method used. Ninety cm pole sections, located 2.5 meters off the ground, were obtained from six in-service poles, which were being taken out of service. Similar samples were taken from untreated and freshly treated poles. The N/S/E/W orientations of the in-service poles was established as the pole was removed from service, or surmised from the weathering pattern of the pole. The age and wood type were taken from pole brand information, on all but one pole. For this pole, age information was available but the wood type information was obscured. Section A of each pole, the 30 cm uppermost section, was used for the study,

while Section C has been retained for future possible study. Section A was sliced into 8 equal-thickness slabs, as in Figure 1 (b). Pole quarters, corresponding to the north, south, east, and west orientations were marked on each slab, as shown in Figure 1 (c). Figure 1 (d) shows how radial locations were marked on each slice, numbered from the center out. These locations correspond to fractions of the radius. For example, 0.9r refers to 90% of the radial distance from the center. The samples were obtained by collecting the shavings produced by drilling a series of holes at each location.

The pole sampling progressed in two phases, starting with the collection of four poles in 1997, including an untreated pole, a freshly treated pole, a 23- and a 34-year-old pole. During 1998, four additional poles were sampled, including two 11-year-old poles (one serving as a “duplicate” of the other), a 4- and a 1-year-old pole. The 1997 poles were analyzed for PCP, moisture content, and all toxic dioxin/furan congeners, with the exception of the seven hexa CDD/F congeners. The 1998 poles were checked for PCP presence by use of an immunoassay, analyzed for moisture content, and in this case, all 17 CDD/F congeners. Two other changes for the 1998 poles include the sampling from the growth ring center of the pole rather than the geometric center, and the systematic archiving of alternate 2- and 3-position samples for cost considerations.

### Methods

Ten g wood samples were analyzed using isotope dilution HRGC/HRMS based on US EPA Method 1613. The percent moisture was determined for each sample gravimetrically, using standard methods, and the sample size used for extraction was adjusted to ensure a sample size of 10 g on a dry weight basis. The samples were spiked with the  $^{13}\text{C}_{12}$  dioxin and furan internal quantitation standards. Analysis for HpCDD and OCDD required dilution of the extract by factors as high as 10,000. Because it was impractical to fortify the sample with sufficient quantities of  $^{13}\text{C}_{12}$  HpCDD and OCDD, an internal standards method of quantitation was used for these analyses rather than isotope dilution.

For any aged pole, it is not possible to know the original CDD/F concentration-depth profiles. Therefore, one cannot directly calculate the effect aging has on dioxin distribution or loss. It is possible, however, to indirectly determine migration trends if one assumes that the original distribution patterns of CDD/Fs in aged poles are the same as the freshly treated pole of this study, even if the absolute CDD/F concentrations varied from pole to pole. This was assumed for this study. Each pole's concentration data were normalized such that results from analogous positions on poles of different ages could be directly compared.

This was achieved by first determining each pole's average concentration for a given congener as,  $\text{Pole}_{\text{avg}} = (S_{\text{avg}} + 4_{\text{avg}} + 3_{\text{avg}} + 2_{\text{avg}} + C_{\text{avg}})/5$ , where  $S_{\text{avg}}$  is the average congener concentration for the outermost position - the average of N5, S5, W5, and E5, and so on, with C defined as the pole center. Then, the relative depth-profile trend for each congener and pole position can be described as a concentration ratio (CR), for example,  $S_{\text{avg}}/\text{Pole}_{\text{avg}}$ .

### Results

Figures 2 and 3 show a subset of results of this study. Figure 2 shows the CR for the freshly treated pole for three dioxin congeners and for positions 5, 4, 3, 2, and C. Figure 3 shows the CRs for four dioxin congeners, three positions - 5, 4, and 3, and for all the ages of poles starting from freshly treated up until the 34-year-old pole.

The freshly treated pole revealed a reasonably uniform concentration through the outer

third of the pole (positions 5, 4, and 3), with CR ranging from 1.0 to 2.2. This was followed by a drop-off to position 2 and only minor penetration to the center of the pole. Untreated poles had more uniform CRs ranging 0.5 to 1.5 through the pole center. The freshly treated pole had significantly lower concentrations of CDD/Fs than any of the aged poles, and 2378-TCDD and 2378-TCDF were not detected at all in this pole (detection limit = 2-3 pg/g, or ppt). In contrast, the 4-year-old pole had 2378-TCDD concentrations up to 80 pg/g (ppt) and 2378-TCDF concentrations up to 20 pg/g in position 5. Even though low in CDD/F concentrations relative to aged poles, the freshly treated pole had concentrations of CDD/Fs up to an order of magnitude higher than the untreated pole for congeners detected in both.

Using the concentration ratio, CR, approach to analyze the data revealed two different and distinct congener distribution patterns associated with pole aging. For higher chlorinated congeners, pole age appears to have a limited effect on congener distribution. This can be seen in Figure 3 by the relatively stable CR ranging from 1.0 to 2.0 for positions 5, 4, and 3 for 1234678-HpCDD and OCDD over time. For lower chlorinated congeners, the CR of the outermost position 5 appears to increase with the age of poles while the CR of positions 4 and 3 appear to decrease with age. This can be seen in Figure 3 for 2378-TCDD and 12378-PCDD. Similar trends were found for the furan congeners.

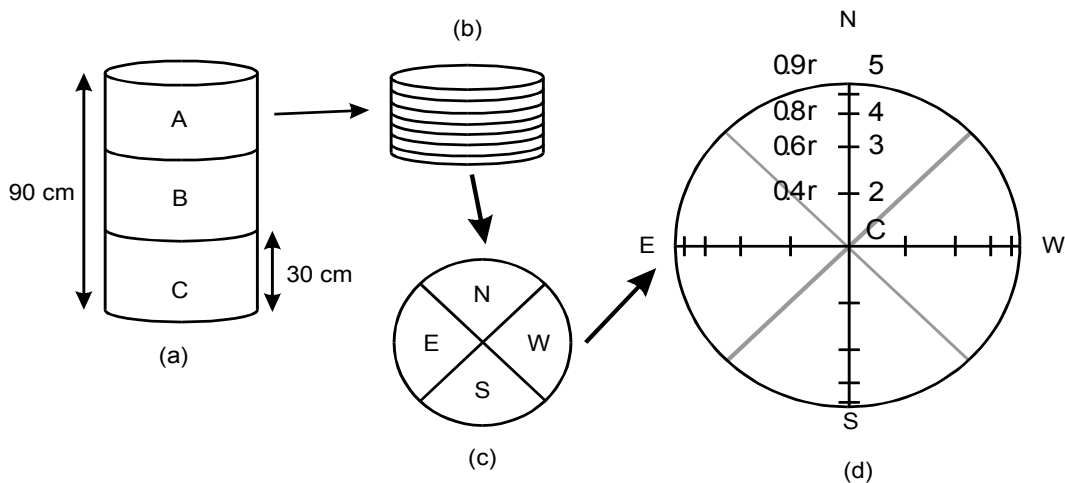
### Comments

The principal uncertainties and data limitations include: the limited number of poles sampled and the representativeness of the one freshly treated pole as a baseline for all poles. Still, tentative conclusions can be drawn. The simplest explanation for the changes in distribution of tetra and penta dioxins is that they have migrated towards the outside of the pole with the passage of time. (Another possible explanation, discounted by the authors, is that dioxins within the pole degraded while outer portion dioxins remained constant). It is beyond the scope of the study to determine if this migration included enhanced release from the pole to the environment. However, given that the mobility of the tetra and penta congeners has been established and their proximity to the environment enhanced, the hypothesis that utility poles can serve as a reservoir source for these congeners is strengthened as a result of this study. Likewise, for hepta and octa congeners, this study supports the hypothesis that most of the mass of these congeners remain in the pole through its useful life. More work will be needed before definitive explanations can be developed or emission factors established. Additionally this study only addressed dioxin mobility during a poles useful life. It does not address the question of dioxin mobility or environmental release as a result of pole disposal practices.

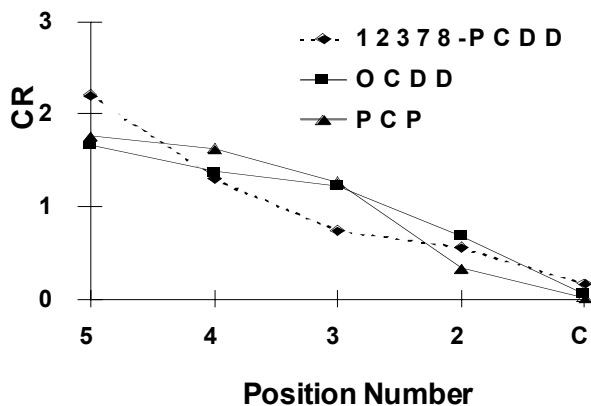
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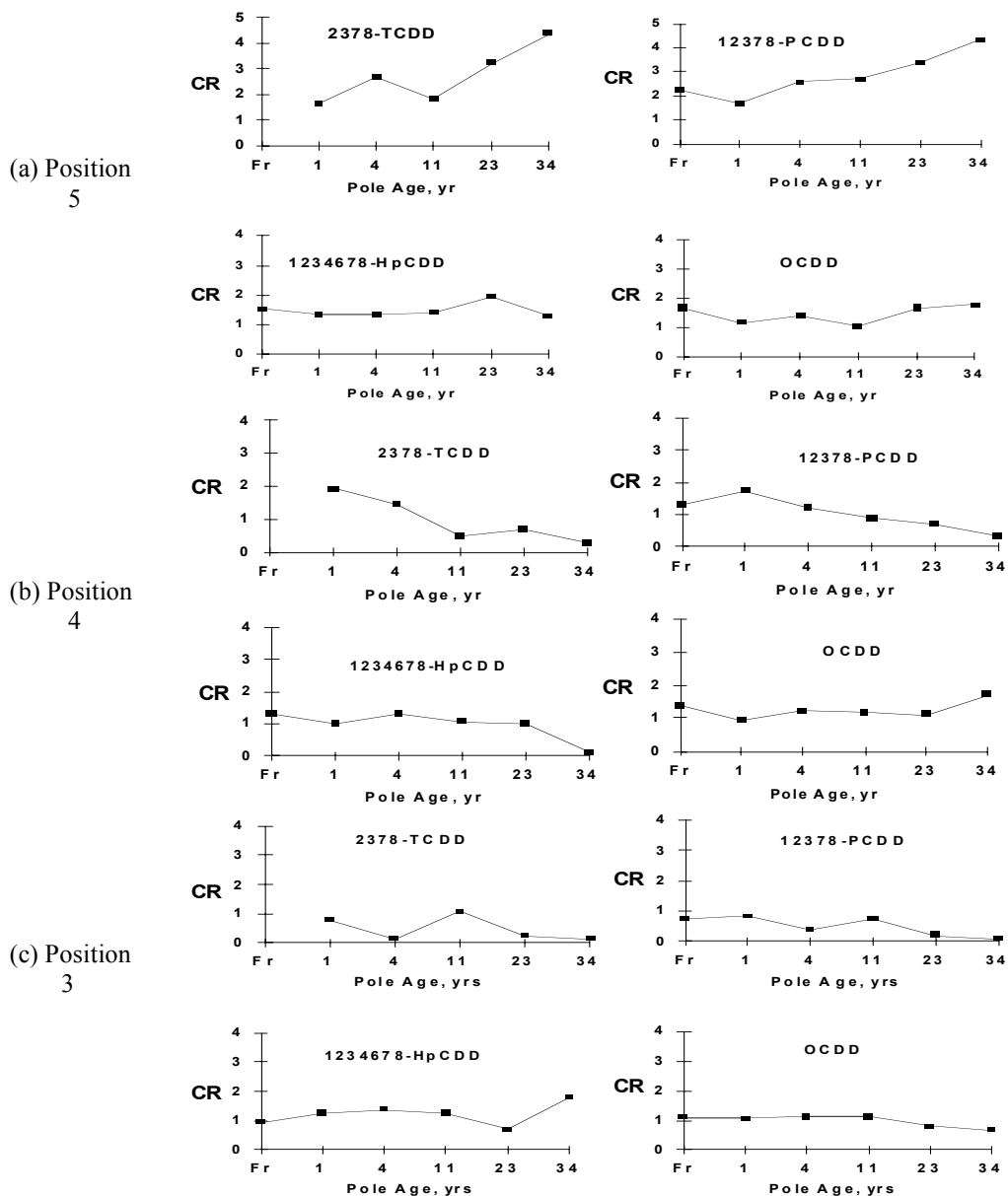
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**Figure 1.** Schematic of the sampling method showing (a) the 90-cm pole section sectioned into A, B, and C, (b) the selection of section A and the division into 8 slices, (c) identification, orientation and division of each slab into quarters corresponding to North, South, etc., (d) shows the locations of the five positions and their distance from the center as a function of the radius,  $r$ .



**Figure 2.** CR for a freshly treated pole for 12378-PCDD, OCDD, and PCP.



**Figure 3.** The relative Concentration Ratios, CR, for positions 5, 4, and 3 (see text for detail).



