EVIDENCE FOR THE TRANSPORT OF CHLORINATED DIOXINS AND FURANS FROM AERATED EFFLUENT TREATMENT BASINS BY AEROSOLS

Haley, R.E, Festarini, L.F. and Hallett, D.J.
Eco Logic International Inc., 143 Dennis Street, Rockwood, Ontario, Canada, N0B 2K0

INTRODUCTION:

The five-mill study sponsored by the United States Environmental Protection Agency (US EPA) was the first comprehensive report to indicate that 2,3,7,8-tetrachlorodibenzo-*p*-dioxin (TCDD) and 2,3,7,8-tetrachlorofuran (TCDF) were released into the environment from bleached pulp and paper mills.[1] Further study by the US EPA revealed that the 2,3,7,8-tetrachlorinated isomers predominated in the effluent, sludge and pulp.[2,3]

Concern for the release of polychlorinated dibenzo-p-dioxins (PCDDs) and polychlorinated furans (PCDFs) from pulp and paper mills has primarily focused on effluent releases, sludge disposal or pulp contamination.[4] There has been little study on the release and transport of these compounds from aerated treatment basins via aerosols. As part of a study to examine the release of chlorinated organics from a pulp mill's aerated effluent treatment basins, we identified elevated soil concentrations of PCDDs and PCDFs in soil samples taken near the aerated basins. We attribute the elevated soil concentrations of these compounds to be the result of transport of these compounds as aerosols or particulates released by aerators.

EXPERIMENTAL:

Four sample locations approximately 150 meters downwind of the aerated treatment basins were selected and soil samples obtained by routine sampling techniques. Two control samples were obtained from the same geographical location but in an area exclusive of the pond's influence. The methods used for analysis of PCDDs and PCDFs was based on US EPA method 8280 with modification and US EPA method 1613.

RESULTS AND DISCUSSION:

Figure 1 compares the total 2,3,7,8-TCDD toxic equivalents (TEQ's) detected in soil samples from our study to levels identified in urban soils.[5] Compared to the Birmingham data, total TEQ's are approximately 10-fold and 2.5-fold greater in samples S1 and S2, respectively. The contribution to the total toxicity from each isomer group was estimated by calculating the total TEQ's (see figures 2 through 4). In typical urban soils, total TEQ's for each isomer group

are approximately 2 ppt for PCDDs and approximately 0.5 ppt for PCDFs (figure 4). This pattern differs from samples S1 and S2 (figures 2 and 3). Sample S1 has concentrations of tetra, penta and hexa-substituted PCDD isomers approximately 2 to 8-fold greater than background. A similar pattern is observed for the PCDFs. Sample S2 also has elevated tetra, penta and hexa PCDD and PCDF concentrations compared to background. The elevated tetra, penta and hexa PCDDs and PCDFs observed in samples S1 and S2 are consistent with the sludge isomer profile for these compounds from this mill.[3] Data obtained from the 104-mill study indicates that the ratio of 2,3,7,8-TCDF relative to 2,3,7,8-TCDD released from this mill is high.

The concentrations of PCDFs detected in our samples indicate a nearby PCDF emission source. Preliminary emission modelling data indicate that the movement of PCDDs and PCDFs occurs via aerosols and suspended sludge particulates released by the aerators and that, as expected, vaporization is not a significant factor.[6] We attribute the unusually high levels of PCDFs in samples S1 and S2 to the release and transport of aerosols and particulate matter released by aeration of the treatment basins. We are in the process of further examining this transport mechanism and the results will be reported elsewhere.

We cannot exclude the possibility that the dioxins and furans detected in our test samples may have come from other sources. However, we do not feel that this is likely for several reasons: First, although land application of primary and secondary sludge from this mill has occurred, records indicate that land application at sample locations S1 and S2 did not occur. Second, application of contaminated phenoxy herbicides may have contributed to the elevated 2,3,7,8-TCDD levels. However, this does not explain the elevated PCDF concentrations and we are not aware of any data indicating 2,3,7,8-TCDF contamination of phenoxy herbicides. Third, PCDD and PCDF concentrations and isomer profiles in control samples C1 and C2 are similar to the levels detected in urban soil,[6] but dissimilar to samples S1 and S2. This indicates that a source high in PCDFs and to a lesser extent PCDDs is close to sample locations S1 and S2.

In conclusion, our data suggests that transport of PCDDs and PCDFs from a pulp mill's aerated stabilization basin has occurred. Release of aerosols and sludge particulates containing PCDDs and PCDFs by aerator turbulence is thought to be the major transport mechanism. This may represent an important exposure pathway of chlorinated dioxins and furans to individuals living adjacent to these facilities.

REFERENCES:

1. US EPA/Paper Industry Cooperative Dioxin Screening Study. Office of Water Regulations and Standards, Washington, DC, EPA-440/1-88-025.
2. Whittemore, R.C., et al. (1990). USEPA/Paper Industry Cooperative Dioxin Study: The 104 mill study. Chemosphere 20: 1625-1632.
3. US EPA/Paper Industry Cooperative Dioxin Screening Study: The 104 mill study. Office of Water Regulations and Standards, Washington, DC.
4. Integrated risk assessment for dioxins and furans from chlorine bleaching in pulp and paper mills. Office of Pesticides and Toxic Substances, Washington, DC, EPA-560/5-90-011.
5. Birmingham, B. (1990). Analysis of PCDD and PCDF patterns in soil samples: use in the estimation of the risk of exposure. Chemosphere 20: 807-814.
6. Gresham, D. et al. Unpublished results.

Figure 1
2,3,7,8-TCDD Toxic Equivalents Detected in Soil

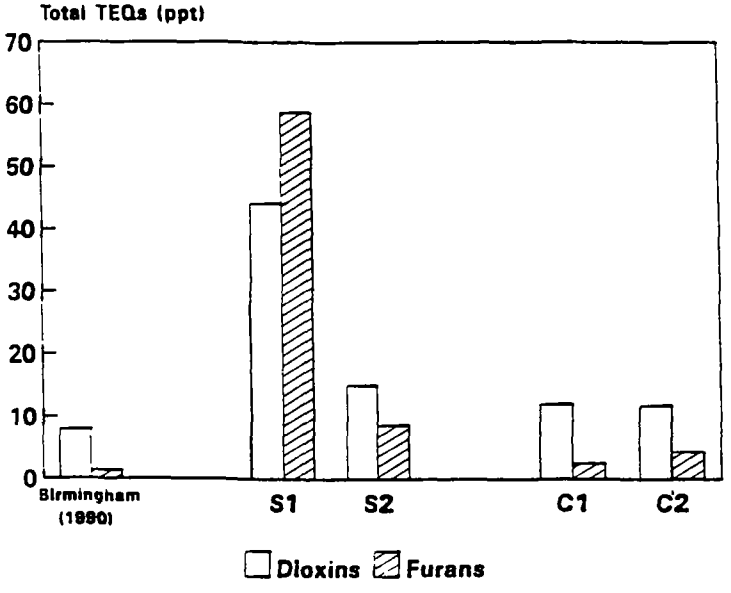


Figure 2
2,3,7,8-TCDD Toxic Equivalents Detected in Sample S1

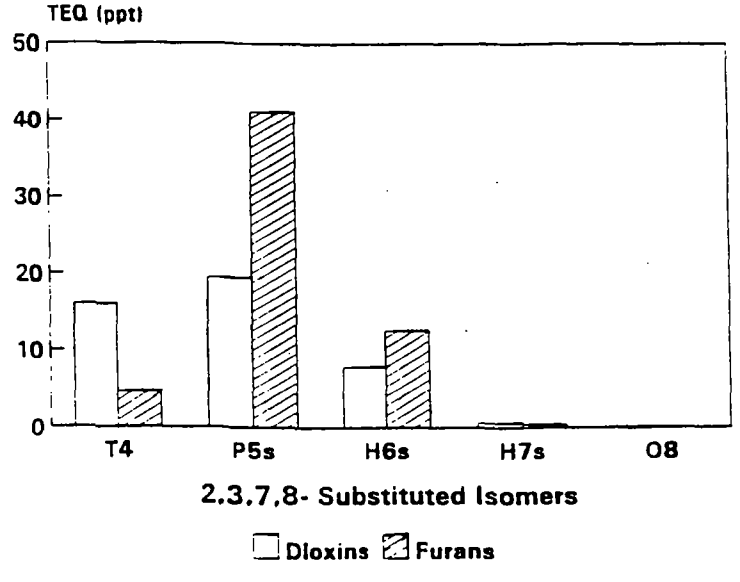
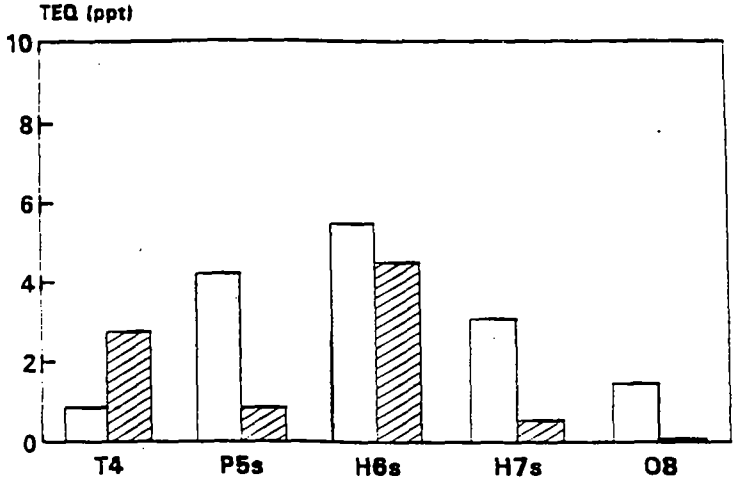


Figure 3

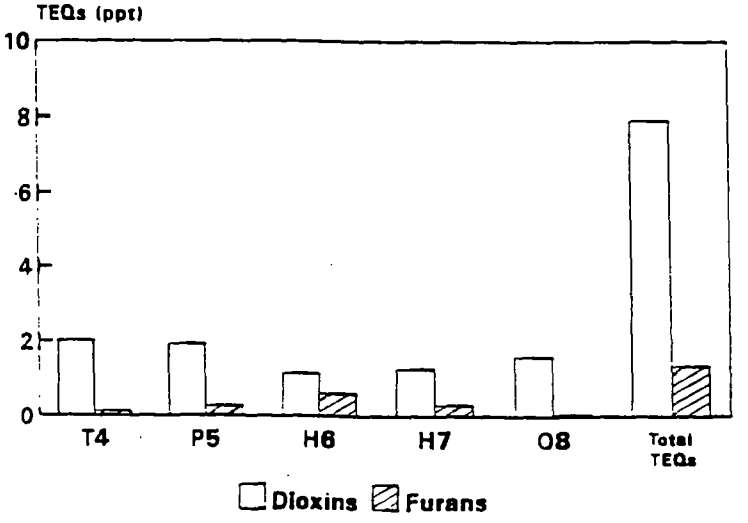
2,3,7,8-TCDD Toxic Equivalents Detected in Sample S2*



*Values are the average of two samples

Figure 4

2,3,7,8-TCDD Toxic Equivalents in Typical Urban Soils in North American Cities



Adapted from Birmingham (1990)