Comparison of 1997 and 1998 PCB concentrations in conifer forest vegetation in the region of Swan Hills, Alberta, Canada.

Kenneth L. Froese, Jules M. Blais
Departments of Public Health Sciences and Biological Sciences
University of Alberta, Edmonton, Alberta, Canada

Derek C.G. Muir
Environment Canada
National Water Research Institute, Burlington, Ontario, Canada

Introduction

In October 1996, a leak in the PCB incineration process at the Alberta Special Waste Treatment Centre (ASWTC) near Swan Hills was detected. This leak has been estimated to have released 2 - 5 kg of volatilized PCBs to the surrounding environment. Resulting health concerns associated with measured PCB residues in samples of deer, moose and fish after the incident led Alberta Health to issue health advisories on the consumption of wild game and fish within a 30 km radius of the plant site (Guidotti et al. 1998; Gabos et al. 1998a & b). We determined that vegetation samples, specifically spruce needles, were a viable medium to initiate a study of the extent of PCB contamination due to the accidental release of PCBs from the ASWTC, and preliminary results from 1997 samples were reported previously (Froese et al. 1998). Undertaking a study of the extent of source/time specific PCB contamination in the region surrounding the ASWTC through forest vegetation sampling is a first step in addressing further issues of the forest ecosystem impact, human health risks, and ultimately, the risk management implications of hazardous waste disposal.

Methods

The Swan Hills region, 250 km NW of Edmonton, Alberta, Canada, rises to an elevation of about 1200 m asl (4000 ft asl). The region is largely covered with mixed forests of spruce, pine, fir, birch and aspen, interspersed with peat-bogs. Forestry and oil/gas production are the primary economic activities in the region, aside from recreational and subsistence fishing and hunting (moose, deer, bear). White spruce, *Picea glauca,* and witches' hair (lichen), *Alectoria sarmentosa*, were chosen for sampling, with lichen sampled at Site 15b (0.7 km E) only in 1997. Snow samples were collected at the same time (Blais et al. 1998). Samples were collected in March and July 1997 and March 1998. Samples were frozen (-50°C) until extraction. Five gram samples were ultrasonically extracted in acetone/hexane (20/80), solvent exchanged to hexane and then cleaned up using acid silica gel/activated silica gel followed by elution through Florisil SPE tubes. The extract was concentrated to a final volume of 1.0 mL. A 200 µL sample aliquot was shipped to the National Laboratory for Environmental Testing, National Water Research Institute, Burlington, Ontario, for GC-ECD analysis. Analysis was done on an HP 5890 Series II GC with electron capture detection and a 30 m x 0.25 mm; 0.25 µm DB-5 capillary column (J&W Scientific). The instrument was calibrated using a 6 point calibration curve ($r^2 > 0.99$), from which 2-point curves most closely bracketing the sample concentration ranges were used for quantitation.

RESULTS AND DISCUSSION

PCB data were blank-subtracted on an individual congener basis prior to calculating ΣPCB values. A clear relationship of ΣPCB with distance and direction from the ASWTC is evident for both 97 and 98. The prevailing winds on the days immediately surrounding the process gas release were from the west, as is the annual average prevailing wind. The resolution of the data (i.e. PCB blank concentrations) does not allow concentration trends to be distinguished greater than 5 km from the incinerator. Note that the lichen samples generally have 3 to 6 times greater ΣPCB than the spruce needles at the same sites, while maintaining the same concentration/distance-direction relationship as the needles. Lichens offer many advantages over conifer needles for such biomonitoring, such as: they lack a cuticle and its associated wax-like components, which can cause substantial analytical interferences in PCB quantitation; they provide a much greater surface area per unit mass for adsorption of lipophilic substances from the air; they receive their nutrients and water from the atmosphere, thus are well suited to monitoring airborne contaminants (Muir et al. 1993).

At the upwind sites and distant downwind sites, the congener pattern in the needles is weighted in the tetra to hexa congeners, and ΣPCBs are approximately 10 to 20% of the concentrations measured immediately E of the incinerator [Figure 1]. The pattern in the needles and lichen within 2 km in a NE to SE quadrant is weighted more heavily toward the hexa to octa congeners. The lack of this pattern in the sites within 3 km to the west of the incinerator suggests that this PCB congener mixture is representative of the emissions from the incinerator, however, insufficient data is available to conclude that the October 1996 incident was responsible for this congener pattern. PCB patterns observed upwind or at greater distances downwind are likely more representative of long term, fugitive and stack-gas emissions.

While congener profiles change with direction and distance from the incinerator for the spruce needles (new growth), the patterns remained identical for the lichen samples in March 1998, even though the ΣPCBs varied by more than a factor of 10. Because of the preservation of the congener pattern through such a concentration range, it is very unlikely that laboratory contamination (i.e. blanks) were responsible for this observation. Obviously, lichen have a different mechanism of passive sampling/passive PCB collection from the atmosphere than do the spruce needles. Perhaps a significant influence on the congener pattern is the fact that the lichen plants are extremely slow growing and therefore integrate a very long term exposure to airborne contaminants. From the complementary data obtained by sampling both spruce needles and lichen, we can confirm the increased PCB loading to the ecosystem near the ASWTC.

CONCLUSIONS

Results from the 1997 and 1998 sampling indicate that conifer needles provide a good relative method for determining the extent of regional contamination due to fugitive and accidental emissions from a hazardous waste incinerator. The PCB congener-specific data assist in determining source or time-specific emissions, i.e. the presence of higher chlorinated congeners only downwind and < 3 km from the incinerator are likely indicative of the emissions from the incinerator.

Table 1. Summary of ΣPCB in 97 & 98 samples. The data is organized according to distance from the ASWTC in order to highlight the effect of incinerator nearness and direction on ΣPCB concentration.

Site i.d.	Distance (km)	Direction	ΣPCB (ng/g_{ww}) needle 97	ΣPCB (ng/g_{ww}) needle 98	ΣPCB (ng/g_{ww}) lichen 98
Site 15 B	**0.7**	**E**			*290 (97)*
Site 15 B	0.7	E	91	75	320
Site 7 A	0.9	W-NW	10		
"	0.9	W-NW	21*		
Site 22 C	0.9	SE		77	360
Site 16B/24C	1.5	E-SE		25	170
Site 13 B	1.6	E-SE	33		
Site 14 B	1.6	E-SE	37		
Site 31 C	1.7	W-NW		7	36
Site 17 B	1.8	NE	39		
Site 25 C	2.1	S-SE		6	55
Site 10 B	3.6	E-SE	5	5	25
Site 6 A	3.9	W-SW	9		
"	3.9	W-SW	15*		
Site 8 B	5.5	E-SE	7		
"	5.5	E-SE	10*		
Site 27 C	5.5	SE		5	17
Site 11 A	5.7	SE	6		

* Sampled in July 1997.

Lichen may be better suited for long-term contaminant trend monitoring than conifer needles, however, congener patterns are likely more indicative of very long term integration of local air concentrations and PCB deposition, and may be less specific for contaminant source characterization.

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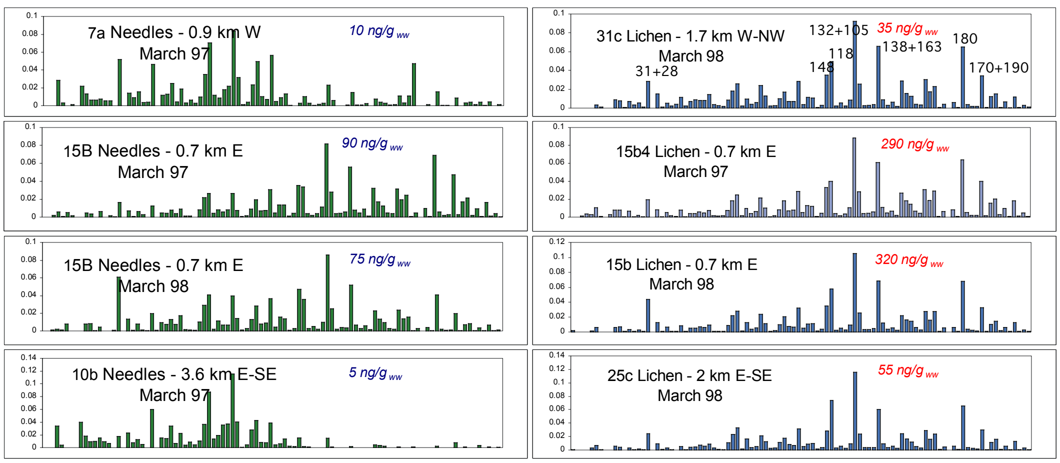

Figure 1. PCB congener pattern trends, charted as % contribution to ΣPCB, from west and east of the ASWTC. A congener pattern gradient is observable for spruce needles but not for lichen. Some of the major congeners are identified in the upper right chart (site 31c).