Assessment of PCBs in Snow and Lake Sediments Following a Major Release From the Alberta Special Waste Treatment Centre Near Swan Hills, Alberta, Canada.

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ABSTRACT:

Samples of snow, and profundal lake sediments were analyzed for PCBs following an accidental release of PCBs and PCDD/Fs from the Alberta Special Waste Treatment Centre (ASWTC) on October 16, 1996. Results indicate pronounced enrichment of PCBs within 3 km to the south-east of the plant, which coincides with the direction of the prevailing winds on the day of the release. The PCBs within 3 km east of the plant showed a predominance of the heavier penta-, hexa- and heptachlorobiphenyls which are known to have relatively short atmospheric residence times. A sediment core was extracted from Chrystina Lake, which lies 1 km to the east of the ASWTC, and dated with ^{210}Pb radiochronology to resolve a temporal pattern of PCB deposition over the past 13 years. Enrichment of PCBs was observed in the surface slice representing sediments deposited in 1997. The PCB accumulation rate for this interval was 82 $\mu g\ m^{-2}\ yr^{-1}$, which is among the highest ever reported for lake sediments in Canada.

INTRODUCTION:

In 1987, the Alberta Special Waste Treatment Centre (ASWTC), owned and operated by Bovar Inc., opened near Swan Hills in central Alberta, Canada, to dispose of PCB wastes by means of a rotary kiln incinerator. The area around the plant has been periodically monitored for PCBs, and PCDD/Fs contamination by Bovar. The concentrations of PCBs in red-backed voles caught within 2 kms of the plant increased from about 0.1 µg/g in 1989, to about 14 µg/g in 1992, and PCDD/Fs increased by over 30 fold during the same time interval. The ASWTC expanded its operations in 1993.

On October 16, 1996, there was a major leak of PCBs and PCDD/Fs to the atmosphere from a corroded duct which transported gases from a PCB volatilization chamber to the main incinerator. As a result of this incident, Alberta Health issued an advisory restricting consumption of wild game within a 30 km radius of the plant. The purpose of the present study was to assess the extent of this release and characterize the compounds that were released to the aquatic environment by sampling snow and dated lake core sediments in the vicinity of the ASWTC.

METHODS:

Snow fell within a few days after the Oct. 16 release, and there was no melting until the following spring. The snowpack was sampled in early March, 1997, when it was reaching its maximum depth of about 30 cm. Snow samples were collected by coring the snowpack in order to obtain a full, integrated sample of snow down to the ground surface. Snow cores were used to measure snow density and depth of snowpacks in water equivalents using a portable weigh-scale.

Snow was stored in clean polyethylene bags, and brought back to the laboratory. The snow samples were slowly melted in sealed aluminum cans that were solvent washed with acetone, hexane and dichloromethane (DCM). Melted snow (20 L) was extracted into 300 ml of DCM by pumping slowly through a large volume Goulden extractor (Goulden and Anthony 1985). Internal standards (1,3,5 -tribromobenzene, 1,3,4,5-tetrabromobenzene, δ-BHC and aldrin) were spiked to the water to calculate extraction efficiencies. The extracts were roto-evaporated and solvent exchanged into 1 ml hexane. Samples were eluted into 3 fractions through 8 g of 1.2% deactivated florasil using hexane and DCM in the following ratios: 1:0, 1:1 and 1:3. Eluates were analysed by GC equipped with a ^{63}Ni electron capture detector. Major peaks were confirmed with GC-MS (HP 5971 MSD) using a 30 m DB-5 column with He carrier gas.

A sediment core was removed from the bottom of Christina Lake, which is 1 km east of the ASWTC, using a Glew KB gravity corer (Glew 1989), and extruded on shore with a close-interval core extruder. Sediments were sectioned into 0.5 cm intervals for the top 5 cm, and 1 cm intervals thereafter. Samples were placed in Whirlpak bags and stored frozen until analysis. Sediments were sub-sampled for ^{210}Pb analysis using the methods in Blais et al. (In press A), and measured for water content. PCB analysis on the sediments followed the protocols of Muir et al. (1996).

RESULTS AND DISCUSSION:

Concentrations of PCBs in snow were highest in the area directly to the south-east of the ASWTC (Table 1, Fig. 1).

Table 1. Site locations showing coordinates relative to the ASWTC. Snow concentrations of PCBs are shown (ng/L) as the sum of 100 congeners.

Site	Easting (km)	Northing (km)	ΣPCB (ng/L)	Snowpack (mm water eq.)	Snow depth (mm)	Snow density (g/ml)	ΣPCB (ng/m^2)
3A	-19.65	-2.37	0.7	160	515	0.31	110
5A	-10.21	-2.15	1.4	114	324	0.35	160
7A	-0.80	0.35	1.7	175	448	0.39	290
8A	-5.46	7.76	1.3	114	311	0.37	150
16A	19.64	-0.12	1.2	106	330	0.32	120
6B	13.40	-0.66	1.1	71	288	0.25	75
8B	5.43	-0.70	2.5	71	251	0.28	180
13B	1.52	-0.39	7.1	89	316	0.28	630
14B	1.59	-0.14	45	48	153	0.32	2200
16B	13.40	-0.66	31	56	215	0.26	1700
18B	4.97	3.76	1.1	76	223	0.34	80
19B	12.66	-21.73	0.8	81	270	0.30	60
Banff			1.1	68	172	0.39	70

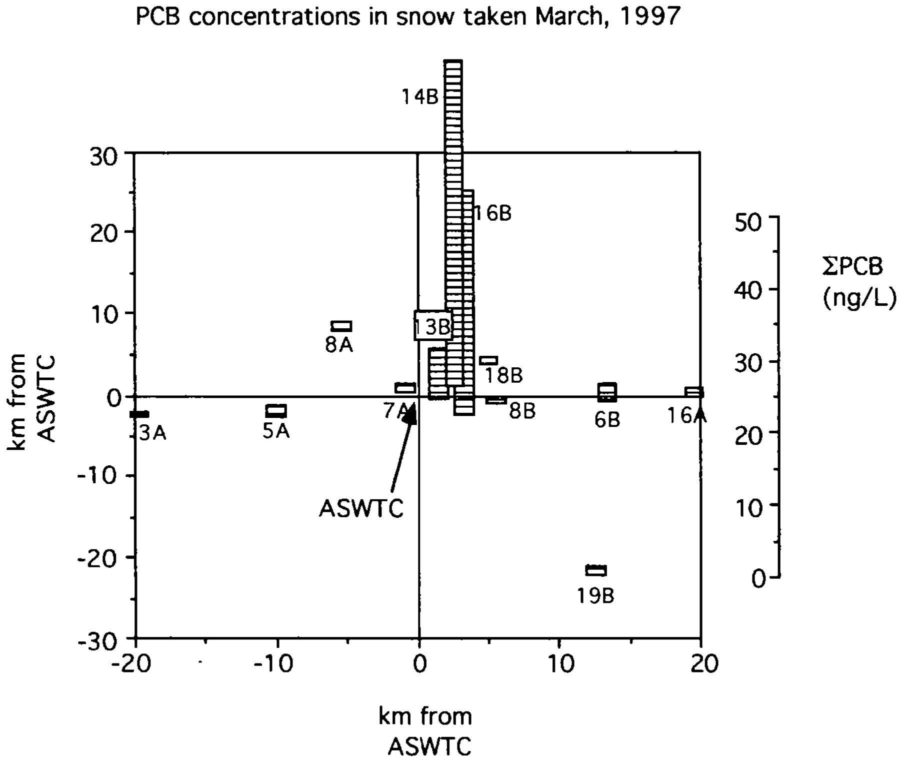

Figure 1. Distribution of PCB concentratations in snow around the ASWTC.

The prevailing winds were from the north-west on Oct. 16, 1996 (Environment Canada), thus the plume of PCBs should extend to the south-east if there was only a single release. There was no discernible enrichment of PCBs in snow in any of the other directions adjacent to the ASWTC (Fig. 1). Snowpack inventories ranged from 75 ng/m^2 from sites to the west of the plant to 2 200 ng/m^2 in a site within 2 kms to the east of the plant (Table 1).

A predominance of high molecular weight PCBs (138-163, 151, 153, 170-190, 180, 187-182) was observed in the sites closest to the ASWTC (Fig. 2). The concentrations of many of these same congeners were elevated in fish and wild game caught within 20 km of the plant as well as in blood from ASWTC employees relative to the general Alberta population (see papers by Chen and Gabos, this volume). Sites that were distant from the plant (>10 km) were characterized by the lighter, more volatile congeners such as 8-5, 18, and 31-28 that are known to be transported over long ranges to remote areas (Muir et al. 1996, Blais et al. In Press B). The total PCB inventory in snow within 3 km of the ASWTC was estimated to be aproximately 20-40 g. Stack emission test results by Bovar following the release estimate that between 2 and 5 kg of PCB were

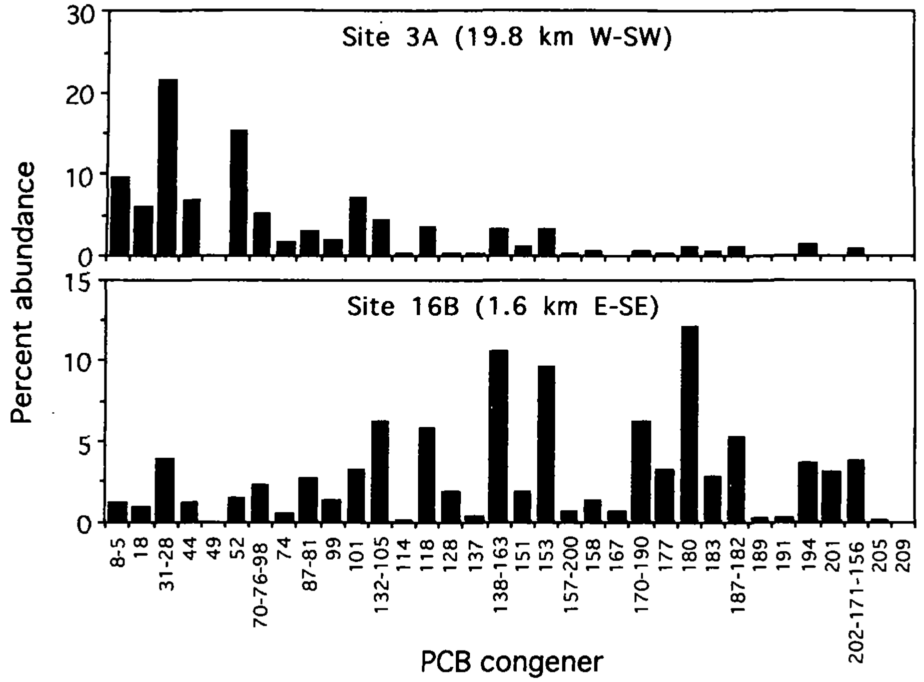

Figure 2. PCB congener abundance in snow samples from site 3A, which is 19.8 km W-SW of the ASWTC, and site 16B, which is 1.6 km E-SE on the ASWTC.

released over an 8 hour period on Oct. 16. The remainder of the stack release must either be in other ecological compartments, or it has been dispersed over long distances at low concentrations.

The profundal sediment core from Chrystina Lake (Fig. 3) records a large increase in PCB deposition in the very recent sediments. PCB accumulation rates increased from about 3 $\mu g\ m^{-2}\ yr^{-1}$ in the late 1980s to a maximum of 82 $\mu g\ m^{-2}\ yr^{-1}$ in 1997. There is also a smaller increase in PCB accumulation rates in sediments after 1993 (Fig. 3) which is the year that the processing of PCB wastes at the ASWTC was increased.

These results characterize and quantify the PCB enrichment in the vicinity of the ASWTC. Further studies must examine the fate of these compounds through the aquatic and terrestrial ecosystems, and monitor their gradual biomagnification through foodwebs. The presence of PCB congener 'fingerprints' relating the presence of certain congeners to the activities of the ASWTC could contribute to our understanding of chemical fate in the environment.