Elevated Levels of PCBs in First Nation Communities of the Western James Bay Region of Northern Ontario, Canada: The Use of Correspondence Analysis to Identify Source of Exposure

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A series of radar stations were built in Canada during the 1950s in response to the perceived threat of a nuclear strike originating from the arctic region of Russia (Myers and Munton, 2000). The Mid-Canada Radar Line (MCRL) built at approximately the 55th parallel (Environmental Sciences Group [ESG], 1999a) was an entirely Canadian endeavour (Canadian Cabinet Defence Committee, 1954; ESG, 1999a). In 1965, the MCRL was retired. Owing to improper decommissioning, these abandoned radar sites have become point sources of contamination for polychlorinated biphenyls (PCBs; ESG, 1999a, b). Eigen analysis (Principal Component Analysis) has been used successfully in several studies to identify source of PCB contamination (using congener [CB] composition) with respect to radar line bases located in the Arctic region of North America (Bright et al. 1995a, b; Dushenko et al. 1996).

In previous papers, we showed that PCB body burdens were elevated for individuals who inhabited Fort Albany First Nation (the site of an abandoned MCRL, Site 050) and Kashechewan FN (a nearby FN control population) compared to people from Hamilton, Ontario (a non-Native comparison population) and other northern Aboriginal communities with similar diets (i.e., a traditional diet of wild meats that does not contain any marine mammals). Moreover, the levels of PCBs in females living in Fort Albany and Kashechewan FNs were similar to and greater than values reported for Inuit females (whose subsistence diet occasionally contained marine mammals) living in the central Northwest Territories, Canada (Tsuji et al. in press). In the present study, we explore sources of exposure for each community with respect to PCBs (Aroclor mixtures) to assess whether the presence of MCRL Site 050 had an impact on PCB body burden with respect to the people of Fort Albany.

METHODS AND MATERIALS

Fort Albany and Kashechewan FNs are located in the western James Bay region of northern Ontario, Canada, on the Albany River. Fort Albany is located on Sinclair Island with people also inhabiting nearby Anderson Island (the site of abandoned MCRL Site 050) and the mainland (Tsuji et al. 2001). Kashechewan FN is located 20 km north of Fort Albany on the mainland. Both FNs are remote

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fly-in communities accessible only by air year-round. People from both communities still harvest and consume traditional wild meats, berries and plants (Tsuji et al. MS). The City of Hamilton is a community located in the Great Lakes region of southern Ontario.

Briefly, adults (≥ 18 years old) participated from Fort Albany FN (48 females, 51 males), Kashechewan FN (48 females, 50 males) and Hamilton (27 females, 25 males). Each participant donated blood into a 10-ml glass vacutainer (EDTA, Becton-Dickinson #7665) that was subsequently centrifuged. The resulting plasma was transferred via polyethylene pipettes to hexane-washed glass vials with teflon-coated lids. These vials were frozen, stored at -20°C, and shipped frozen for analyses at the Centre de toxicologie du Québec, Sainte-Foy, Quebec. For a detailed account refer to Tsuji et al. (in press).

Fourteen CBs (28, 52, 99, 101, 105, 118, 128, 138, 153, 156, 170, 180, 183, 187) were measured in plasma. Gas chromatography (HP-5890 series II) was used to quantify CB concentrations. Detection limits were calculated as 0.02 μg/L for CBs. Percent recoveries of reference standards were >95%. Quality assurance and control protocol at the Centre de toxicologie du Quebec, as well as a detailed description of analyses protocol can be found in Tsuji et al. (in press).

The frequencies of detectable concentrations of CBs were used to determine which of the variates could be reliably used in analyses to identify the source of contamination. Only those CBs for which frequency of detection was ≥64% (i.e., CBs 99 [frequency of detection 78%], 118 [90%], 138 [100%], 153 [100%], 156 [82%], 170 [90%], 180 [98%], 183 [64%], 187 [90%]) were examined by correspondence analysis. Undetectable concentrations of CBs were imputed as one-half the detection limit.

The proportional concentrations of these nine CBs were summarized in lower dimensionality using correspondence analysis. This statistical procedure produces a smaller number of uncorrelated variates which contain most of the variance of the raw data. This type of eigen analysis reduces the large number of inter-correlated variables to fewer, uncorrelated variables which have clear associations with the original CB variates (Gauch, 1982; Thioulouse et al. 1997).

Sources of PCB contamination (Aroclor mixtures) for the different communities were investigated by *a posteriori* projection of various Aroclor mixtures (proportions of the nine CBs [99, 118, 138, 153, 156, 170, 180, 183, 187]) onto the CA space of the same nine CBs (also as proportions) for humans. Congener-specific PCB composition data were obtained from the US Environmental Protection Agency web site for PCBs; they based their composition data on a spreadsheet condensed by G. Frame from the Frame et al. (1996) study. In our projections, our designations refer back to Frame's mixtures as follows: Aroclor 1248 refers to A1248g (Lot G3.5); Aroclor 1254a represents A1254a (Lot A4); Aroclor 1254b correlates to A1254g (Lot G4); and Aroclor 1260 refers to A1260 (Mean 3 Lots). Scatter plots of the CA scores for human subjects at each location

are delimited by the 95% bivariate (i.e., variance-covariance) confidence ellipses for each location plotted. These 95% confidence ellipses for the data enclose all the data points for the group, 95 times out of 100. The *a posteriori* projected points for the various Aroclor mixtures were not used in the generation of confidence ellipses.

RESULTS AND DISCUSSION

When the first four CA axes were extracted from the matrix of nine CBs and 249 subjects, they accounted for 87.8% of the variance in the original matrix with CA-1 explaining 53.7%, CA-2 13.5%, CA-3 11.8%, and CA-4 8.8% of the total variance (Table 1). CA-1 is characterized by a high positive score from CB 180 (0.1792); to a greater extent, it is characterized by high negative scores from CB 99 (-0.3109) and CB 118 (-0.3612; Table 1). CA-2 scores are highest for CB 183 (0.2816) and lowest for CB 118 (-0.1680). CA-3 and CA-4 are characterized by relatively high positive scores; CA-3 with CB 183 (0.1821) and CA-4 with CB 156 (0.2361).

Confidence ellipses (95%) were plotted for all possible combinations of CA axes: CA-1 vs. CA-2, CA-1 vs. CA-3, and CA-2 vs. CA-3 (Figure 1a-c). The Aroclor mixtures were also projected into CA space; Aroclor 1260 was the only mixture enclosed by the 95% confidence ellipse of any of the locations (Hamilton for CA-3; Figure 1c). However, 99% confidence ellipses (not shown) for all three locations enclosed Aroclor 1260 for the first three CA axes. Univariate descriptions (means and their standard errors) for human subject scores on the first three CA axes are presented also, in Table 2, as are the *a posteriori* scores for the projected Aroclor mixtures.

Identifying site-specific sources of Aroclor was important in the present study to evaluate whether MCRL Site 050 acted as a source of PCB exposure for inhabitants of Fort Albany First Nation. Although our results are not inconsistent with Site 050 (PCB contamination mainly Aroclor 1260; ESG 1999a, b) being a source of exposure for Fort Albany residents, we cannot distinguish between PCB input from Site 050 and that from the environment and/or a traditional diet, as the CB pattern of the non-exposed Native community, Kashechewan, and the non-Native community, Hamilton, also most closely resembled Aroclor 1260. Moreover, these results must be interpreted with caution because environmental weathering and biotransformation would change the original mixture of Aroclor 1260 whereby the percentages of CBs in the original mixture are not representative of the environmental mixture (AMAP, 1998; Hansen, 1998).

Our previous work (Tsuji et al. MS) revealed that being active on MCRL Site 050 (but not Anderson Island, in general) had a significant impact on body burden for people of Fort Albany. In addition, a significant difference between people from Fort Albany and Kashechewan with respect to DDE/DDT ratio data was noted, indicating that individuals from Fort Albany were exposed to a source of DDT that the people of Kashechewan were not exposed to (Tsuji et al. MS); high

**Table 1**. Correspondence axes scores for nine PCB congeners (CB).

CB	CA Axis-1	CA Axis-2	CA Axis-3	CA Axis-4
99	-0.3109	0.1289	-0.0646	-0.0374
118	-0.3612	-0.1680	0.1280	0.0194
138	-0.0764	0.0107	-0.0802	-0.0139
153	0.0004	-0.0163	-0.0536	-0.0185
156	-0.0211	0.1008	0.0249	0.2361
170	0.1320	0.0011	0.0158	0.0272
180	0.1792	-0.0374	0.0249	0.0143
183	-0.1482	0.2816	0.1821	-0.0593
187	0.1305	0.0269	0.1038	-0.0918

Table 2. Mean values of correspondence axes scores for locations and Aroclor mixtures.

| CA Axis/Location or Mixture	n	Mean	se
CA Axis 1			
Fort Albany	99	0.011	0.015
Kashechewan	98	0.030	0.013
Hamilton	52	-0.074	0.027
Aroclor 1248	1	-1.568	-
Aroclor 1254a	1	-1.400	-
Aroclor 1254b	1	-1.077	-
Aroclor 1260	1	0.343	-
CA Axis 2			
Fort Albany	99	-0.006	0.008
Kashechewan	98	0.015	0.008
Hamilton	52	-0.017	0.010
Aroclor 1248	1	-0.303	-
Aroclor 1254a	1	-0.592	-
Aroclor 1254b	1	-0.373	-
Aroclor 1260	1	0.114	-
CA Axis 3			
Fort Albany	99	-0.006	0.007
Kashechewan	98	0.022	0.005
Hamilton	52	-0.030	0.013
Aroclor 1248	1	0.350	-
Aroclor 1254a	1	0.329	-
Aroclor 1254b	1	0.090	-
Aroclor 1260	1	0.147	-
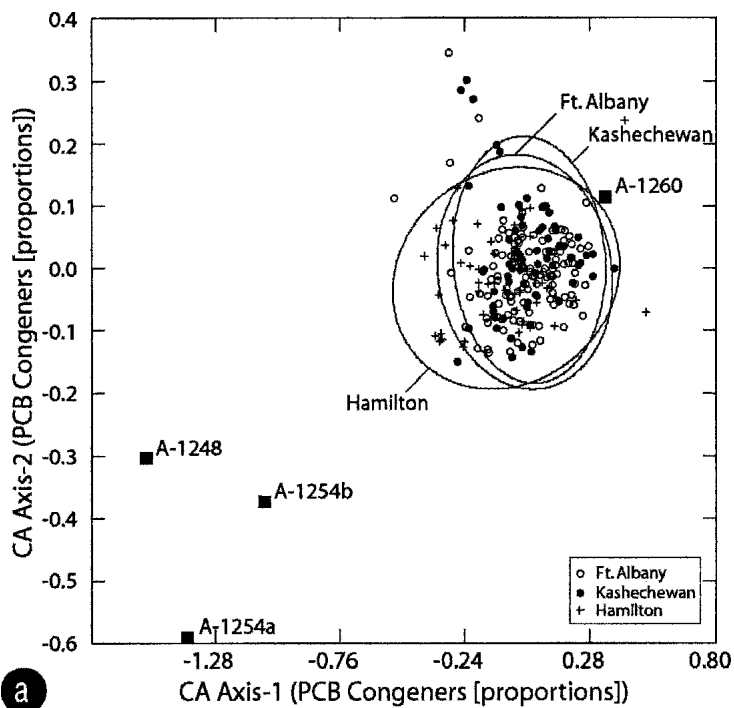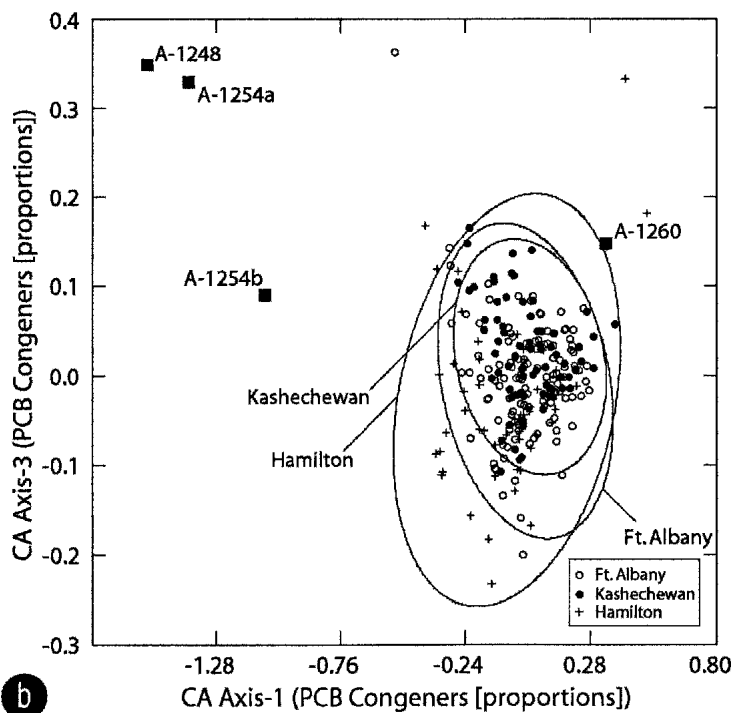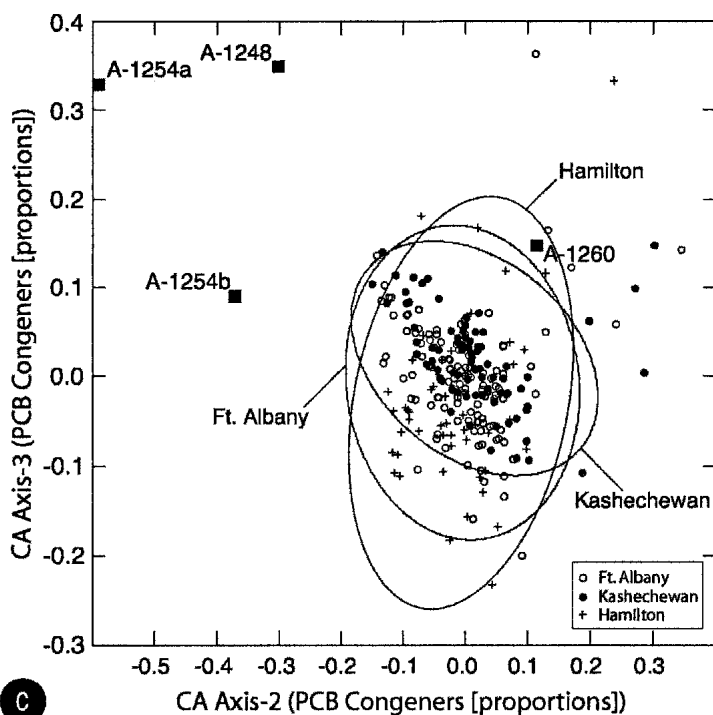
Figure 1. Plots of correspondence analysis (CA) scores for participants from Fort Albany, Kashechewan and Hamilton, Ontario, Canada. Confidence ellipses (95%) for all possible combinations of CA axes and Aroclor mixtures were also projected into CA space.

concentrations of DDT were found in soil samples collected on MCRL Site 050 to the extent where remediation was required (ESG, 1999a, b). When the data from the Tsuji et al. (MS) study and the present study are viewed as a whole, it is suggestive that contaminants originating from MCRL Site 050 did impact body burdens in Fort Albany, but the data are not definitive. As stated by Tsuji et al. (MS), the traditional diet of First Nation people may obscure any point source contamination.

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