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Occurrence of PCB Residues in Burbot *(Lota lota)* and Lake Trout *(Salvelinus namaycush)* from the Churchill Falls Power Development Area

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Although restrictions have been placed on polychlorinated biphenyls (PCBs) in recent years limiting their use to closed applications, they continue to be released into the environment, for example via discharge of municipal wastewater (McDERMOTT-EHRLICH & YOUNG 1978). Recent work has indicated that at higher trophic levels e.g. in human milk, PCB levels have not declined in the years 1972-1977 while levels of the less stable organochlorine compounds p,p'-DDT and p,p'-DDE have (WESTOO & NOREN 1978). Similarly, PCB levels in marine species such as cod *(Gadus morhua)*, have not shown decline in recent years but appear to be increasing (KIHLSTROM & BERGLUND 1978, FALANDYSZ 1977).

Therefore, it is imperative that PCB baselines in the environment continue to be determined so that any new major inputs of PCB into the biosphere can be identified. Such an input has been identified by analysis of large fish from a relatively unpopulated area in northeastern Canada. High levels of PCB were found associated with the Churchill Falls hydroelectric power project in Labrador, Canada (lat. 45°N, long. 65°W). We have been unable to find any documentation of PCB inputs associated with hydroelectric developments and wish to alert other investigators to this occurrence.

MATERIALS AND METHODS

The samples of burbot *(Lota lota)* liver and Lake Trout *(Salvelinus namaycush)* mesentery fat were collected in the summer of 1977 at the sampling sites shown in Figure 1. Eight sites (2-9 inclusive) were selected to cover a wide area of the reservoirs, consisting of pre-existing natural lakes and newly-flooded area. One site (Site 1) was chosen at the outfall of the Churchill Falls power plant, which is referred to as the "tail race". The samples were wrapped in hexane - washed aluminum foil and frozen at -22C until analysis.

Prior to analysis, the samples were homogenized with a Polytron homogenizer. Half a gram of homogenate was weighed into a stainless stell ball mill (GRUSSENDORF et al. 1970) along with 15g hexane-washed sodium sulfate and

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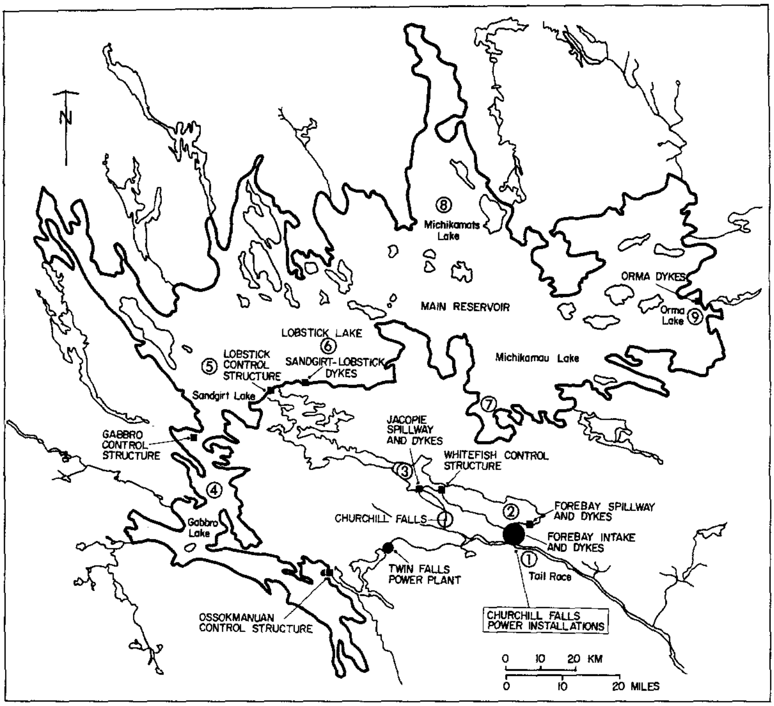

Fig. 1 Churchill Falls hydroelectric power project, indicating sampling locations

20 mL acetone:hexane (1:1, V/V). The mill was capped and shaken for 20 min on a Burrell wrist-action shaker fitted with extension clamps to give at least a 5cm stroke. The resulting finely-divided mixture was suction filtered through a medium frit filter funnel into a tared 100 mL round-bottom flask and the residue and ball mill rinsed three times with 10 mL of acetone: hexane (1:1, V/V). The solvent was removed under reduced pressure at 35C, and the lipids weighed. The lipids were applied to a 21mmID x 450mmL Florisil column prepared by activating 28.0g of Florisil at 450C overnight and deactivating with 1% water (to lauric acid number 88). The column was prewashed with 60 mL hexane dried over sodium sulfate and the lipids applied in 2 mL hexane followed by three 2 mL hexane washes. The column was percolated with 125 mL dried hexane, discarding the first 40 mL of eluant; the remaining 85 mL contained the PCBs, hexachlorobenzene, p,p'-DDE and Mirex, if present. Recovery of 90.9% + 3.3% on PCB-spiked samples were obtained.

The PCB fraction was further cleaned up by saponification with 0.54M methanolic KOH followed by oxidation in 0.30M CrO_3 in glacial acetic acid and subsequent column chromatography on 1g of 1% water deactivated Florisil. This procedure removed p,p'-DDE and other artifacts which partially obscured the PCB peak pattern.

Gas chromatographic analyses were performed on a gas chromatograph fitted with a Ni^{63} detector and a 182cmL x 4mmID glass column packed with 3% OV-101 on 80/100 mesh Supelcoport. The carrier gas was argon/methane 95/5 at a flow rate of 40 mL min^{-1}. The detector, oven and injection port temperatures were 350, 200 and 250C, respectively.

The GC-MS data were generated on a Hewlett-Packard Model 5980 with Model 5933 data system and operated in the selected ion monitoring mode. The GC column used was 91cmL x 2mmID packed with 3% OV-101 on 100/120 mesh Gas Chrom Q, with carrier flow 25 mL min^{-1} and oven temperature at 180C.

RESULTS AND DISCUSSION

The PCB patterns obtained from the fish taken at sampling sites 2-9 inclusive (upstream of the Churchill Falls generating station) were most closely matched by mixtures of Aroclors 1254 and 1260 in ratios ranging from approximately 2:1 to 1:1 1254:1260. These results are consistent with the ratios of 1254 to 1260 found in marine fish such as cod from the offshore fishing grounds in the general area of the east coast of Canada (MUSIAL 1977). However, the pattern obtained from fish taken at Site 1, just below the Churchill Falls power plant (the "tail race"), was most closely matched by Aroclor 1260 solely, with depression of certain penta- and hexachlorobiphenyl peaks and two of the octachlorobiphenyl peaks (Figure 2). This is interesting in view of the fact that 1254 is the principal mixture used in these hydroelectric power installations and may reflect an unusual degree of volatilization of the lower molecular weight components of Aroclor 1254 or an adsorption or other type of reaction which would result in removal or unavailability of these components for uptake by the fish.

A selected ion chromatogram of a pooled sample taken from the tail race showed the presence of tetra- and pentachlorobiphenyl, m/e 290 and 324 respectively (Figure 3).

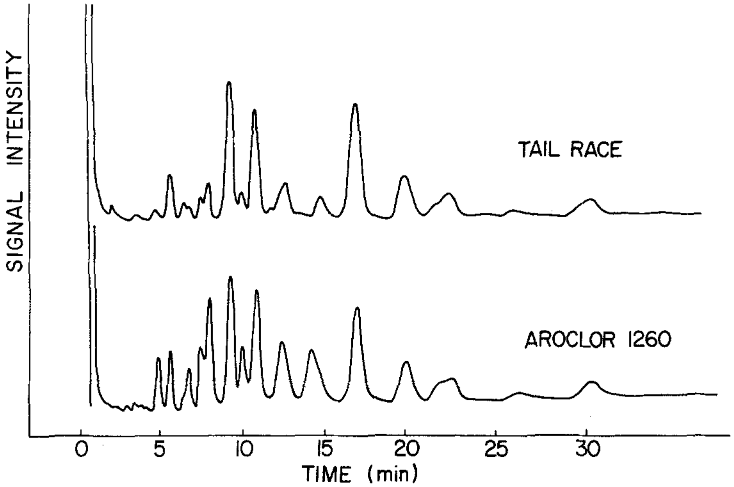

Fig.2 Gas chromatogram of Tail Race sample and Aroclor 1260 standard

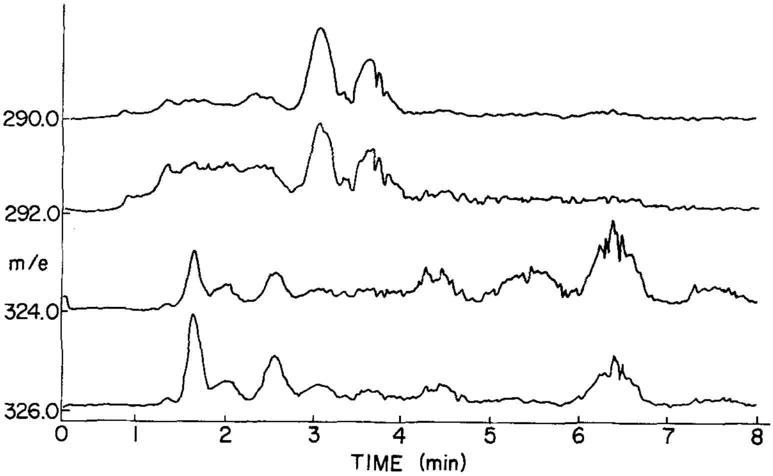

Fig.3 Selected ion chromatogram of Tail Race sample indicating presence of m/e 290 (tetrachlorobiphenyl) and 324 (pentachlorobiphenyl)

The PCB values found in burbot livers and mesentery fat of lake trout are given in Table 1. An interesting PCB distribution pattern emerged in that the PCB levels in the fish from the tail race were up to two orders of magnitude higher than those in fish from the general area above the power plant. The latter levels ranged from 0.04 to 1.11 μg/g wet weight with a mean value of 0.51μg/g for burbot liver and 0.50 μg/g for lake trout fat while the levels in burbot livers taken from the tail race (Site 1, below the power plant) ranged from 1.2 to 35.4 µg/g wet weight, with a mean of 17.1 µg/g. The upstream levels can be thought of as representing the general background levels in the area, resulting from long-range aerial fallout and/or from construction of the power plant and are approximately one-third of the amounts found in offshore fishery products such as cod from Nova Scotia (International Council for the Exploration of the Sea, 1976).

TABLE 1

PCB (µg/g wet wt) In Burbot Liver and Lake Trout Mesentery Fat From Churchill Falls

Sample type	Site Number								
	1	2	3	4	5	6	7	8	9
burbot liver	21.7	0.62	0.56	0.45	0.38	0.30	0.56	0.28	0.89
"	17.1		0.60		0.48	0.55	0.04		0.27
"	35.4		0.07		0.69	0.68			0.30
"	18.1		0.67		0.39	0.37			0.38
"	7.1				1.11				
"	15.1								
"	21.4								
"	1.2								
"	10.4								
trout fat						0.55			
"						0.46			
"						0.44			
"						0.43			
"						0.53			
"						0.37			
"						0.69			
"						0.49			

Originally it was thought that the levels in fish from the tail race might have resulted from leaks at the Churchill Falls and/or the defunct Twin Falls plant (see map, Figure 1). However, further checking into the construction of the Twin Falls plant disclosed that only mineral oil had been used in these transformers (WILSON 1978). Therefore the source of the tail race PCB would seem to be the Churchill Falls plant itself, or a possible PCB dump or discarded transformers upstream of the tail race Sampling Station.

The total quantity of PCB being released into the river cannot be calculated at present because the levels in the water and sediments have not been determined. However, the high levels in the tail race fish indicate an important source of PCB contamination in the Churchill Falls area. By a second sampling in the fall of 1978 it should be possible to isolate this source.

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