

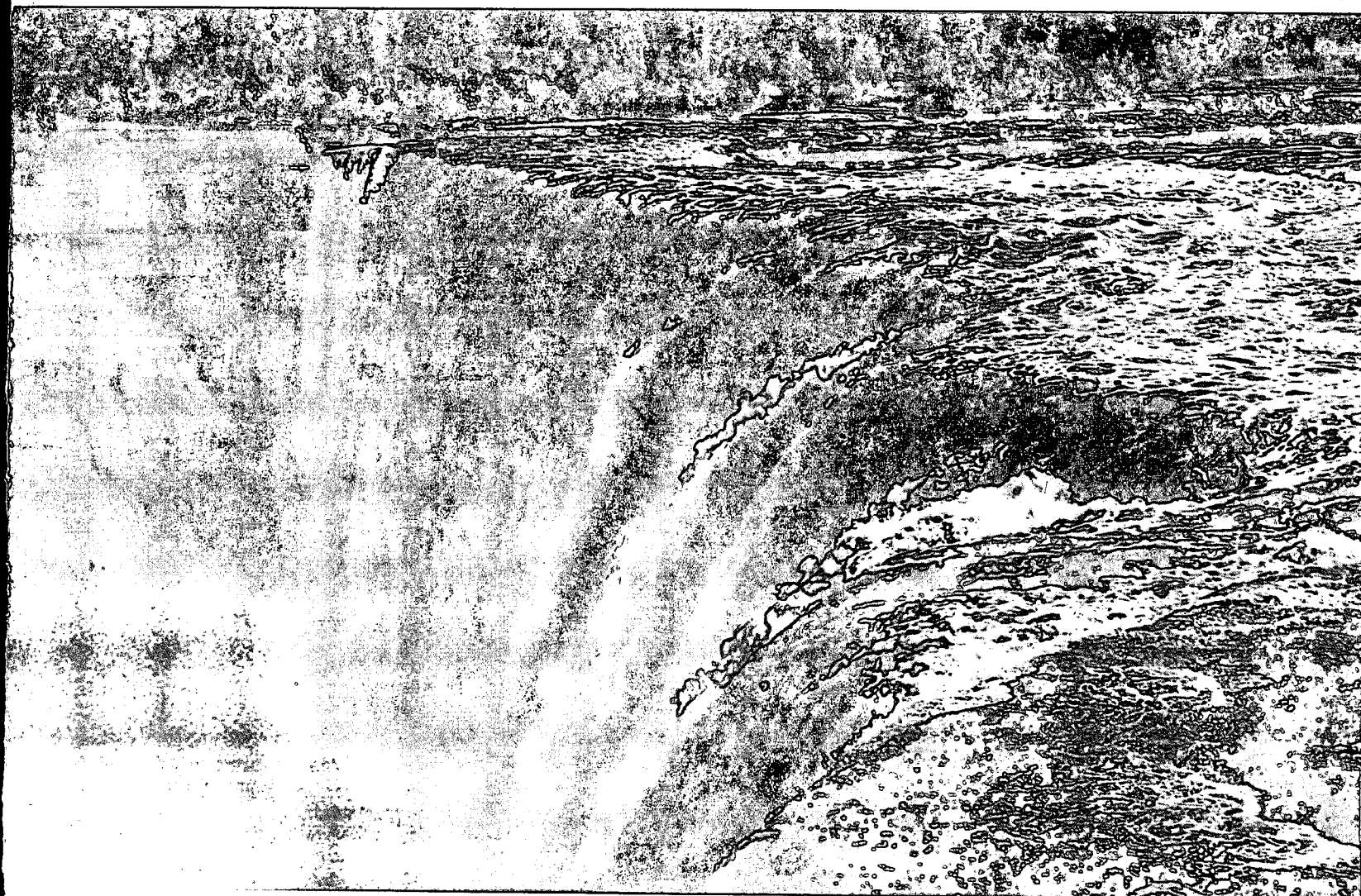


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Pesticide Distribution, Lower Ottawa River, 1986

J.C. Merriman and J.L. Metcalfe



TECHNICAL BULLETIN NO. 160

INLAND WATERS DIRECTORATE
ONTARIO REGION
WATER QUALITY BRANCH
BURLINGTON, ONTARIO, 1988

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Abstract

The Water Quality Branch, Ontario Region, surveyed the lower Ottawa River during 1986 to determine the concentration and distribution of chlorophenols (CPs) and organochlorine pesticides (OCs) in water, bottom sediment and biota.

Concentrations of CPs and OCs in water were well below established guidelines for the protection of freshwater aquatic life and were found for the most part to be below the analytical detection limit for OCs in both sediment and biota. Chlorophenol concentrations in sediment and biota were also very low.

Résumé

La Direction de la qualité des eaux, Région de l'Ontario, a effectué en 1986 une étude du cours inférieur de la rivière des Outaouais pour déterminer la concentration et la répartition des chlorophénols (CP) et des pesticides organochlorés (OC) dans l'eau, les sédiments de fond et les organismes aquatiques.

Les concentrations de CP et d'OC dans l'eau étaient bien inférieures à celles recommandées pour la protection des formes de vie dulcicoles. Dans les sédiments et les organismes aquatiques, les teneurs en OC étaient la plupart du temps inférieures au seuil de détection, et les concentrations de chlorophénols étaient également très faibles.

Pesticide Distribution, Lower Ottawa River, 1986

J.C. Merriman and J.L. Metcalfe

INTRODUCTION

The water quality of the Ottawa River from the National Capital Region (NCR) downstream to the Ontario-Quebec border is influenced by a number of point and non-point source inputs. These include numerous municipal and industrial discharges in the Ottawa-Hull area as well as inputs from pulp and paper mills in Ottawa-Hull, Gatineau, Masson and Thurso. There is considerable agriculture in the lower part of the Ottawa River basin resulting in non-point source runoff directly into the river or its tributaries.

The Water Quality Branch (WQB), Ontario Region, as part of a departmental Pestfund study, carried out a survey on the lower Ottawa in conjunction with the National Water Research Institute (NWRI) of Environment Canada. The objective of the survey was to ascertain the concentration and distribution of organochlorine pesticides and chlorophenols in water, bottom sediment and biota, as well as to determine the potential origin and effects on water uses of the pesticides.

Organochlorine pesticides (OCs) and chlorophenols (CPs) were specifically chosen for study because OCs have been detected in water in the National Capital Region (Merriman and McCrea, 1985; Coordinating Committee for Water Quality in the Ottawa River, 1986) and CPs have been found in pulp and paper mill discharges (Health and Welfare Canada, 1980). Furthermore, several of the substances are on the list of active ingredients for the 1986 Pesticide Registrant Survey (Environment Canada, 1987) and can be quantitatively analyzed by the National Water Quality Laboratory (NWQL) in Burlington, Ontario.

Chlorophenols are a major group of chemicals with a variety of uses based on their pesticidal or biocidal activity. They can be used as bactericides, slimicides, fungicides, herbicides and insecticides. Their primary use in Canada is as a wood preservative, but other preservative uses are for paint, drilling muds, photographic solutions, hides, leather and textiles. They are used as antimicrobials in industrial

cooling systems and pulp and paper mills, and in the agricultural sector as herbicides and pesticides.

Chlorophenols enter the aquatic environment in a number of ways, including via industrial effluents from pulp and paper mills and wood treatment plants. They may also enter bodies of water from the chlorination of sewage treatment plant effluents, the chlorination of drinking waters that contain phenols, and as nonpoint source runoff from agricultural lands (Jones, 1981). CPs are widespread in the aquatic environment and have also been found in precipitation (Jones, 1981; National Research Council of Canada, 1982).

Organochlorine compounds are used mainly for insecticidal purposes in both domestic and commercial applications. All of the organochlorines are imported (these compounds are not manufactured in Canada) and all are registered for use in Canada by Agriculture Canada. The organochlorines in comparison with other insecticides, such as organophosphates and carbamates as well as herbicides, show a higher toxicity to aquatic life, have a higher potential for uptake and bioconcentration, and are more persistent in aquatic ecosystems (Edwards, 1977).

METHODOLOGY

The sampling sites are shown in Figure 1. Table 1 indicates dates and media sampled.

Table 1. Stations, Dates and Media Sampled, Ottawa River, 1986

Station	Date of sampling	Water	Sediment	Mussel (<i>E. complanata</i>)
South Nation	86-07-16	Yes	Yes	Yes (caged)
Treadwell A	86-07-16	Yes	Yes	Yes (caged)
Treadwell B	86-07-16	Yes	Yes	No
Treadwell C	86-07-16	Yes	Yes	Yes (caged)
Carillon A	86-07-15	Yes	Yes	Yes (resident)
Carillon B	86-07-15	Yes	Yes	No
Carillon C	86-07-15	Yes	Yes	Yes (caged)

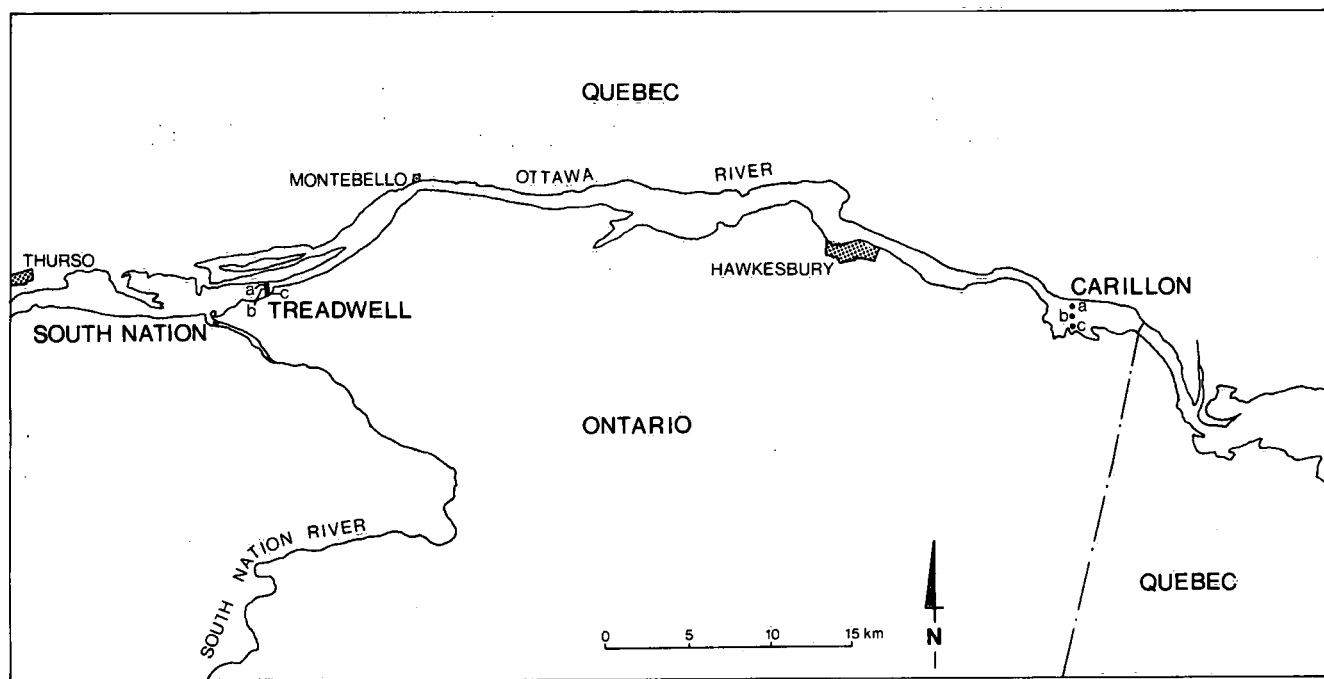


Figure 1. Ottawa River sampling sites, 1986.

Water

River water was clarified on site using a Westfalia separator. Water was pumped at a rate of $6 \text{ L} \cdot \text{min}^{-1}$ using a March 5C-MD submersible magnetic drive pump. A Teflon hose encased in stainless steel was used as a transfer line between the pump and centrifuge.

Two pre-cleaned 20-L stainless steel containers were used to hold each large-volume organochlorine sample. Chlorophenol samples were collected in 1-L pre-cleaned, pre-acidified glass bottles and refrigerated until time of analysis.

The large-volume samples were returned daily to a trailer in Ottawa where they were extracted using a continuous-flow extractor, recently developed by NWRI (Goulden and Anthony, 1985). It is a mixer-settler extractor that isolates and concentrates trace organics from water into dichloromethane (DCM) (Fig. 2). Initially, 200 mL of glass distilled DCM was pumped into the mixing chamber, and the solvent pump rate re-established to sustain that volume of solvent. A glass wand, inserted into the end of the Teflon water feed line, was submerged in the stainless steel container and the water feed pump started at a rate of $640 \text{ mL} \cdot \text{min}^{-1}$. As ambient water temperatures were

around 20°C , the heater tube was not used. Surrogate standards were added to the sample at $1.4 \text{ mL} \cdot \text{min}^{-1}$ using a metering pump. The run time was recorded to determine the volume of standards added. After all the sample had passed through the extractor, the water, solvent, and spike feed pumps and the stirrer were shut off and the run time recorded. After the DCM separated from the water, it was drained from the bottom of the mixing chamber into a Teflon separatory funnel. The solvent extract was then transferred into a 500-mL pre-cleaned amber glass bottle. Water in the extractor was drained into the separatory funnel, then re-used to wash the packed column. Any remaining DCM was collected and added to the amber bottle, which was stored in the dark at 4°C until analysis at the National Water Quality Laboratory.

In the laboratory, the DCM extracts were cleaned and concentrated to an appropriate volume for direct GLC analysis. Detection and measurement was completed using electron capture gas chromatography.

Chlorophenol samples were extracted with DCM. The DCM extract was then base-partitioned with 2% potassium bicarbonate. The phenols in the basic extract were derivatized and cleaned on a silica gel column before GLC analysis using an electron capture detector.

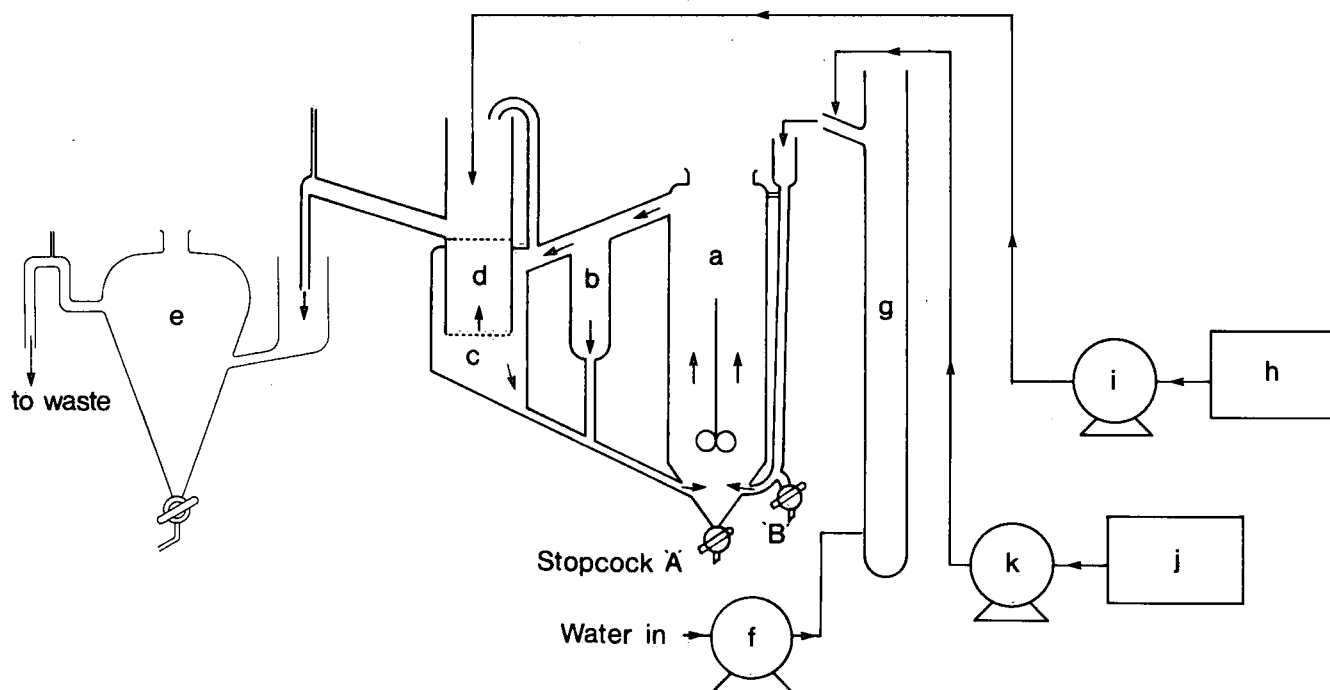


Figure 2. Flow diagram of large-volume extractor (from Neilson *et al.*, 1987). *a* – mixing chamber; *b* – first settling chamber; *c* – second settling chamber; *d* – packed column; *e* – separator trap; *f* – metering pump - water; *g* – heater tube; *h* – solvent bottle; *i* – solvent make-up pump; *j* – surrogate standards bottle; *k* – “spiking” pump.

Sediment

Bottom sediments were collected at all stations using a Ponar dredge. The top 3 cm of the sample was removed, placed in solvent-washed glass jars with foil-lined caps, and frozen.

Before analysis, samples were thawed, excess water was decanted and the sample homogenized. Sediment was extracted with 1:1 hexane-acetone, and partitioned with water and back extracted into benzene. The combined extracts were dried, reduced in volume, subjected to gel permeation chromatography and further cleaned on a silica gel column from which two fractions were obtained. Each fraction was analyzed using GLC for organochlorine pesticides.

Sediment for chlorophenol analysis was acidified to pH 1, then Soxhlet extracted with acetone-hexane. The extract was base-partitioned with 2% sodium bicarbonate solution, and then acetylated while being extracted into

petroleum ether. The resulting extract was dried and concentrated before being cleaned on a silica gel column. The fraction containing the phenol acetates was collected for determination by GC-ECD and GC-MSD analyses.

Organic carbon and nitrogen content in sediment samples was determined by thermal combustion at 850°C to form CO₂, H₂O and N₂ gases which were then separated chromatographically. Quantitation was made with a thermal conductivity detector coupled with a recorder and electronic integrator.

Particle size analysis on bottom sediment was determined using the sieve and sedigraph method, which provides percentages for gravel, sand, silt and clay. Samples were freeze-dried and gently broken up with a mortar and pestle. All particles large enough to block the sedigraph suction tube (0.80 mm) were removed. The sample was then dispersed in a Calgon suspension and automatic analysis was done with the sedigraph. Results were processed with SIZDIST, a FORTRAN IV computer program

(Sandilands and Duncan, 1980). A more detailed description of the methodology may be found in Duncan and LaHaie (1979).

Biota

Elliptio complanata collected from Balsam Lake, a pristine source, were placed in stainless steel cages at all sites. After approximately ten weeks of exposure in the river, the mussels were removed, frozen and transported back to the laboratory. Resident mussels were collected using a Ponar dredge. They were frozen immediately and returned to the laboratory on completion of the survey. Both resident and caged mussels were analyzed for organochlorine pesticides, chlorophenols and lipid content. Unfortunately, the cages at the Carillon A site were missing on return at the end of the ten-week exposure period, and thus the data at this site are based on resident mussels only.

For organochlorine pesticide analysis, mussel tissue was homogenized and dried by adding sodium sulphate. Lipids were extracted with dichloromethane. Lipid removal was done on a gel permeation column and a silica gel column was used for further cleanup. Each of the two resulting fractions were quantified by GLC analysis.

Chlorophenols were analyzed by acidifying the tissue and extracting with toluene. The extract was then dried with acidified sodium sulphate. Lipids were removed using a gel permeation column. The extract was base-extracted, derivatized with acetic anhydride, then passed through a silica gel column and quantified by GC-MSD.

Lipid content in mussels was determined by homogenizing sodium sulphate and petroleum ether with the tissue. The residue was then Soxhlet extracted with petroleum ether. The extract after distillation to 1 mL was dried overnight and weighed to determine the percent lipid content.

RESULTS AND DISCUSSION

Chlorophenols

Water

Speciated chlorophenol analyses in the National Water Quality Laboratory commenced in 1986. Because of the new method development, no detection limits had been established at the time of writing, and chlorophenols were reported as nanograms per sample. When detection limits are established, some of the samples in which trace amounts

were found will most likely be below their analytical detection limit.

Chlorophenol data for water, sediment and mussels are presented in Tables 2, 3 and 4. Of 20 chlorophenols analyzed, only four were detectable. Those detected included 4-chlorophenol (4-CP); 2,4,6-trichlorophenol (2,4,6-TCP); 3,4,5-trichlorophenol (3,4,5-TCP); and pentachlorophenol (PCP). With the exception of 3,4,5-TCP, all the chlorophenols detected in this study are commercially used or marketed in Canada (Jones, 1981).

Concentrations of individual chlorophenol isomers in Ottawa River water were less than $100 \text{ ng}\cdot\text{L}^{-1}$, with the exception of one sample in which the concentration of 3,4,5-TCP was slightly higher. As shown in Table 5, all concentrations in water were well below the Canadian water quality guidelines for the protection of freshwater aquatic life (CCREM, 1987).

The most frequently detected chlorophenol in water, 4-CP, was found at every site and ranged in concentration from 6 to $75 \text{ ng}\cdot\text{L}^{-1}$. The 3,4,5-TCP isomer was detected in five out of seven water samples and ranged in concentration from ND to $115 \text{ ng}\cdot\text{L}^{-1}$. Carey *et al.*, (1986) report that 3,4,5-TCP is the major degradation product in the anaerobic dehalogenation of PCP. Another trichlorophenol (2,4,6-TCP) was found in four out of seven water samples in concentrations ranging from ND to $17 \text{ ng}\cdot\text{L}^{-1}$. Pentachlorophenol was detected in four water samples but only in trace amounts with a maximum concentration of $5 \text{ ng}\cdot\text{L}^{-1}$.

Concentrations of chlorophenols in water show two anomalies. First, concentrations found in the South Nation River near its confluence with the Ottawa River were the lowest of all the stations sampled. With the exception of trace amounts of 4-CP, all other chlorophenols were non-detectable. This station was selected because it was thought to be representative of agricultural land use. The chlorophenol levels found in water suggest that chlorophenol input from agricultural sources is very low. Both 2,4,6-TCP and PCP, however, were found in *E. complanata*, suggesting sources of chlorophenols in the watershed.

Secondly, concentrations were consistently the highest at the Carillon A station. This is most likely due to inputs from pulp and paper mills located along the Quebec shore in Gatineau, Masson and Thurso, and also from municipal discharges. These major point source inputs are also located upstream from the Treadwell transect as well, yet the Treadwell A station showed lower concentrations than found downstream at Carillon A. There may be other point source inputs downstream from the Treadwell site which caused the higher concentrations at Carillon.

Table 2. Chlorophenols in Ottawa River Water, 1986 (ng)

Compound	South Nation	Treadwell			Carillon		
		A	B	C	A	B	C
2-Chlorophenol	ND	ND	ND	ND	ND	ND	ND
3-Chlorophenol	ND	ND	ND	ND	ND	ND	ND
4-Chlorophenol	6	41	14	64	75	16	24
5-Methyl-2-chlorophenol	ND	ND	ND	ND	ND	ND	ND
2,6-Dichlorophenol	ND	ND	ND	ND	ND	ND	ND
3-Methyl-4-chlorophenol	ND	ND	ND	ND	ND	ND	ND
2,4-Dichlorophenol	ND	ND	ND	ND	ND	ND	ND
3,5-Dichlorophenol	ND	ND	ND	ND	ND	ND	ND
2,3-Dichlorophenol	ND	ND	ND	ND	ND	ND	ND
3,4-Dichlorophenol	ND	ND	ND	ND	ND	ND	ND
2,4,6-Trichlorophenol	ND	ND	3	12	17	3	ND
2,3,6-Trichlorophenol	ND	ND	ND	ND	ND	ND	ND
2,3,5-Trichlorophenol	ND	ND	ND	ND	ND	ND	ND
2,4,5-Trichlorophenol	ND	ND	ND	ND	ND	ND	ND
2,3,4-Trichlorophenol	ND	ND	ND	ND	ND	ND	ND
3,4,5-Trichlorophenol	ND	12	31	18	115	14	ND
2,3,5,6-Tetrachlorophenol	ND	ND	ND	ND	ND	ND	ND
2,3,4,6-Tetrachlorophenol	ND	ND	ND	ND	ND	ND	ND
2,3,4,5-Tetrachlorophenol	ND	ND	ND	ND	ND	ND	ND
Pentachlorophenol	ND	ND	2	3	5	2	ND

Note: All samples = 1 L.

ND = Non-detectable.

Table 3. Chlorophenols in Ottawa River Bottom Sediment, 1986 (ng)

	South Nation	Treadwell			Carillon		
		A	B	C	A	B	C
Sample weight (g)	40.18	47.85	42.09	33.33	32.92	26.56	40.00
2-Chlorophenol	ND	ND	ND	ND	ND	ND	ND
3-Chlorophenol	ND	ND	ND	ND	ND	ND	ND
4-Chlorophenol	ND	ND	ND	ND	ND	ND	ND
5-Methyl-2-chlorophenol	ND	ND	ND	ND	ND	ND	ND
2,6-Dichlorophenol	ND	ND	ND	ND	ND	ND	ND
3-Methyl-4-chlorophenol	ND	ND	ND	ND	ND	ND	ND
2,4-Dichlorophenol	ND	ND	ND	ND	ND	ND	ND
3,5-Dichlorophenol	ND	ND	ND	ND	ND	ND	ND
2,3-Dichlorophenol	ND	ND	ND	ND	ND	ND	ND
3,4-Dichlorophenol	ND	ND	ND	ND	ND	ND	ND
2,4,6-Trichlorophenol	ND	ND	ND	96.6	ND	ND	ND
2,3,6-Trichlorophenol	ND	ND	ND	ND	ND	ND	ND
2,3,5-Trichlorophenol	ND	ND	ND	ND	ND	ND	ND
2,4,5-Trichlorophenol	ND	ND	ND	ND	ND	ND	ND
2,3,4-Trichlorophenol	ND	ND	ND	ND	ND	ND	ND
3,4,5-Trichlorophenol	ND	ND	ND	ND	ND	ND	ND
2,3,5,6-Tetrachlorophenol	ND	ND	ND	ND	ND	ND	ND
2,3,4,6-Tetrachlorophenol	ND	ND	ND	ND	ND	ND	ND
2,3,4,5-Tetrachlorophenol	ND	ND	ND	ND	ND	ND	ND
Pentachlorophenol	ND	ND	ND	341.0	ND	ND	ND

ND = Non-detectable.

Table 4. Chlorophenols in Ottawa River Mussels (*E. complanata*), 1986 (ng)

	South Nation (caged)	Treadwell (caged)		Carillon (resident)		Balsam Lake
		A	C	A	C	
Lipid content (%)	0.99	0.98	0.68	1.13	0.85	0.69
Sample weight (g)	10.82	10.25	9.68	8.34	10.22	11.87
2-Chlorophenol	ND	ND	ND	ND	ND	ND
3-Chlorophenol	ND	ND	ND	ND	ND	ND
4-Chlorophenol	ND	ND	ND	ND	ND	ND
5-Methyl-2-chlorophenol	ND	ND	ND	ND	ND	ND
2,6-Dichlorophenol	ND	ND	ND	ND	ND	ND
3-Methyl-4-chlorophenol	ND	ND	ND	ND	ND	ND
2,4-Dichlorophenol	ND	ND	ND	ND	ND	ND
3,5-Dichlorophenol	ND	ND	ND	ND	ND	ND
2,3-Dichlorophenol	ND	ND	ND	ND	ND	ND
3,4-Dichlorophenol	ND	ND	ND	ND	ND	ND
2,4,6-Trichlorophenol	20.6	13.1	16.6	17.1	21.4	ND
2,3,6-Trichlorophenol	ND	ND	ND	ND	ND	ND
2,3,5-Trichlorophenol	ND	ND	ND	ND	ND	ND
2,4,5-Trichlorophenol	ND	ND	ND	ND	ND	ND
2,3,4-Trichlorophenol	ND	ND	ND	ND	ND	ND
3,4,5-Trichlorophenol	ND	ND	ND	ND	ND	ND
2,3,5,6-Tetrachlorophenol	ND	ND	ND	ND	ND	ND
2,3,4,6-Tetrachlorophenol	ND	ND	ND	ND	ND	ND
2,3,4,5-Tetrachlorophenol	ND	ND	ND	ND	ND	ND
Pentachlorophenol	28.1	ND	18.0	ND	22.0	ND

ND = Non-detectable.

Table 5. Chlorophenol Freshwater Aquatic Life Guideline Exceedences

Compound	Guideline ($\mu\text{g}\cdot\text{L}^{-1}$)	Concentration range ($\mu\text{g}\cdot\text{L}^{-1}$)	Exceedences
Monochlorophenols	7	0.006-0.075	0
Dichlorophenols	0.2	ND	0
Trichlorophenols	18	ND-0.132	0
Tetrachlorophenols	1	ND	0
Pentachlorophenol	0.5	ND-0.005	0

ND = Non-detectable.

These two anomalies highlight the deficiencies of a one-time sampling survey which may not reflect ambient or general water quality conditions. More frequent sampling would have to be done before more conclusive findings could be made.

Sediment

Chlorophenols were detected in only one sediment sample at low concentrations (Table 3). Pentachlorophenol and 2,4,6-TCP were found at the Treadwell C station in the

low parts per billion range. All other samples showed no detectable levels of chlorophenols.

Particle size analysis results of the bottom sediment proved to be quite variable (Table 6). The clay-sized fraction was the lowest at the Treadwell C station, while organic carbon content was the highest. Karickhoff *et al.* (1979) reported that sorption of hydrophobic compounds on sediments was directly related to organic carbon content of the sediment. This is probably a more important factor than particle size and may account for the chlorophenol detections at Treadwell C.

Table 6. Particle Size Analysis and Organic Carbon in Ottawa River Bottom Sediment, 1986 (%)

Station	Gravel	Sand	Silt	Clay	Organic carbon
South Nation	0	10.8	45.5	43.8	1.6
Treadwell A	0	43.1	40.2	16.8	3.8
Treadwell B	0	32.5	39.9	27.6	3.2
Treadwell C	0	77.9	9.0	13.1	4.0
Carillon A	0	4.9	54.6	40.5	0.9
Carillon B	0	14.3	43.7	42.1	2.4
Carillon C	0	12.9	52.1	35.0	1.7

Biota

The shell size and tissue weight of *E. complanata* are presented in Table 7. The lipid content is given in Table 4. The Carillon A station was the only site at which resident *E. complanata* were analyzed. At all of the other sites caged *E. complanata* were analyzed after approximately two months of exposure. There was no apparent difference between the caged mussel results and the resident mussel results. Pentachlorophenol and 2,4,6-TCP were the only isomers found in mussel tissue. In the case of 2,4,6-TCP, it was found in every sample, while PCP was detected in three out of five samples. Concentrations of 2,4,6-TCP in *E. complanata* showed little spatial variation with concentrations ranging from 1.3 to 2.1 ng·g⁻¹, while PCP concentrations ranged from non-detectable to 2.6 ng·g⁻¹. Chlorophenol concentrations appear to be quite low and reflect ambient or background levels.

Table 7. Size and Weight of *E. complanata*, Ottawa River, 1986

Station	Size (mm)	Weight (g)
South Nation (caged)	7.55	16.64
	7.04	12.45
	7.29	14.89
	6.75	16.31
	7.10	14.37
Treadwell A (caged)	7.12	14.22
	7.02	10.83
	6.30	15.68
	7.22	12.96
	6.44	11.24
Treadwell C (caged)	6.90	11.06
	6.72	9.08
	6.12	12.88
	6.76	11.94
	6.22	9.78
Carillon A (resident)	6.65	13.73
	7.53	14.38
	7.20	9.17
Carillon C (caged)	6.30	12.52
	6.75	11.68
	6.46	9.33
	6.71	12.73
	7.27	10.18
Balsam Lake	6.54	16.00
	7.02	10.43
	7.25	11.51
	6.36	16.82
	6.67	12.80

Size — Shell length.

Weight — Tissue only.

Bioconcentration factors (BCFs) were calculated for stations where chlorophenols were detectable in both

water and mussels. Treadwell C and Carillon A BCFs for 2,4,6-TCP were 142 and 124, respectively, and the Treadwell C station had a BCF of 633 for PCP. Bioconcentration factors tend to increase with the higher chlorinated phenols. Although uptake of chlorophenols has been shown to be fast, depuration is also quite rapid (Ontario Ministry of the Environment, 1984).

Organochlorine Pesticides

Water

Results for the 17 organochlorine pesticides analyzed in water, sediment and biota are presented in Tables 8, 9 and 10. Five out of 17 pesticides and metabolites were detected at very low concentrations in large-volume water samples. Of those detected, namely α -BHC and γ -BHC (lindane), dieldrin, heptachlor epoxide and p,p'-DDE, each compound displayed very little variation in concentration. α -BHC and lindane, which are ubiquitous in the aquatic environment, were detected in all of the water samples collected. Concentrations ranged from 1.5 to 1.6 ng·L⁻¹ for the isomer, while lindane was found in concentrations ranging from 0.4 to 1.4 ng·L⁻¹. α -BHC showed very little spatial variation, whereas lindane concentrations ranged from 0.4 to 0.5 ng·L⁻¹ at the Ottawa River stations to almost three times higher at the South Nation site. Although it is only one sample, it suggests that lindane is being used in the South Nation River watershed.

Dieldrin was the only other organochloride detected in all of the samples, with concentrations ranging from 0.06 to 0.07 ng·L⁻¹. As in the case of BHC, it is also widespread in the aquatic environment. Heptachlor epoxide was found in five out of seven samples, ranging from non-detectable to 0.04 ng·L⁻¹. The only other parameter detected in water was p,p'-DDE, which ranged from non-detectable to 0.06 ng·L⁻¹. It is a breakdown product of DDT, which was restricted in use in 1972.

Freshwater aquatic life guidelines, as formulated by the Canadian Council of Resource and Environment Ministers (1987) for organochlorine pesticides, were not exceeded (Table 11). All concentrations were well below the established guidelines, which suggests that the concentrations found are no threat to aquatic life.

Sediment

Organochlorine pesticides were below the analytical detection limit of 4 ng·g⁻¹ in bottom sediment samples (Table 9). A number of pesticides were below the detection limit but not confirmed. They included α -chlordane, p,p'-

DDE, and p,p'-TDE, which for the most part were found in concentrations below 1 ng·g⁻¹. Contamination of bottom sediments is not a problem for the parameters examined.

The degradation products of DDT, namely p,p'-DDE and p,p'-TDE, were found in trace amounts, as in the case of p,p'-DDE in water.

Table 8. Organochlorine Pesticides in Ottawa River Water Samples, 1986 (ng·L⁻¹)

Compound	South Nation	Treadwell			Carillon		
		A	B	C	A	B	C
α-BHC	1.550	1.605	1.565	1.600	1.463	1.470	1.470
Lindane	1.350	0.448	0.500	0.495	0.428	0.435	0.438
Heptachlor	ND	ND	ND	ND	ND	ND	ND
Aldrin	ND	ND	ND	ND	ND	ND	ND
Heptachlor epoxide	ND	0.026	0.036	0.031	0.029	0.032	ND
γ-Chlordane	ND	ND	ND	ND	ND	ND	ND
α-Chlordane	ND	ND	ND	ND	ND	ND	ND
α-Endosulphan	ND	ND	ND	ND	ND	ND	ND
p,p'-DDE	0.058	0.037	0.045	0.053	ND	ND	ND
Dieldrin	0.072	0.059	0.074	0.065	0.073	0.073	0.073
Endrin	ND	ND	ND	ND	ND	ND	ND
o,p'-DDT	ND	ND	ND	ND	ND	ND	ND
p,p'-TDE	ND	ND	ND	ND	ND	ND	ND
p,p'-DDT	ND	ND	ND	ND	ND	ND	ND
β-Endosulphan	ND	ND	ND	ND	ND	ND	ND
Mirex	ND	ND	ND	ND	ND	ND	ND
Methoxychlor	ND	ND	ND	ND	ND	ND	ND

ND = Non-detectable.

Table 9. Organochlorine Pesticides in Ottawa River Bottom Sediment, 1986 (mg·kg⁻¹)

Compound	South Nation	Treadwell			Carillon		
		A	B	C	A	B	C
α-BHC	ND	ND	ND	ND	ND	ND	ND
Lindane	ND	ND	ND	ND	ND	ND	ND
Heptachlor	ND	ND	ND	ND	ND	ND	ND
Aldrin	ND	ND	ND	ND	ND	ND	ND
Heptachlor epoxide	ND	ND	ND	ND	ND	ND	ND
γ-Chlordane	ND	ND	ND	ND	ND	ND	ND
α-Chlordane	ND	ND	ND	ND	ND	ND	ND
α-Endosulphan	ND	ND	ND	ND	ND	ND	ND
p,p'-DDE	ND	ND	ND	ND	ND	ND	ND
Dieldrin	ND	ND	ND	ND	ND	ND	ND
Endrin	ND	ND	ND	ND	ND	ND	ND
o,p'-DDT	ND	ND	ND	ND	ND	ND	ND
p,p'-TDE	ND	ND	ND	ND	ND	ND	ND
p,p'-DDT	ND	ND	ND	ND	ND	ND	ND
β-Endosulphan	ND	ND	ND	ND	ND	ND	ND
Mirex	ND	ND	ND	ND	ND	ND	ND
Methoxychlor	ND	ND	ND	ND	ND	ND	ND

ND = Non-detectable.

Table 10. Organochlorine Pesticides in Ottawa River Mussels (*E. complanata*), 1986 (mg·kg⁻¹)

	South Nation (caged)	Treadwell (caged)		Carillon (resident)		Balsam Lake
		A	C	A	C	
Lipids (%)	0.99	0.98	0.68	1.13	0.85	0.69
α-BHC	ND	ND	ND	ND	ND	ND
Lindane	ND	ND	ND	ND	ND	ND
Heptachlor	ND	ND	ND	ND	ND	ND
Aldrin	ND	ND	ND	ND	ND	ND
Heptachlor epoxide	ND	ND	ND	ND	ND	ND
γ-Chlordane	ND	ND	ND	ND	ND	ND
α-Chlordane	ND	ND	ND	ND	ND	ND
α-Endosulphan	ND	ND	ND	ND	ND	ND
p,p'-DDE	0.005	ND	0.004	ND	ND	ND
Dieldrin	ND	ND	ND	ND	ND	ND
Endrin	ND	ND	ND	ND	ND	ND
o,p'-DDT	ND	ND	ND	ND	ND	ND
p,p'-TDE	ND	ND	ND	ND	ND	ND
p,p'-DDT	ND	ND	ND	ND	ND	ND
β-Endosulphan	ND	ND	ND	ND	ND	ND
Mirex	ND	ND	ND	ND	ND	ND
Methoxychlor	ND	ND	ND	ND	ND	ND

ND = Non-detectable.

Table 11. Organochlorine Pesticide Freshwater Aquatic Life Guideline Exceedences

Compound	Guideline (ng·L ⁻¹)	Concentration range (ng·L ⁻¹)	Exceedences (%)
BHC isomers	10	1.9-2.9	0
Dieldrin	4	0.059-0.074	0
Heptachlor epoxide	10	ND-0.036	0
DDT + metabolites	1	ND-0.058	0

ND = Non-detectable.

Biota

Organochlorine pesticides were virtually absent in mussel tissue. Only two out of 17 were detected regularly and of the two, only p,p'-DDE was found above the detection limit (Table 10). The highest DDE concentration was found in the South Nation River, as in the case of water, which suggests that background levels for DDE are slightly higher in this watershed due to agricultural activity. All other stations had concentrations in *E. complanata* below the detection limit. α-BHC was found in trace amounts below the detection limit at four out of five sites, suggesting that there is uptake of this compound by *E. complanata*.

SUMMARY AND CONCLUSIONS

The water quality of the Ottawa River with respect to the pesticides examined is very good. Levels of both CPs and OCs were very low in water and well below the recommended guidelines for the protection of freshwater aquatic life as established by the Canadian Council of Resource and Environment Ministers (1987). There is no restriction on water use as a result of the levels found in this study.

Concentrations of both CPs and OCs in sediment and *E. complanata* were very low when detected. In some cases there were slight elevations in concentrations, suggesting increased usage or input from point and/or non-point sources.

Only 4 out of 20 chlorophenols and 7 out of 17 organochlorine pesticides were found to be present. Of these, water was the medium in which there was the highest frequency of detection for both CPs and OCs, while biota ranked second in percent detections in CPs and third for OCs. Bottom sediment proved to be a poor medium for detecting chlorophenols.

Some spatial variability was evident in the data. The highest chlorophenol concentrations in water were found at

the Carillon A station, possibly due to pulp and paper mill effluents along the Quebec shoreline. The only two detections of chlorophenols in bottom sediments were found at the Treadwell C station. Although CPs were not found in the bottom sediment of the South Nation nor farther downstream at Carillon along the Ontario shoreline, they were found in *E. complanata* at both the South Nation and Carillon C sites.

Lindane was found to be almost three times higher in water from the South Nation River compared with the Ottawa River sites. DDE in water and *E. complanata* were also higher at this station. It appears that some organochlorine compounds were used in agricultural applications in the South Nation watershed, resulting in slightly higher levels at this site compared with the Ottawa River.

In the lower Ottawa River, where concentrations of CPs and OCs are very low, water is the preferential medium for sampling to determine presence or absence, because detection limits are at the sub parts per trillion level, whereas sediment and biota detection limits are at the parts per billion level. Further work is required to evaluate whether suspended sediments would be a better sampling medium than bottom sediments and whether other biota such as juvenile fish would be better than mussels for the determination of the concentration and distribution of chemical substances.

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